Reeve Slough Feasibility Assessment 2019
Final Report

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Prepared for Fish & Wildlife Compensation Program
Prepared by North Fraser Salmon Assistance Project Society
Prepared with financial support from the Fish & Wildlife Compensation Program,
on behalf of its program partners
BC Hydro, Province of BC, Fisheries and Oceans Canada, First Nations and Public Stakeholders
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Executive Summary

The Reeve Slough Feasibility Assessment 2019 was undertaken by North Fraser Salmon Assistance Project Society and Fisheries and Oceans Canada to assess the feasibility of restoring flows and fish access to Reeve Slough, a relic channel of the Coquitlam River, which could provide 31,800 m2 of rearing habitat for salmonids. This is the largest parcel of unrestored, off-channel habitat remaining in the Coquitlam River watershed. Restoration of this site would primarily benefit Coho Salmon, but would also be accessible and utilized by Chinook, Chum, Sockeye, Pink, Coastal Cutthroat and Steelhead juveniles.

This enhancement opportunity is feasible (technical, permits, permissions, budget, risk). If this project were to proceed, the water levels in the slough would likely be more consistent, with lower winter water levels and slightly higher summer levels. Lower winter water levels may be a net gain for the Kwikwetlem Nation Graveyard as will be the ongoing monitoring of beaver activity.

The project would require:

Inflows
The results of the assessment suggest there is no persistent water supply sustaining a perennial flow-through hydrologic regime at Reeve Slough. The offsite Reeve Park Pump Station and associated flow provides a unique opportunity to establish an upstream water supply. The installation of a culvert, designed to deter beaver activity, under the road access to the Kwikwetlem First Nation Graveyard and a weir to maintain base flows can bring the required flows to the slough.

Outflows
There are two options to enable outflows and fish access/egress; however, there is a preferred option:

LiDAR based hydrologic model and field assessments confirmed periodic flood inundation of Reeve Slough. During a high-water event February 2020, overbank flood inundation connected the slough with the Coquitlam River along a previously unmapped seasonal channel. However, summer assessments suggest that this outlet channel is inactive with the exception of those high flow events. Despite the apparent significance of the seasonal channel during high water events, the potential for this drainage connection to facilitate upstream fish access would be a challenge due to two factors: gradient between 7% and 14% which would be even steeper during low water conditions and beaver activity.

The preferred option is to construct a channel parallel to the existing dyke, though longer, would reduce intrusion into the habitat, and physical construction, monitoring and operational requirements would be reduced. The scale of the potential construction phase and access impacts would be reduced. Also, the channel could be viewed from the dyke thus making long-term monitoring and maintenance less costly and thus more frequently undertaken. This channel is the best path as it is low gradient and does not require breaching the natural height of land. The Reeve Slough range of water levels would be maintained by the outflow invert level. This path would require a simple survey to confirm elevations.

The project assessment had high consideration of flooding concerns regarding the Kwikwetlem First Nation Cemetery which are significant due to the ongoing beaver activity and observed floodplain connectivity between the Coquitlam River and Reeve Slough.

This project is linked to: Coastal Watershed Action Plan: Coquitlam River Watershed Action Plan Ecosystem Chapter associated with the project Priority Action: Rivers, Lakes & Reservoirs

Priority Action Type: Habitat-based Action: Collect information necessary to evaluate, review and implement subsequent conservation, restoration and enhancement actions
Priority Action Summary: Improve rearing habitat capacity for Chinook and Coho Salmon and Steelhead

Secondary Action Type: Habitat-based Action: Implement habitat enhancements in Lower Coquitlam R.
Secondary Action Summary: Continue to build partnerships to undertake habitat works in the Coquitlam River watershed and encourage long-term monitoring, future habitat enhancements and on-going maintenance.

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1.0 Introduction

In 1900, the Coquitlam River watershed had all seven species of Pacific salmon as well as Bull Trout (*Salvelinus confluentus)* and/or Dolly Varden (*S. malma*) present. This salmonid abundance supported the Kwikwetlem First Nation people as well as other indigenous communities and settlers while supporting the watershed ecosystem.

By 1969, less than 50 salmon returned to the Coquitlam River watershed.

Since 1993, more than 15 habitat restoration projects have been completed, helping to recover lost habitat, which has resulted in over 7,300 m2 of spawning habitat and 54,130 m2 of critical off-channel rearing habitat for salmonids and their interdependent species. Project effectiveness monitoring of the constructed off-channel habitat by Fisheries and Oceans Canada (DFO) Salmon Enhancement Program (SEP) indicate that these projects support approximately 50% of the wild Coho Salmon (*Oncorhynchus kisutch*) smolts emigrating from the watershed. These works double the wild Coho Salmon produced by the Coquitlam River.

These habitat restoration projects, augmented by Coho Salmon released from three volunteer operated conservation hatcheries in the watershed, are increasing Coho Salmon abundance to once again allow for limited Indigenous and recreational fisheries.

1.1 Project Need

There is need for more habitat to support the continuing recovery of Coho Salmon and other salmonid species in the Coquitlam River watershed at all life stages. The amount of salmonid habitat lost is still far greater than the constructed works.

The importance of the Coquitlam River Chinook (*O. tshawytscha*), Chum (*O. keta*) and Coho Salmon which utilize off channel habitat has increased. Critical habitat, as described in the Recovery Strategy for the Northern and Southern Resident Killer Whales (*Orcinus orca*) in Canada clarified the features, functions and attributes of critical habitat. Critical habitat includes feeding and foraging, reproduction, socializing, resting, and additionally for Northern Resident Killer Whales, beach rubbing areas. Availability of Chinook and Chum Salmon, and other important prey species, is the first attribute listed in the description of the Southern Resident Killer Whale critical habitat and the returns to the Coquitlam River would be part of this designation. All efforts to recover and enhance habitat to increase abundance of Chinook and Chum in the Coquitlam River watershed contribute to the potential recovery of these SARA listed species.
(http://www.dfo-mpo.gc.ca/species-especes/consultations/sara-lep/pacific/2018/killerwhales-epaulards/faq-eng.html).

Time is of the essence for this assessment and potential restoration as climate change impacts are increasing the frequency and intensity of storms and catastrophic flows, increasing summer water temperatures and decreasing low flows. Urban and linear development are impacting terrestrial and aquatic habitats in the watershed. Providing as much productive rearing and refuge habitat as possible, in the shortest time frame, will allow salmonids as much time as possible to adapt and conserve their unique gene pools natal to the Coquitlam watershed. Time is of the essence for the animal. Providing access to restored historic habitat will contribute to this.

The Reeve Slough Feasibility Assessment 2019 project, located in Port Coquitlam, BC on land managed by Kwikwetlem First Nation, was undertaken to assess the slough and its potential to be restored to salmonid habitat. This important work was undertaken with financial support from the Fish and Wildlife Compensation Program (FWCP), on behalf of its program partners BC Hydro, Province of BC, Fisheries and Oceans Canada, First Nations and Public Stakeholders.

1.2 Background

Reeve Slough is approximately 1,060 m long and averages about 30 m in width for a total of 31,800 m2 of potential salmonid habitat. The slough is the largest parcel of unrestored off-channel habitat remaining in the Coquitlam River watershed. Assessment and restoration of this site would primarily benefit Coho Salmon, but would also be accessible and utilized by Chinook ,Chum, Sockeye (*O. nerka*), Pink (*O. gorbuscha*), Coastal Cutthroat (*O. clarkii clarkii*.) and Steelhead (*O. mykiss*) juveniles.

2.0 Goals and Objectives

The Reeve Slough Assessment 2019 was undertaken with the objective of determining the feasibility of future enhancement works in Reeve Slough to benefit all life stages of Coho, Chinook, Chum, Sockeye, Pink, Coastal Cutthroat and Steelhead and with the goal of habitat enhancement.

This project links to Action 1, Research and Information Acquisition, of the FWCP Coquitlam River Watershed Action Plan 2017 of the Rivers, Lakes & Reservoirs Ecosystem category:
Collect information necessary to evaluate, review and implement subsequent conservation, restoration and enhancement actions. The following identified limiting factors or knowledge needs were addressed by the Reeve Slough Feasibility Assessment 2019 Project:

- Habitat area
- Habitat quality
- Access
- Diversions

2.1 Linkage to FWCP Action Plan and Specific Actions

Priority Action

Linked to: Coastal Watershed Action Plan: Coquitlam River Watershed Action Plan
Ecosystem Chapter associated with the project Priority Action: Rivers, Lakes & Reservoirs
Action Type: Habitat-based Action
Priority Action: COQ.RLR.HB.13.01 Improve rearing habitat capacity for Chinook & Coho Salmon & Steelhead-P1
Priority Action Summary: Undertake a project feasibility assessment of Reeve Slough which could provide 31,800 m2 of potential rearing habitat for salmonids. This is the largest parcel of unrestored off-channel habitat remaining in the Coquitlam watershed. Assessment and restoration of this site would primarily benefit Coho salmon, but would also be accessible and utilized by Chinook, Chum, Sockeye, Pink and Cutthroat and Steelhead juveniles.

Secondary Action

Linked to: Coastal Watershed Action Plan: Coquitlam River Watershed Action Plan
Ecosystem Chapter associated with the project Priority Action: Rivers, Lakes & Reservoirs
Action Type: Habitat-based Action
Secondary Action: COQ.RLR.HB.12.01 Implement habitat enhancements in Lower Coquitlam River-P1
Secondary Action Summary: Continue to build partnerships to undertake habitat works in the Coquitlam River watershed and encourage long-term monitoring, future habitat enhancements and on-going maintenance.

3.0 Study Area

Reeve Slough is located in the Coquitlam River watershed. The Coquitlam River headwaters, Disappointment Lake east of Mt. Bonnycastle, are located in the southwestern relief of the Pacific Range, the southernmost subdivision of the Coast Mountains.

The upper Coquitlam River flows into the Coquitlam Lake Reservoir and exits through the 3.6 k Buntzen Lake Tunnel and powerhouse network into Indian Arm and a BC Hydro dam into the lower Coquitlam River.

The lower Coquitlam River flows 14.2 k from the dam, across the historic Fraser River floodplain, through the Cites of Coquitlam and Port Coquitlam to the confluence at the Fraser River, west of Douglas Island (Table 1 Study Area Summary).

The study area and project sites are on the Coquitlam River floodplain downstream of the BC Hydro Coquitlam River Dam. This area is impacted by the Coquitlam River dam footprint as described in Coquitlam River Buntzen Lake Watersheds Strategic Plan.

Table 2 Study Area Summary

Study Area Description	Coquitlam River Watershed, Port Coquitlam BC ~3,500 m Upstream of Fraser River Confluence
Watershed Code	100-024500-00000-00000-000-000-000-000-000-000
Map References	Geodata BC TRIM Map 92G.026 Natural Resources Canada NTS 92G/2
Co-ordinates	UTM Zone 10 5463673N 516511E NAD83
Land Management	Kwikwetlem First Nation
First Nation Traditional Territory	Kwikwetlem Nation Primary Territory
Land Use	Historical: Floodplain Current: Kwikwetlem Nation Graveyard, Kwikwetlem Nation traditional flora and fauna foods and medicine Fish and wildlife habitat

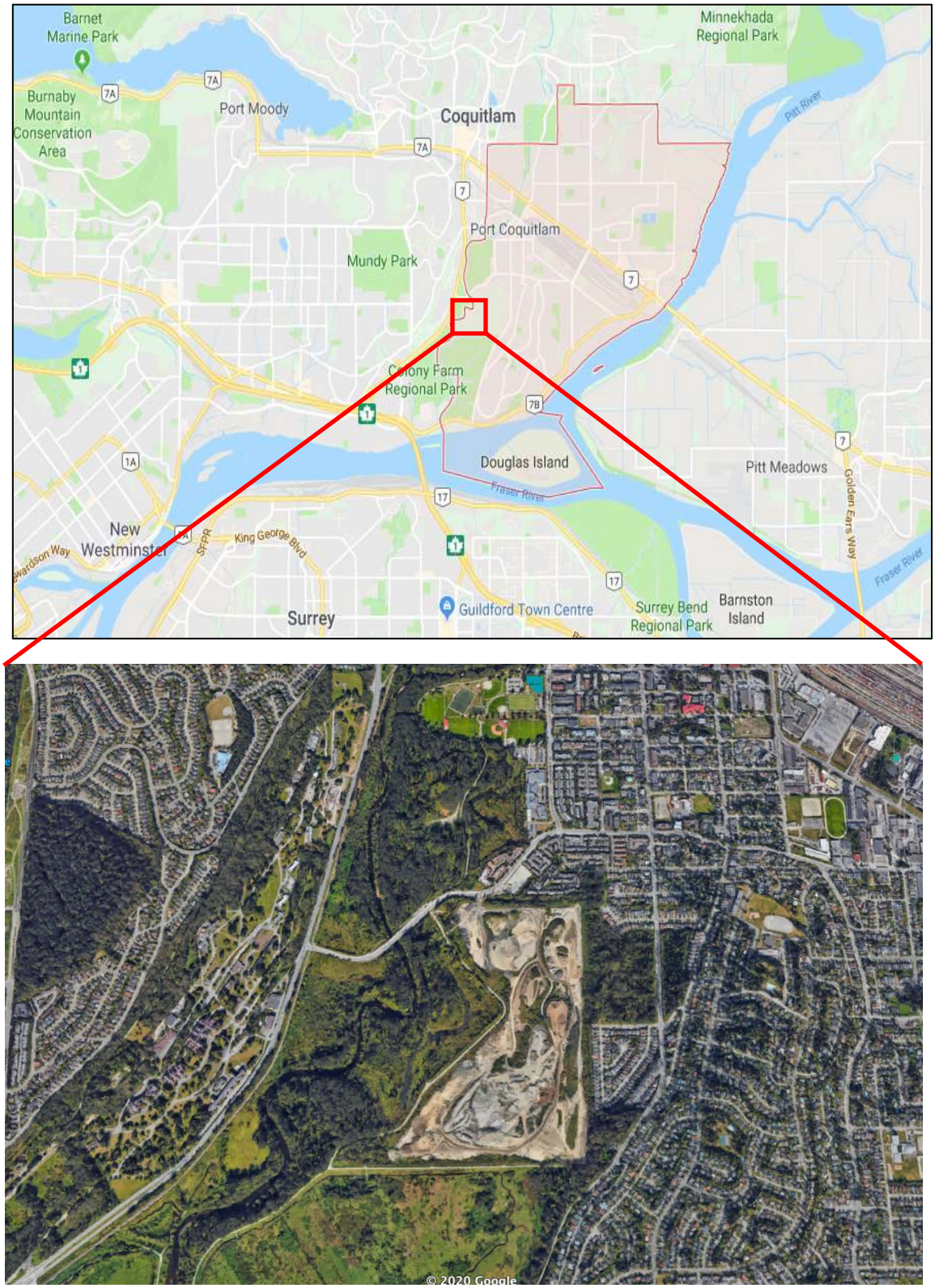

Figure 3 Reeve Slough Project Site, Port Coquitlam BC (Map courtesy of Google Maps)

3.1 Project Site

Reeve Slough is located on the left back of the Coquitlam River, approximately 3,500 metres upstream from the confluence with the Fraser River. The site is immediately downstream of the Pitt River Road Red Bridge on Kwikwetlem First Nation Reserve Lands in Port Coquitlam, BC (Figure 1 Reeve Slough Project Site, Port Coquitlam BC).

Reeve Slough is approximately 1,060 m long and averages about 30 m in width and consist of off-channel wetlands and open water areas. Off-channel habitats are critical in flashy, relatively steep river systems like the Coquitlam River as they provide refuge from high flows and excellent rearing conditions for juvenile salmonids.

4.0 Methods

The purpose of the feasibility assessment was to link Indigenous knowledge, existing watershed information, past reports such as the Coquitlam River Watershed: Kwikwetlem Side-Channel Habitat Restoration Report funded by Bridge Coastal Rehabilitation Program, 2003 01-LM-19, (Appendix 1 Kwikwetlem Side-Channel Habitat Restoration Report 2003) and new survey results to address knowledge gaps to support the future detailed planning for a potential Reeve Slough Habitat Restoration Project.

This project was implemented through a joint management team consisting of North Fraser Salmon Assistance Project Society (NFSAPS) and Fisheries and Oceans Canada (DFO) RRU Engineering and Biological staff and the Salmon Enhancement Program Community Advisor to ensure technically sound methods were implemented and consistent oversight was maintained. Support and input were received from Kwikwetlem First Nation council members and staff who contributed Indigenous knowledge and contracted the archeological and ethnobotany surveys.

Appropriate professionals were contracted by the team to undertake the necessary studies to determine if, what and how enhancement works could be undertaken to restore the slough habitat to provide maximum, self-sustaining benefit to salmonids and their ecosystem and reduce harm to the Kwikwetlem First Nation Graveyard.

The Team contracted, undertook and supported the following Project Feasibility Assessment tasks to link existing knowledge, past reports and new information:

4.1 Archaeological Assessment of Indigenous Occupation

Extracted from the Reeve Slough Feasibility Assessment 2019, Preliminary Archaeological Review and Recommendations (Appendix 2): There are sixteen archaeological sites recorded within three kilometres of Kwikwetlem IR2 which informed the preliminary field reconnaissance. This was followed by 24 shovel tests dug in the project area of interest, approximately 200 metres by 20 metres to assess local area sediments and project area potential for buried cultural materials. The Kwikwetlem First Nation Cemetery was not assessed as it is outside the area of project interest.

4.2 Ethnobotany Assessment of Indigenous Traditional Use Plants

Extracted from the Kwikwetlem First Nation Reeve Slough Ethnobotany Report 2019 (Appendix 3): Based on the Biogeoclimatic Ecosystem Classification of BC the area of project interest is within the Coastal Western Hemlock dry maritime (CWHdm) subzone, site series CWHdm09: Black Cottonwood – Red-osier Dogwood. In addition, the area of interest is located on a medium bench floodplain, likely subject to flooding at least every five years, and with human disturbance impacts (e.g. dyking, flood controls, tree clearing) which have altered the ecological conditions of the area. An overview survey was undertaken within the preliminary project boundaries, approximately 200 metres by 20 metres, August 2019. The Kwikwetlem First Nation Cemetery was not assessed as it is outside the area of project interest.

4.3 Fish Habitat Enhancement Feasibility Assessments

Extracted from the Reeve Slough Fish Habitat Enhancement Feasibility Assessments 2020 (Appendix 4). The following surveys were undertaken by Qualified Environmental Professionals (QEP) under the direction of DFO and NFASPS to inform the feasibility assessment:

4.3.1 Topographic Survey of the Project Area of Interest

A topographic survey of the project area of interest was undertake, from Red Bridge to 100 metres downstream of the Reeve Slough confluence with Coquitlam River, from the eastern edge of Coquitlam River west to the toe of the fill of Kwikwetlem First Nation Business Park (Kwikwetlem IR2) to delineate key topographic and ecological boundaries and coordinate acquisition of a detailed topographic survey of key control points determined to be relevant to future drainage modifications to achieve the fish habitat restoration objectives. Key control points included the topographic break-lines and natural boundaries associated with the adjacent PoCo Slough, including both the historic dike crossing and associated culvert and the Kwikwetlem First Nation Cemetery access road. Downstream survey locations included the northwestern terminus of the slough, topographic break-lines and natural boundary conditions at Reeve Slough, the Coquitlam River, the anthropogenic drainage ditch, and identified high water discharge points associated with the seasonal drainage pathway through the floodplain habitat. The point of confluence from the confirmed seasonal flow path and the left bank of the Coquitlam River was also surveyed. Field surveys at the downstream controls included pickup of field delineations of ecological boundaries established by ENKON.

4.3.2 Bathymetric Survey of Reeve Slough Open-Water Habitat

Bathymetric survey of Reeve Slough open-water habitat areas was undertaken using a SonarMite single-beam SEA1002 transducer. The transducer and data collection equipment were mounted to a custom fabricated wood platform and deployed below the static water surface to record depth to substrate from a single person kayak. Shallow and heavily weeded areas were measured using a calibrated rod and mapped utilizing a Trimble R1 GNSS receiver paired to an ArcCollector and field tablet computer.

4.3.3 LiDAR Data Sets 2012

LiDAR data sets 2012 were acquired from the City of Port Coquitlam for analysis including preliminary watershed modeling.

4.3.4 Orthophotograph Imagery 2018

Orthophotograph imagery 2018 was obtained from the City of Coquitlam

4.3.5 Sediment sampling

Sediment sampling and preliminary analysis of organic sediments and interpretation of depth -to - underlying mineral substrate at 69 sampling locations was undertaken by manual, inserted-to-refusal rod method to estimate the depth of unconsolidated substrate and sample the sediments to determine if fines, clay or gravels.

4.3.6 Water level monitoring

Water level monitoring was initiated by the installation of three Solinst model 3001 Levelogger Edge data loggers and one barometric datalogger, a Solinst Barologger Edge, to facilitate barometric compensation and improve accuracy and inform the evaluation of Year 1 data of potential linkages and relationships between the Coquitlam River and Reeve Slough. Equipment to facilitate the long-term operation of the level loggers by DFO and the NFSAPS has been acquired as one year of data is informative; however, long-term data sets improve the resolution of the analysis.

4.3.7 Hydrologic Analysis

Hydrologic analysis was undertaken of flow direction. Flow accumulation datasets were analyzed to model preferential surface flow pathways to inform targeted field investigations to assess for permanent or seasonal drainage connections between Reeve Slough and the Coquitlam River. Field verification followed. Field assessments were conducted at the upstream limit of Reeve Slough following extreme rain events to assess for the potential presence of a buried or obstructed culvert linking the adjacent PoCo Slough to Reeve Slough.

4.3.8 Species at Risk Act (SARA)

Species at Risk Act (SARA**)** overview level reconnaissance surveys and habitat assessments were undertaken by conducting desktop and field-based assessments to assess wildlife habitat suitability with a focus on SARA species. A reconnaissance level review of terrestrial and aquatic vegetation communities was also conducted during Species at Risk assessments.

4.3.9 Fish Species Habitat Utilization, Water Quality and Vegetation Survey

Extracted from the Restoration Plan for Reeve Slough, 2020 BC Institute of Technology (BCIT) Bachelor of Science in Ecological Restoration: Bondartchouk, Chestnut, Waiz (Appendix 5).
Fish species habitat utilization was surveyed by DFO in Reeve Slough March 2019 by soaking twenty-five Gee minnow traps for 24 hours. BCIT undertook additional surveys October 2019 and March 2020 using thirteen Gee minnow traps.

Water quality was assessed by BCIT in Reeve Slough at four stations using a handheld YSI multiparameter meter October 2019, January and March 2020. Temperature, pH (the measure of the molar concentration of hydrogen ions in the solution and as such is a measure of the acidity or basicity of the solution) and dissolved oxygen (DO) were measured.

A vegetation survey was conducted by BCIT October 2019 and assessed ten randomly selected survey tracks, each 10 m by 1 m, running parallel to the shore. Four tracks were near-shore (0 m), four were mid-shore (15 m) and two were far-shore (30 m). Each plant species was given a rating based on abundance in the transect, designated as low (L), abundant (A), or dominant (D). One species per transect was assigned as dominant.

4.4 Risk Management

This feasibility assessment was low risk and no negative impacts on the environment, or the personnel involved resulted. Experienced professionals were contracted as required.

4.5 Communications

Public recognition of the Fish and Wildlife Compensation Program and the partners involved with the project was achieved through regular updates provided to the Coquitlam River Watershed Roundtable, and site tours.

5.0 Results and Outcomes

5.1 Archaeological Assessment of Indigenous Occupation

The archaeological assessment report states that given the duration and intensity of indigenous community occupation in the Coquitlam-Port Coquitlam area, and that 16 archeological sites are within 3 k of the project area of interest in Kwikwetlem IR2, predictably there could be many more archaeological sites which remain undetected and undocumented.

Archaeological site DhRq 10 is in immediate vicinity to the Reeve Slough project area of interest. Archaeological site boundaries have not been systematically documented west of the IR2 dike/trail; however, in 1953 anthropologist Walter Kenyon and Coquitlam William observed archaeological materials on the surface on a site visit to the Kwikwetlem First Nation Cemetery, adjacent to the project area of interest.

Though no evidence of anthropogenic sediments or materials were observed during the archaeological assessment, the findings of the assessment conclude that all areas associated with the project area of interest have HIGH potential to encounter undocumented archaeological materials.

5.2 Ethnobotany Assessment of Indigenous Traditional Use Plants

The ethnobotany assessment documented 34 species in the survey area, of these, 13 were identified by Kwikwetlem First Nation as priority plants. Of the priority tree species two were abundant; however, two were rare, Western Redcedar (*Thuja plicata*) and Cascara (*Rhamnus purshiana*), both less than 5%. Priority fruit bearing shrubs compromised less than 40% of the shrub layer. Less than 5% of the herb/forb/grass layer are priority plants. The timing and scope limitations associated with the ethnobotany assessment precluded a more detailed survey. Other ecologically suitable plant species not listed in this report, including those used traditionally by Kwikwetlem First Nation, may occur in the project area.

5.3 Fish Habitat Enhancement Feasibility Assessments

5.3.1 Topographic Survey

Topographic Survey of the project area of interest identified four survey locations as key physical controls to any future fish habitat enhancement opportunities. BC Land Survey pickup included key topographic break-lines and natural boundary/high water mark conditions at the following locations:

1. PoCo Slough culvert crossing of historic dike road
2. KFN Cemetery access road separating PoCo Slough and Reeve Slough
3. Northwest terminus of Reeve Slough at interface with left bank of Coquitlam River, including the linear drainage ditch feature, and
4. Seasonal drainage channel confluence linking Reeve Slough outflow with Coquitlam River left bank.

Key physical variables relevant to the potential establishment of flow connections and fish access to Reeve Slough have been identified and provided as both a PDF (Figure 2 Reeve Slough Outflow Channel Map) and as a CAD dataset (.dwg format) to support future detailed design and feasibility studies.

5.3.2 Bathymetric Survey

Result of the bathymetric instrumentation was the interpretation of maximum slough depth which was recorded as 1.92m with an average of 0.7m for the accessible areas of the slough. The result is limited due to fouling from aquatic plants which precluded the possibility of the development of bathymetric mapping. Any future detailed bathymetry requirements should be pursued only under winter high water conditions. Even then, the expectation of detailed bathymetric datasets should be tempered due the prevalence of obstructions, aquatic weed fouling, and relatively shallow depths. The manual bathymetric analysis facilitated by the sampling at 69 stations increased the mapped area, thus providing additional detail of the depth to benthic surface material which ranged from 0.4 to 2.1 m, with an average slough depth of 1.28 m.

5.3.3 Sediment Sampling

The approximate depth of unconsolidated substrate was assessed. Benthic material ranged from 0.02 m to 1.88 m with an average mud depth of 0.77 m. Two locations had depths of benthic material over 3 m. The analysis included a qualitative interpretation of the underlying substrate (e.g. mineral materials below organic substrate). Some areas had clear evidence of coarse sand or gravel substrate which may suggest presence of historic alluvium and the potential for enhancement of groundwater or hyporheic zone interactions.

5.3.4 Water level monitoring

Leveloggers and barometric compensation units were deployed at locations within Reeve Slough and the surrounding waterbodies to facilitate the interpretation of relative water level fluctuations and potential hydrologic linkages between Reeve Slough, Coquitlam River and PoCo Slough – notably in

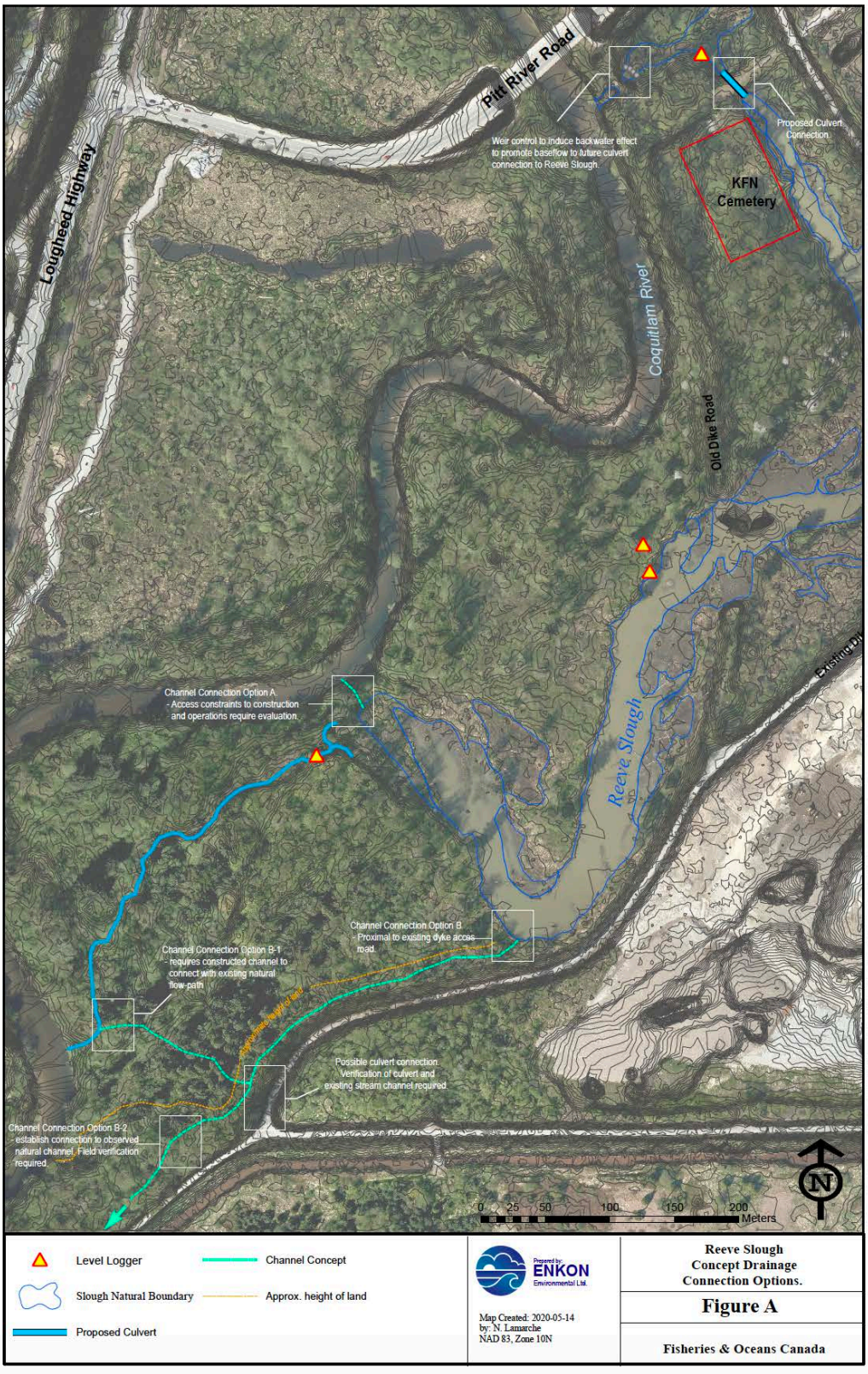

Figure 4 Reeve Slough Outflow Channel Map, ENKON 2020

response to the variable hydrologic dynamics related to the operation of the Reeve Park pump station.

The initial download was completed February 3, 2020 and revealed a significant data anomaly attributed to fouling of the barometric compensation deployment. Two discrete spikes in barometric pressure were noted in the raw data analysis and were manually removed from the dataset as anomalies; however, after removal the data set's record reflected changes in the water levels associated with a change in discharge to the Coquitlam River associated with the BC Hydro dam, confirmed by Water Survey of Canada dataset for the Coquitlam River at Port Coquitlam station, located upstream at Kingsway Avenue (Station ID 08MH002). They also recorded changes in water levels associated with culvert maintenance at the old dyke and the fluctuating water levels in the river at low tide conditions. The loggers remain in place and future data will be downloaded by DFO and NFSAPS.

5.3.5 Hydrologic Analysis

Hydrologic survey analysis of the project area of interest were first modeled, then verified in the field. Field assessments coinciding with a storm event in early February 2020 which confirmed direct floodplain inundation with a ubiquitous veneer of sand deposits on the immediate floodplain surfaces of the northwest area of Reeve Slough and confirmed a sustained flow path draining the slough along the approximate alignment of the modeled drainage pathway. The field-verified high-water confluence was physically flagged to inform the location for future survey pickup.

A secondary drainage feature, likely of anthropogenic origin, was verified during dry weather field reconnaissance. The drainage function was confirmed during high water; however, the ditch feature is insignificant in comparison to the main flow path mapped from the northwest terminus of the slough as mentioned above. The ditch connection does not interface with the main open water boundary of the slough and drains a limited volume flow and would not afford potential fish access.

No upstream connection between PoCo Slough and Reeve Slough was identified, and no subsurface connections were found either. Field observations suggest periodic inundation of the Kwikwetlem First Nation Cemetery access road under high water conditions.

5.3.6 Species at Risk Act (SARA)

Wildlife field assessments were conducted in September and October 2019. Reeve Slough has high wildlife habitat value for many species. The aquatic and wetland ecosystems provide habitat for invertebrates, fish and amphibians. It also supports herons, ducks and eagles. The riparian vegetation and floodplain forest habitats provide habitat for deer, bears, coyote and other large wildlife. The habitat has high suitability to support the following species of conservation concern:

- American Bittern
- Band-Tailed Pigeon
- Barn Swallow
- Pacific Sideband Snail
- Purple Martin
- Northern Red-Legged Frog
- Pacific Water Shrew
- Olive-Sided Flycatcher
- Western Toad
- Trowbridge's Shrew

- Western Painted Turtle
- Western Screech-Owl.

There is suitable habitat for Great Blue and Green Heron which were frequently observed in Reeve Slough during the survey period. Wildlife trees were present and provide habitat for birds, squirrels and bats. Course woody debris (CWD) is available in the forest to provide cover for rodents and other small animals. A Bald Eagle nest was observed in the area of interest and the slough provides fish, waterfowl, herons and beavers as prey. The presence of the eagle nest may deter Great Blue Herons from selecting Reeve Slough as a potential breeding colony.

Reeve Slough is large enough to host five beaver lodges which were observed during field surveys.

The full extent of the study area is within a designated Critical Habitat polygon for Western Painted Turtle (*Chrysemys picta)* and the presence of sandy and granular materials underlying local soils provides potentially suitable nesting substrate for them.

5.3.7 Fish Species Habitat Utilization, Water Quality and Vegetation Survey

Fish Species Habitat Utilization Survey conducted by DFO using 25 Gee traps for 24 hours documented only non-native, invasive species in Reeve Slough: Brown Bullhead (*Ameiurus nebulosus*), Pumpkinseed (*Lepomis gibbosus*), Black Crappie (Pomoxis nigromaculatus) and Weather Loach (*Misgurnus anguillicaudatus*). BCIT trapping results mirrored DFO results. Their 13 traps soaked for 24 hours also found Brown Bullhead, Pumpkinseed, Black Crappie and Weather Loach.

Four water quality stations were established and each sampled three times between October 2019 and March 2020 by BCIT who note their survey results were outside the optimal ranges for juvenile salmonid growth and survival, including high pH, 9.6 following a storm event, with 6-8.5 being optimal for juvenile salmonid and DO measurements out of range with readings of 4.9 and 5.5, below the optimal 6.5-8.0 range.

The BCIT vegetation survey documented 49 plant species. Of the 19 plant species identified as abundant and dominant, four were invasive species including Reed Canary Grass (*Phalaris arundinacea*), Yellow Iris (*Iris pseudacorus),* Himalayan Blackberry (*Rubus ameniacus)* and Purple Loosestrife (*Lythrum salicaria*). Also identified as abundant or dominate was Salmonberry (*Rubus Spectabilis*), a plant identified by Kwikwetlem First Nation as having high ethnobotany value.

5.4 Communications

NFSAPS hosted or attended more than 18 project meetings and tours. Meetings with Kwikwetlem First Nation and DFO on site were followed up weekly and then monthly meetings with Kwikwetlem First Nation. Site tours with a Port Coquitlam City Council member and an expert fisheries habitat biologist were undertaken. An Interim Report Meeting with Kwikwetlem First Nation and DFO at the Kwikwetlem Band Office was attended by four members of the Kwikwetlem First Nation and a Council member. Two Coquitlam River Watershed Roundtable Core Committee Meeting presentations were given in June and September 2019.

Interviews with the local newspapers and all in person meetings have been postponed until Provincial Health Orders due to COVID-19 on nonessential travel or meetings have been rescinded.

6.0 Discussion and Recommendations

During the past year a suite of tasks were completed that illuminated the opportunity at hand in Reeve Slough to improve fish habitat and also identified future challenges.

6.1 Archaeological Assessment of Indigenous Occupation Recommendations and Considerations

Twenty-four shovel tests in the vicinity of the project area of interest did not observe evidence of anthropogenic sediments or materials; however, the findings of the assessment conclude that all areas associated with the Project have HIGH potential to encounter undocumented archaeological materials. In view of the archaeological potential of the study area and to assist future potential development activities, the experts contracted by Kwikwetlem First Nation provide the following recommendations:

1. Full systematic surface survey of all proposed impact areas and immediate surroundings be undertaken prior to habitat development. Survey should take place during a period of low vegetation (eg. Nov. to March) to maximize ground surface visibility.
2. Subsurface testing should be undertaken at all proposed habitat development areas with potential to lead to ground disturbance prior to construction initiation. Archaeological monitoring may be recommended by the archaeological team in select conditions, following the surface and subsurface assessment.
3. Archaeological review of all final design and construction plans to identify areas and/or activities that may result in meaningful ground disturbances and that may warrant assessment, for example, grubbing, tree stump removal, creation of temporary access routes, installation of erosion mitigation fixtures, and so on.
4. No further archaeological assessment is required in the proposed rearing channel project area, provided that development impacts do not extend beyond the archaeologically tested area.

6.2 Ethnobotany Assessment of Indigenous Traditional Use Plants

The ethnobotany assessment report provides a summary of preliminary findings based on a limited field survey. Ethnobotany experts contracted by Kwikwetlem First Nation provide the following recommendations:
1. Include Kwikwetlem First Nation in future planning for habitat restoration. Kwikwetlem First Nation is in the process of compiling preferred replanting approaches for restoration projects that will include a focus on traditional plants. Community engagement with Kwikwetlem First Nation should continue beyond the conceptual stages to ensure KFN interests are fully considered as part of this restoration project. Future project costs should account for KFN involvement in restoration planning, including a more thorough ethnobotanical study and inclusion of traditional plants in planting palettes.
2. Complete detailed ethnobotanical surveys and ecological assessments. It is acknowledged that the timing and intensity of this preliminary survey precludes compilation of a definitive list of all plant species potentially located in the proposed project area, including traditional plants used by KFN. Seasonal surveys are recommended to best detect plants as this method will capture the flowering periods of most plants. For example, timing windows for many herbaceous plants are April to June, and sedges and grasses in late July. Therefore, more detailed plant surveys using best practices will be required to identify plants that may occur within the project area. These plants may include traditionally used species, rare and endangered species, and other plants that may grow seasonally or in specific habitats.

Additionally, the project area boundaries have not been finalized, so it is likely that the survey area will need to be refined at future planning stages.
3. Limit disturbance to existing forest ecosystems. Minimize disturbance to vegetation and soil outside of channel area. In areas where disturbance cannot be avoided, implement measures to mitigate/limit soil and vegetation disturbance (e.g., establish tree root protection zones) and monitor/manage the spread of invasive plant species. Include access management strategies to support restoration and help maintain KFN priority plant species.
4. Manage for biodiversity. Manage forest, riparian, and aquatic ecosystems to maintain or enhance biodiversity (e.g., maintain or enhance wildlife trees, coarse wood debris, understory diversity, tree species diversity). Implementation of specific mitigation measures for managing invasive plant species, as outlined in 3 above, will also assist in preserving biodiversity.
5. Implement a Monitoring Plan. Include KFN as part of a monitoring program to ensure restoration objectives are being met, including maintenance and establishment of priority plants.

6.3 Fish Habitat Enhancement Feasibility Assessments

All survey datasets have been compiled to inform the feasibility study, and future conversations with Kwikwetlem First Nation and other partners on the potential to develop and implement a comprehensive Reeve Slough Restoration Plan.

6.3.1 Reeve Slough Outflow

From the expert report: LiDAR based hydrologic model and field assessments have confirmed periodic flood inundation of Reeve Slough. During high-water, overbank flood inundation appears to connect the northwest limit of the slough with the Coquitlam River along a previously unmapped seasonal channel connection. However, summer assessments suggest that this outlet channel is inactive with the exception of those high flow events. The following are the outflow options, shown in Figure 5: Reeve Slough Outflow Channel Map:

Less Preferred Option: B1
Despite the apparent significance of the seasonal channel connection during high water events, the potential for this drainage connection to facilitate upstream fish access would be a challenge due to two factors: gradient and beaver activity.

Analysis of the topographic survey datasets and interpretations of the high-water mark/natural boundary suggests a direct connection to the Coquitlam River through the seasonal channel connection, though shorter, would need to breach the height of land and have channel gradients between 7% and 14% depending on the final location. This connection during low water conditions would have even steeper gradients and challenges with the maintenance of stable base-level controls. Considerations of a constructed spillway would require explicit considerations of the risks posed by beaver activity. In addition, challenges related to construction access and long-term maintenance are significant.

Preferred Option: B2
The preferred option, though longer, would be to construct an outflow channel parallel to the toe of dyke where intrusion into the habitat would be less and physical construction, monitoring and operational requirements would not face the above access constraints, and the scale of potential construction phase and access impacts would be reduced. In addition, the channel could be viewed from the dyke thus making long-term monitoring and maintenance less costly. This channel is the best path as

it is low gradient and does not require breaching the natural height of land. The Reeve Slough range of water levels would be maintained by the outflow invert level. This path would require a simple survey to confirm elevations.

6.3.2 Reeve Slough Inflow

A formal streamflow connection into Reeve Slough is viable. The land-bridge resulting from the road access to the Kwikwetlem First Nation Cemetery includes a discrete side channel area that suggests the location of a historic connection; however, field investigations revealed no evidence of any drainage connectivity.

The installation of a simple culvert connection under the road access, with beaver management measures, could provide a significant and relatively persistent baseflow contribution from the Reeve Slough Pump water, which would benefit water quality and connectivity through Reeve Slough. These inflows would be maintained by the construction of a weir or berm to maintain water levels.

The establishment of a formal drainage connection into the slough; however, would require explicit consideration of risks posed by beaver activity and potential water impoundments and flood concerns related to the Kwikwetlem First Nation Cemetery. Fisheries and Oceans Canada Resource Restoration Unit has designed, installed and monitored beaver deterrent devices in the immediate area which will be assessed to determine the best design for this site. Monitoring and maintenance of beaver activity would be part of the go-forward plan.

Establishment of this formal drainage inflow from the Reeve Park pump station discharge would yield no significant increase of risk of inundation of the slough or surrounding floodplain habitats, when subject to regular inspection and maintenance.

Establishing formal streamflow connectivity baseflows and flushing flows through Reeve Slough would increase the aquatic habitat values of Reeve Slough.

A survey of the elevations, for detailed designs, of the Poco Slough and Reeve Slough inverts under low water conditions is recommended.

6.4 Challenges

6.4.1 Fish Assess

The project's most significant constraints to the establishment of fish access and egress between the Coquitlam River and Reeve Slough, or the water supply to the slough, is the prevalence of beaver activity. Restoration recommendations will need to consider ongoing maintenance and management of beaver dams to allow for the intended flow paths to function and convey water and mitigate the risk of flood inundation of the Kwikwetlem First Nation Cemetery. Multiple active beaver dens and dam structures are present within the slough.

6.4.2 Water Quality

Water quality monitoring was undertaken by BCIT of dissolved oxygen, temperate and pH, with pH having the greatest deviation from optimum for salmonids. The source of the anomaly is unknown.

Longer-term monitoring is recommended. Temperature data from the single Reeve Slough levelogger from September 2019 to date recorded a maximum 17.8°C and minimum of 5.4°C. Significant water quality impacts attributed to offsite construction and earthworks have been observed during multiple site assessments. The source of turbidity has been confirmed as a culvert connection through the current dyke and drainage connections to the adjacent fill site behind the dike. Mitigation of sediment erosion will be increasingly important prior to the establishment of formalized and consistent hydrologic connections to the Coquitlam River.

6.5 Summary

A suite of studies was undertaken to assess Reeve Slough for potential fish habitat enhancements to achieve suitable salmonid off-channel rearing habitat within the relict channel of the Coquitlam River. The results of the assessment suggest that there is no persistent water supply sustaining a perennial flow-through hydrologic regime at Reeve Slough. The Reeve Park Pump Station flows provide a unique opportunity to establish an upstream water supply with the ultimate downstream connection remaining the Coquitlam River as the receiving environment.

The establishment of a water supply will require the construction of an outlet to the Coquitlam River that can be accessed, monitored, and maintained as the risks of beaver activity water impoundment are significant. A future project design will consider the existing flood concerns associated with the Kwikwetlem First Nation Cemetery which is located on the immediate right bank of Reeve Slough. The flooding concerns affecting the cemetery are assumed to be significant due to the ongoing beaver activity and observed floodplain connectivity between the Coquitlam River and Reeve Slough during high-water.

Beaver activity within Reeve Slough is significant. The present-day hydrologic controls are the direct result of beaver activity at the northwest terminus of the slough.

In summary, the enhancement is feasible, and the water levels in the slough should be more consistent with lower winter water levels and slightly higher summer levels. Lower winter water levels may be a net gain for the Kwikwetlem Nation Graveyard as will be the ongoing monitoring of beaver activity.

7.0 Acknowledgements

Reeve Slough Feasibility Assessment 2019 was managed and delivered with financial support from the Fish and Wildlife Compensation Program. www.fwcp.ca

North Fraser Salmon Assistance Project Society appreciatively acknowledges the financial support of the Fish and Wildlife Compensation Program for its contribution to the Reeve Slough Feasibility Assessment 2019. www.fwcp.ca

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- City of Coquitlam for donation of Orthophotograph imagery.

Cover Photo: Reeve Slough beaver lodge, 2019: D Ramage

Appendix 1
Kwikwetlem Side-Channel Habitat Restoration Report 2003

COQUITLAM RIVER WATERSHED: KWIKWETLEM SIDE-CHANNEL HABITAT RESTORATION, PUBLIC AWARENESS, AND REPORT HISTORY

BRIDGE COASTAL REHABILITATION PROGRAM
FINAL REPORT - OCTOBER 2003

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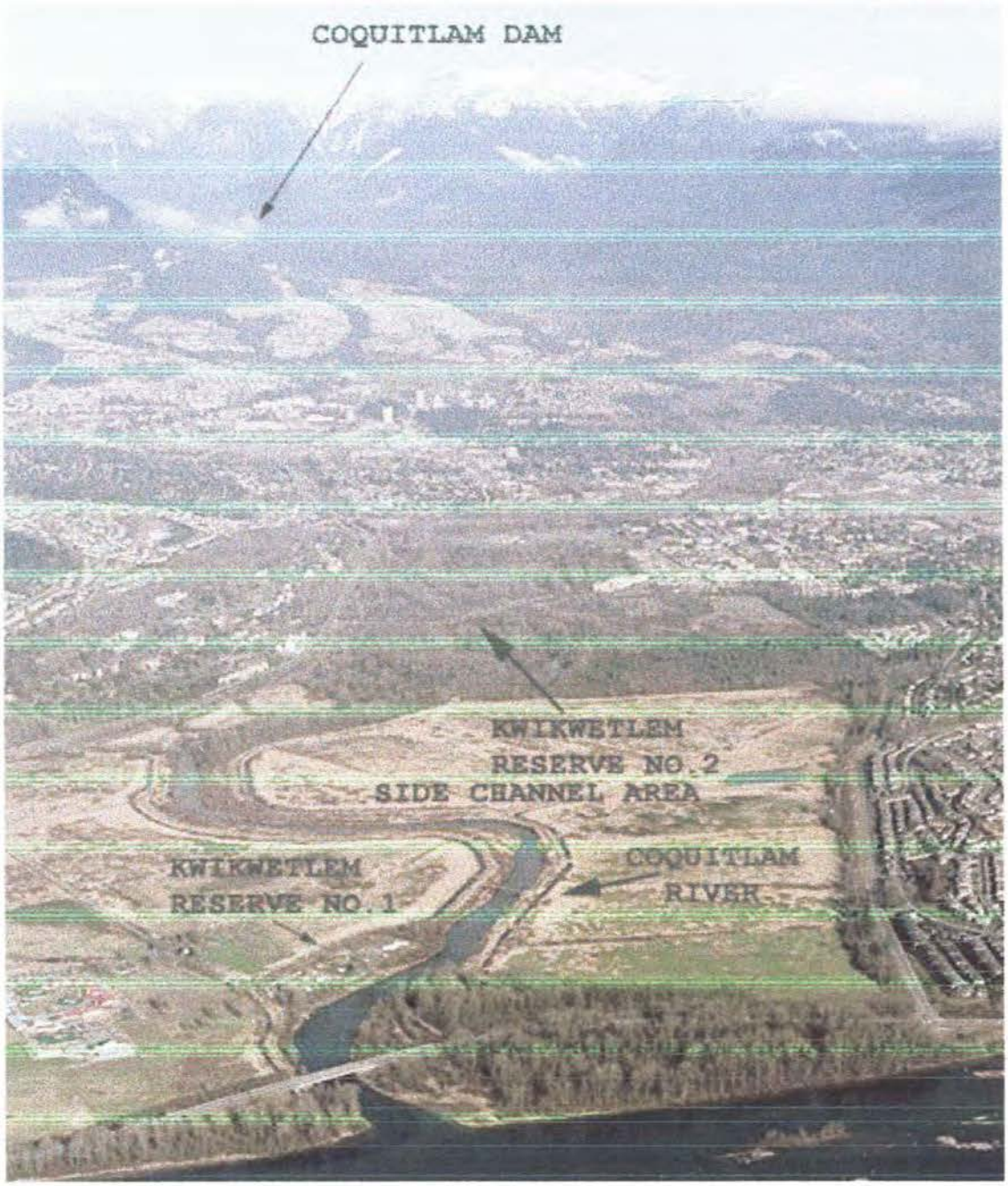

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EXECUTIVE SUMMARY

The Kwikwetlem Nation, located near the mouth of the Coquitlam River, was provided a grant by B.C. Hydro's Bridge Coastal Rehabilitation Program for two interrelated projects: a feasibility study to reactivate a Coquitlam River side channel, located within the boundaries of Kwikwetlem Reserve No. 2, for critical salmon habitat; and for an early report history (1898-1914) on the former Coquitlam River salmon populations, the impacts of the two Coquitlam dams on the salmon, and the relationship between the salmon and the Kwikwetlem Nation.

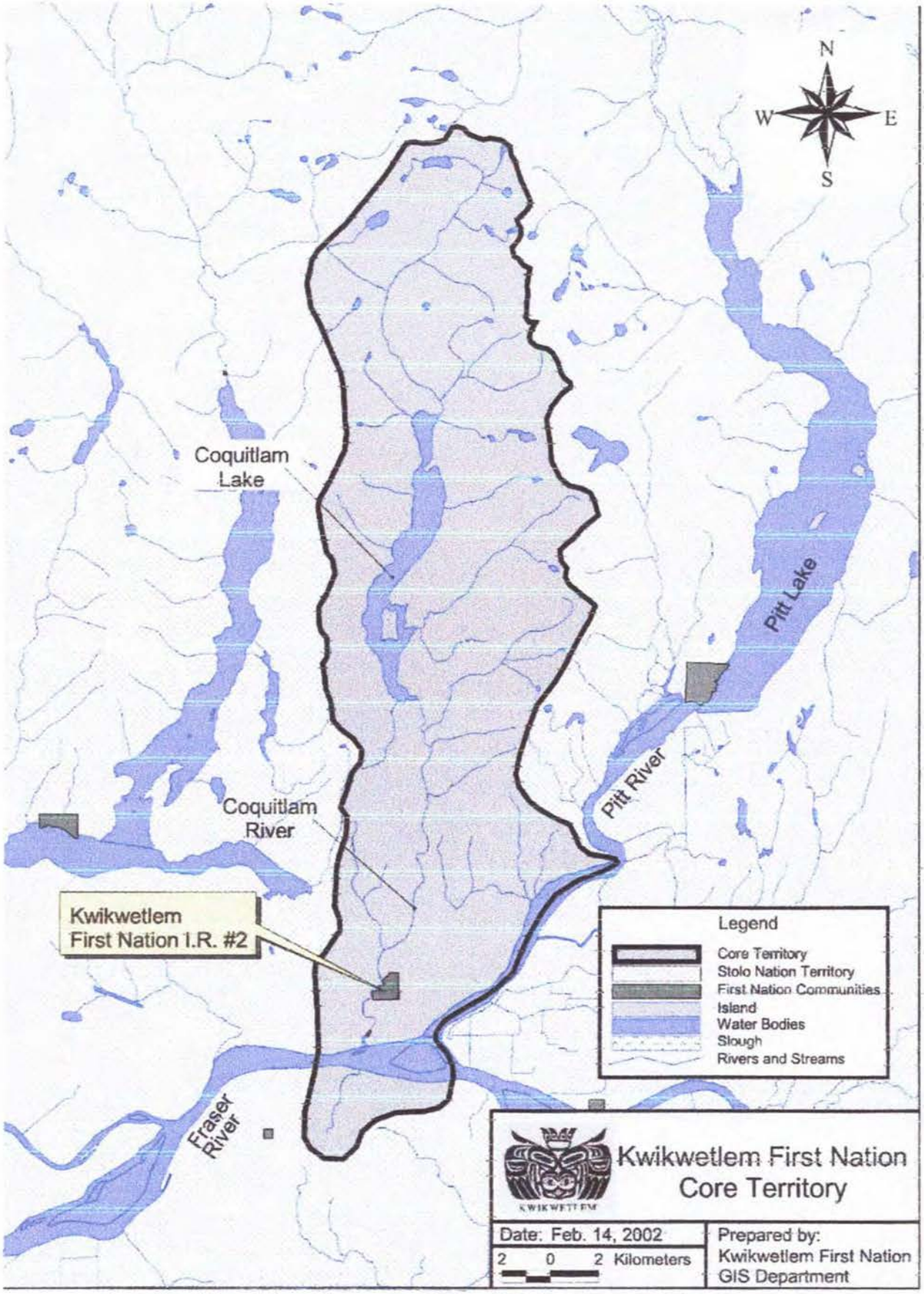
Engineering consultants with Kerr, Wood, Leidel completed a feasibility study report in early December 2001. The study examined options for reactivating approximately 1.2 kilometres of a former Coquitlam River channel that municipal authorities closed off decades ago. The study also included options for mitigating groundwater seepage into a Kwikwetlem cemetery site beside the northern end of the side channel. The study recommended that the side channel would provide critical rearing habitat for coho salmon. Proposed side channel reactivation costs were estimated at $150,000, and an additional $75,000 for groundwater controls at the cemetery site.

A detailed report on the early history of the Coquitlam River, *Red Fish Up The River - A Report on the Former Coquitlam Salmon Migrations and the Hydro-Electric Developments at Coquitlam Lake, British Columbia, Pre-1914*, was completed on October 1, 2001. The report established that large populations of salmon and steelhead trout migrated into and out of the former Coquitlam Lake area that was obstructed by the placement of a second dam structure in 1913. The first small 1905 dam incorporated a fish ladder, designed by the federal Department of Fisheries, which allowed fish passage. A former early run of a distinct sockeye species, which the Kwikwetlem Nation were named after, became extinct as a result of the later dam. Evidence of fishing camps collected from archeologists along the eastern shorelines of Coquitlam Lake indicates the historic significance of the area for the Kwikwetlem Nation and their dependence on the former runs of salmon. Kwikwetlem Chief Johnny confirmed this in an 1889 letter, where he described that his people and their culture utterly depended on the salmon. Scientists, conducting fish surveys in the Coquitlam Reservoir, recently discovered a direct genetic link to this lost race of salmon described as "residualized sockeye", provided in their March 2003 report to the Bridge Coastal Rehabilitation Program, *Feasibility of Reintroducing Sockeye and Other Species of Salmon in the Coquitlam Reservoir, B.C.*

ACKNOWLEDGMENTS

The Kwikwetlem Nation is indebted to B.C. Hydro's Bridge Coastal Fish and Wildlife Restoration Program and Management Board for critical project funding for the feasibility and historical reports. In association, many thanks to B.C. Hydro's Coquitlam Water Use Plan Consultative Committee for addressing many related issues.

This report is dedicated to all of the Kwikwetlem Nation elders that have passed on. Thanks also to the assistance from Mel Bailey from Katzie First Nation.



Location Map of Coquitlam watershed and Kwikwetlem traditional territory.

COQUITLAM RIVER WATERSHED: KWIKWETLEM SIDE-CHANNEL HABITAT RESTORATION, PUBLIC AWARENESS, AND REPORT HISTORY

1. OVERVIEW

B.C. Hydro's Bridge Coastal Fish-Wildlife Restoration Program approved of two interrelated projects for the Kwikwetlem First Nation in 2001: a report history of the Coquitlam River salmon and the Kwikwetlem people, and; reactivation feasibility of a former lower Coquitlam River channel located within the boundaries of Kwikwetlem Reserve #2, to provide critical salmon habitat with a corresponding public viewing and informational centre.

1.1. Report History of Coquitlam River

The purpose of the report was twofold:

- to compile and describe early records on salmon populations prior to and following B.C. Hydro's twin-phase dam construction periods (1903-1905; 1911-1913) situated at the mouth of Coquitlam Lake, and;
- to establish the historic dependence of the Kwikwetlem people on salmon for their livelihood and culture.

Photo 1.1. National Archives reference centre.

The final October 1, 2001 report, *Red Fish Up The River*, was researched, compiled, and written over a two and a half month period by Will Koop, a Vancouver researcher. Koop was familiar with relevant historic records, summarized in his April 1994 report, *A Presentation on the History of the Coquitlam Watershed and River from 1898-1914*. Apart from conducting research at local and provincial archival repositories, the National Archives in Ottawa were visited over a four-day period to review critical documents. The Kwikwetlem Nation released the report on April 18, 2002 through a press statement and conference. The information generated

much public interest, featured in local newspapers, and was the subject of a ten-minute documentary on CBC radio.

The report confirmed the previous existence of large numbers of salmon migrations in the Coquitlam River and their spawning habitat in the former Coquitlam Lake area, with records documenting Kwikwetlem Nation's former long-held dependence on the salmon. Substantiated by early newspaper references, their name-title, "Red Fish Up the River", originated from a unique and extinct run of sockeye, referred to by early federal fishery inspectors as the "bastard" sockeye.

Photo 1.2. "Kokanee", or "residualized sockeye", discovered in Coquitlam Reservoir at Cedar Creek. Photo courtesy of Bob Bocking, LGL Limited.

The report also became a catalyst for proposals to conduct fish surveys and the reintroduction of salmon species in the Coquitlam Reservoir as discussed by members and concerned specialists at B.C. Hydro's Coquitlam Dam Water Use Planning meetings. Amazingly and coincidentally, scientists may have recently discovered this former race of salmon in the Coquitlam Reservoir. In the LGL Limited report, *Feasibility of Reintroducing Sockeye and Other Species of Pacific Salmon in the Coquitlam Reservoir*, the scientists suggest that the Kokanee may in fact be the "bastard" salmon, and have proposed measures to increase its remaining few numbers in the Reservoir impoundment area.

1.2. The Side-Channel Restoration Project Feasibility Study

Red Fish Up The River supported and renewed the Kwikwetlem Nation's initiatives for developing proposed critical lower river salmon spawning habitat and public informational viewing areas and kiosks on a former active river channel located within the boundaries of their Reserve lands, I.R. #2.

Following the approval process for the restoration project, the Kwikwetlem Nation acquired the engineering consulting services of Kerr Wood Leidel Associates Limited to prepare a feasibility study. A draft report, *Feasibility Study For A Side Channel Reactivation At*

Kwayhqutlum I.R. No. 2, was presented to the Kwikwetlem on November 30, 2001, "to construct an ecologically sensitive educational and cultural interpretive centre." The report identified that "Funding ... is dependent on the completion of an engineering and hydrogeological feasibility study that addresses flooding concerns at the nearby cemetery and reconnection of the side channel back to the river system". Due to the nature of the Kwikwetlem Reserve lands on a low elevation flood plain and concerns about groundwater affecting the Kwikwetlem's cemetery located within it, the proposed undertaking had associated complications.

The feasibility study included an historical review and assessment of the Coquitlam River and its channel. It related that the Coquitlam dam and river control projects were responsible for removing "channel complexities" associated with a former wild river. Flow control measures at the dam led to "considerable channel narrowing, fine sediment aggradation and loss of fish habitat," resulting from "a reduction of peak flows through upstream discharge controls, dyking, and intensive gravel mining." The study concluded that the "proposed side channel reactivation is a remnant of the river's former complexity" and was therefore critical for adding valuable fish habitat.

Side channels are considered to be critical spawning and rearing habitats for chum and coho salmon, and steelhead trout: "The value of side channel habitat is not only limited to the obvious benefit of protecting juvenile fish from extreme flood events. Their stable flow and temperature regime and generally higher nutrient level provide fertile growing conditions for aquatic plants, insects and fish."

Two options, including benefits and drawbacks, were provided for proposals to increase base flows into the proposed side channel site now filled with pools of water forming "a marshy lake habitat":

- by reconnecting the upstream end of the side channel to the Coquitlam River;
- by diversion of groundwater and upper slope water sources.

The consultants advised that an artificial direct link from the Coquitlam River to the upper side-channel near the cemetery was costly and problematic. Due to factors related to river sedimentation deposits and possible debris jams that would at times impede diversion flows, the second option for groundwater charge was considered "more appropriate". The effectiveness of the second option was dependent upon findings from surface and sub-surface water quality tests for storm-water runoff pollutants from the adjacent Mary Hill residential area. At present, the side-channel "receives a majority of its flow from groundwater sources", and is "overgrown with vegetation and apparently carries stagnant flows for significant portions of the year." "Juvenile coho salmon have been known to migrate" to the upper end of the off-channel "during high flows".

Logistics and options for connecting the mouth of the side-channel to the main stem of the Coquitlam River were described. Due to the incising of the Coquitlam River channel, there is now a one-meter difference in height between the two channels during low water, which prevents juvenile fish from ascending the side channel at low water:

> "Design work for enhancement of the side channel should focus on determining how water levels in the two systems are connected throughout the year.... Determining how

often the two systems are connected is critical in assessing the functionality of the side channel in providing over wintering habitat."

Due to the nature of the side channel itself, the consultants recommended against provisions to enhance the area for "spawning habitat". Rather, the channel area was recommended to develop critical coho salmon "rearing habitat". It was also recommended that all the factors involved in the assessment should be carefully detailed in a "pre-design" study.

According to estimates provided in the November 2001 report, combined costs for both groundwater controls at the cemetery and for side-channel reactivation would amount to approximately $225,000, not including estimates for constructing and producing public education facilities.

2. REPORT DISCUSSION - *RED FISH UP THE RIVER*

According to early government records, the Kwiketlem Nation was dependent upon the Coquitlam River salmon for its livelihood. This was explained in Kwikwetlem Chief Johnny's March 1899 letter of concern to the federal government's Inspector of Fisheries in New Westminster City about the impacts of a dam on his people. Extensive evidence obtained by archeologists of early fishing camps along portions of the eastern perimeter of the Coquitlam Reservoir indicates their subsistence history in the area. During a transition period, when the provincial government granted a water licence at the mouth of Coquitlam Lake in the late 1880s for New Westminster City's domestic water needs, "Indians" were regularly hired by the City during salmon spawning periods to remove the dead fish accumulating near the water intake.

As a result of the federal Fisheries Department's concerns and responsibilities about maintaining salmon migrations into the former Coquitlam Lake area, the first small dam completed in 1905 included a fish ladder structure on its eastern flank. Government and corporate records also show that following proposals for construction of a larger dam in 1909, little regard was provided for the salmon with its completion in 1913, thereby preventing future fish ascent. Prior to the release of *Red Fish Up The River*, little information was known about this history and the large populations of former salmon. Along with the pressures of local settlement and development on the Kwikwetlem Nation's way of life, the loss of salmon in the Coquitlam River system was significant, along with the loss of ancestral fishing grounds at Coquitlam Lake.

After the release of the report to members of BCRP's Management Board and B.C. Hydro's Coquitlam Water Use Plan Consultative Committee, it inspired discussion on the feasibility of reintroducing fish passage into the Coquitlam Reservoir. This led the Committee to fund a critical review by LGL Limited of a recent fish passage report for B.C. Hydro, and on a feasibility study by LGL for reintroducing salmon via fish passage in the Coquitlam Reservoir, *Feasibility of Reintroducing Sockeye and Other Species of Salmon in the Coquitlam Reservoir, B.C.* During the course of sampling for fish species by LGL in the Reservoir, a type of kokanee were discovered at the mouth of Cedar Creek, where they had apparently been spawning since the closure of the River in 1912. Genetic testing was conducted on the fish, with the remarkable finding that the kokanee was in actuality "residualized sockeye", the former parents of the "bastard" salmon lost after the dam prevented their ascent in 1913. LGL concluded that there were no inherent biological impediments to restoring fish passage into the Coquitlam Reservoir.

With the recent proposals for the construction of a new dam facility on the Coquitlam Reservoir, the Consultative Committee and B.C. Hydro representatives negotiated the implementation of a fish passage structure into the proposed dam, with an agreement for increased water flows into the Coquitlam River for fish downstream of the dam.

3. PROPOSED SIDE CHANNEL REHABILITATION STUDY AREA

Kerr, Wood, Leidel Associates Limited included four aerial photographs of the proposed side channel study site in its November 2001 feasibility report. Two of these images were kindly provided.

Figure 3.1, a 1996 color aerial, provides the general inter-urban landscape context surrounding the study area. As is evident, land development is predominant, and very little undeveloped lands remain in the lower reaches of the Coquitlam River. To the immediate right and east of the side channel site, and outside the boundaries of Kwikwetlem Reserve No.2, is the large up-slope Mary Hill urban residential complex within the municipal boundaries of Port Coquitlam City. This interface, as described by the consultants, creates an important concern in their recommended water quality infusion option for the proposed side channel rehabilitation site.

Figure 3.2, a black & white orthophoto, provides detailed visual information about the side channel site. The main stem of the side channel, from its mouth at the Coquitlam River to the Old Pitt River Road (immediately south of the Pitt River Road), showing the pools in the side channel, is approximately 1.1 kilometres in length. The side channel's width varies between ten to thirty meters. In addition, there is also a 140-meter long tributary side channel at the upper eastern end. This is a total of just over 1.2 kilometres of combined side channel habitat. The cemetery is located at the upper end of the side channel, immediately to the west. The Coquitlam River dyke runs along the eastern perimeter of the side channel.

4. PROPOSED METHODS FOR SIDE CHANNEL REHABILITATION

According to the engineering consultants, the proposed reactivation and redevelopment of the lower Coquitlam River side channel involves a series of recommended activities.

4.1. Water level dynamics monitoring program

There is the need for detailed measurements and monitoring programs to determine the present dynamics of water flow interactions between the side channel and the Coquitlam River throughout the year, particularly during critical seasonal coho salmon migration periods.

> "Design work for enhancement of the side channel should focus on determining how water levels in the two systems fluctuate throughout the year.... Determining how often the two systems are connected is critical in assessing the functionality of the side channel in providing over wintering habitat."

Figure 3.1. 1996 aerial photograph of lower Coquitlam River showing urban interface with side channel area. Coquitlam City boundary to left, Port Coquitlam boundary to right.

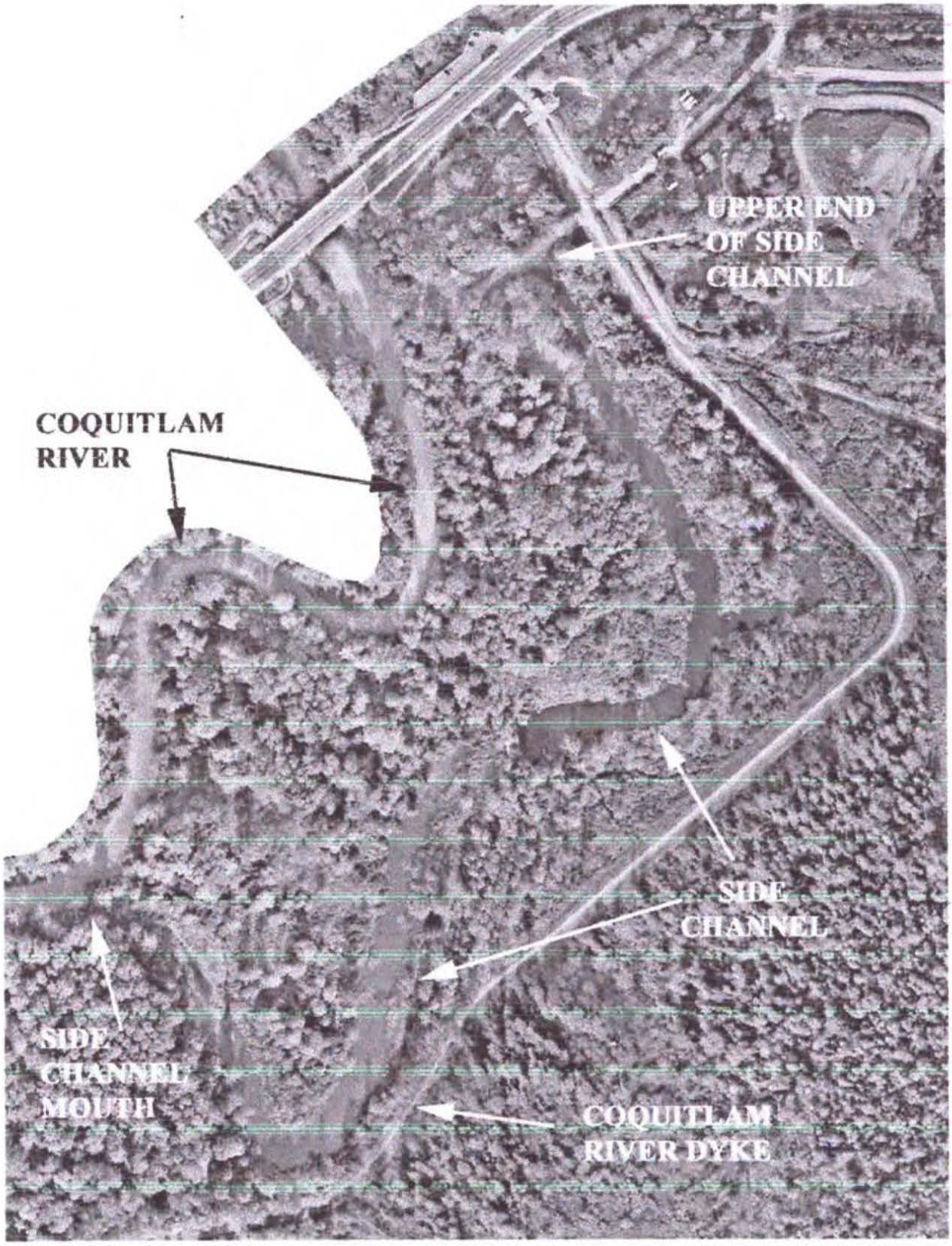


Figure 3.2. Orthophoto showing complete side channel area on Kwikwetlem I.R.#2.

"Determine mainstem channel water levels for various spring and fall discharges at the side channel outlet.... Measure the water level of the side channel near the outlet in the fall and spring.... make an appraisal of their connectivity."

Connectivity between the two sources is also influenced and complicated by tidal surges originating from the Fraser River working upstream to the side channel.

4.2. Lowering the side channel and bathymetric survey

At low water, the Coquitlam River is now one meter lower than the side channel, therefore water flow connectivity may be absent at critical times of the year for coho salmon migration and movement. This may necessitate engineering to lower the bottom side channel. By doing so, this may significantly impact the side channel by reducing "pool depth due to dewatering," necessitating the possibility for lowering much, or all, of the remaining side channel. The consultants recommend a "bathymetric survey of the channel should be completed to determine if pool depth would be significantly impacted by lower water levels."

Photo 4.1. Location of Coquitlam River and side channel mouth.

4.3. Excavation and connection to stormwater pump station

Figure 4-1 of the Kerr, Wood, Leidel report indicates the two options for upper channel connections to the Coquitlam River and the stormwater pump station. As the consultants have recommended the second option, for connection to the pump station, this connection may be made by either the placement of a culvert, or by excavating a one hundred meter trench as an extension of the side channel. Refer to figure 3.2 for the two connectivity locations.

4.4. Woody debris

Should the above-mentioned programs be instituted, it is recommended that "high concentrations of woody debris complexing" be placed throughout the side channel to enhance coho salmon overwintering habitat.

4.5. Estimated Costs

According to "Class D cost estimates" for November 2001 dollars, the program for side channel reactivation is estimated at $150,000 (Appendix).

5. KWIKWETLEM CEMETARY AND GROUNDWATER MITIGATION OPTIONS

Kerr, Wood, Leidel contracted Piteau Associates Engineering Ltd. "to complete a brief hydrogeologic study to address the feasibility of groundwater control options" for Kwikwetlem's cemetery site near the northwest end of the side channel.

> "In discussions with the Band, it is understood that it is not necessary to provide a permanent lowering of the water table. However, the Band does require the ability to temporarily control the local water table, so caskets can be lowered into dry excavations. Groundwater exclusion systems such as cutoff walls are considered to be impractical for the site due to high cost and the potential for extensive site disruption."

A series of test pits were excavated around the cemetery, along with water-pumping tests, in order to understand the nature of groundwater infiltration. Two recommended options were provided to mitigate groundwater depth and inflows:

> (a). To construct french drains on three sides of the cemetery. Such a design, along with a pumping system, would allow the area to be drained "prior to an internment".
>
> (b). To "compact the loose water bearing silt to collapse the voids and reduce its hydraulic conductivity". This could be achieved by the use of commercial vibrating equipment or by replacing the area with suitable "fill".

5.1. Estimated Costs

Cost estimates for temporary groundwater reduction at the cemetery are $75,000 (Appendix A).

Figure 5.1. Cemetery site location; Options 1 & 2; Pump House Station location.

6. RECOMMENDATIONS

DELIVERABLES: One electronic copy (.pdf files in CD-ROM format placed in an adhesive CD-ROM folder at the back of the report) and two hard copies.

REFERENCES

Bocking, R.C., and M.N. Gaboury. *Feasibility of Reintroducing Sockeye and Other Species of Salmon in the Coquitlam Reservoir, B.C.* LGL Limited. March 2003.

B.C. Hydro Report. *Evaluation of Restoring Historic Passage for Anadromous Fish at BC Hydro Facilities.* Global Consultants. June 2001.

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Koop, Will. *A Presentation on the History of the Coquitlam Watershed and River from 1898 - 1914*, for the Port Moody Ecological Society, on the Evening of April 6, 1994, 18 pages. (Located at the Vancouver Public Library & website: www.alternatives.com/bctwa/CoqRivHist.)

Koop, Will. *Red Fish Up The River. A Report on the Former Coquitlam Salmon Migrations and the Hydro-Electric Developments at Coquitlam Lake, British Columbia, Pre-1914.* Presented for the Kwikwetlem Nation through B.C. Hydro's Bridge Coastal Fish and Wildlife Rehabilitation Fund. October 1, 2001.

APPENDIX A: KERR, WOOD, LEIDEL'S SUMMARY OF COST ESTIMATES

Side Channel Reactivation	
Diversion of urban runoff	$20,000
Riprap protection on channel walls	$20,000
Decommissioning dyke penetration at river channel	$10,000
Reuse of culvert across access to cemetery	$5,000
Outlet construction works including access to site	$20,000
Habitat complexing (allowance)	$25,000
Predesign study	$20,000
Engineering and contingency	$30,000
Sub-total	$150,000
Cemetery	
150 metres of perimeter interception ditches at 100/m	$15,000
Ground water control at $75/m	$12,000
Pump station	$15,000
Electrical connection	$10,000
Sedimentation and polishing ponds	$3,000
Engineering and contingencies (30%)	$20,000
Sub-total	$75,000
Grand Total	**$225,000**

APPENDIX B: FINANCIAL STATEMENT

EXPENDITURE ITEM	DESCRIPTION	TOTAL COST
Report History: *Red Fish Up The River.*	Archival research (included a return flight and four days in Ottawa at the Canadian Archives), travel expenses, photo reproduction, photocopying. Per diem: $275.	$11,000

APPENDIX C: Confirmation of BCRP Recognition (newspaper clippings, press releases, newsletters, brochures, photographs of signs/plaques etc.)

Appendix 2
Reeve Slough Feasibility Assessment 2019, Preliminary Archaeological Review

Reeve Slough Feasibility Assessment 2019, Preliminary Archaeological Review and Recommendations

PREPARED KWIKWETLEM FIRST NATION AND ANTON MATAHLIJA

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PERMITS & PERMISSIONS

Non-permit HCA Report

Permissions – Kwikwetlem First Nation

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1.0 INTRODUCTION

This report provides a summary of the objectives, methods, and results of a preliminary archaeological assessment for the Reeve Slough Feasibility 2019 Project for the North Fraser Salmon Assistance Project (Figure 1). The intent of the Feasibility Study is to investigate opportunities for enhancement of off-channel fish habitat along Reeve Slough on Coquitlam IR 2 in Port Coquitlam, BC.

The objective of this assessment was to evaluate the potential for the project area to contain known or undocumented archaeological materials and to compile available information on Kwikwetlem cultural heritage associations and historical uses of the project area.

2.0 STUDY AREA AND PROJECT BACKGROUND

Reeve Slough is a 1060 m long and ca. 30 m wide channel located on Coquitlam IR2 in Port Coquitlam (Figure 1). The locality provides the largest parcel of unrestored off-channel habitat in the Coquitlam Watershed. Well-designed off-channel habitats provide critical growing/rearing locations for juvenile salmonids and refuge protection from flash flows in the Coquitlam River. The purpose of the Reeve Slough Feasibility Study is to evaluate the existing knowledge base in order to optimize habitat planning while ensuring Kwikwetlem land, water, ecosystem, and cultural heritage values and places are protected. Project design elements, impact areas and types, and disturbance boundaries have not been established. The Feasibility Study will consider Project Area topographic survey, bathymetric and hydrology studies, ethnobotanical survey, and archaeological assessment.

2.1 Archaeological Context

Archaeological sites on provincial land in British Columbia are protected under the terms of the Heritage Conservation Act (HCA), and administered by the Archaeology Branch, Ministry of Forests, Lands and Natural Resource Operations[1]. Archaeological sites are protected from *intentional or inadvertent disturbance* if they pre-date 1846 or represent significant events in the history of the Province (i.e., some historic buildings and properties). Contravention of the Act can result in significant fines or incarceration.

Many First Nations consider the definition of an archaeological site as a place featuring only the physical remains of human activity too restrictive and instead advocate the recognition and protection of a wider range of site types, including places of spiritual significance, named locales, known travel routes or resource gathering places, and other sites of cultural value regardless of the presence or absence of physical remains (e.g. *Kwikwetlem Cultural Heritage Resources Policy*, 2011). Such places are referred to as cultural heritage or traditional use sites.

[1] http://www.for.gov.bc.ca/archaeology/index.htm

2.2 Reeve Slough, Coquitlam IR 2

The Kwikwetlem community holds deep cultural, historic and spiritual ties to the project area. Coquitlam IR 2 was established as a reserve during colonial reserve formation based on the presence of a continuously used and occupied village at the location. This named, ancient village - setɬame'kmən (meaning, 'when the tide is high we go') associates with archaeological deposits at least several thousand years old (Kenyon 1953) and Indigenous land use throughout the area has been extensive. Kwikwetlem are strong advocates for best-practice natural and cultural resource management throughout the territory and especially in the lower Coquitlam floodplain.

3.0 APPROACH

This preliminary archaeological assessment focused on compiling available records and information from which to evaluate the likelihood that undocumented archaeological sites may be present within the project area and select area subsurface testing. Sources useful for evaluating known or predicted locations of past Indigenous land use include the following:

- Provincial heritage resources (RAAD and provincial online mapping), Provincial Archaeological Report Library, BC Site Inventory Records.
- Indigenous cultural heritage information relevant to the Project Area described in archival, ethnohistoric, or available traditional knowledge and use reports.
- Available regional ethnographic local history sources and photograph archives.
- Historical air photographs, vegetation records, or landscape attribute maps that may inform the presence or kinds of past cultural activities.

3.1 Subsurface Testing

For this review shovel testing concentrated in the vicinity of a potential proposed rearing channel running west from the most south-easterly u-shaped bend of Reeve slough that runs roughly parallel the IR 2 dike (Figure 1, yellow polygon). A total of 24 shovel tests were placed in an area approximately 200 metres by 20 metres wide to assess local area sediments and project area potential for buried cultural materials.

Tests were placed 5 metres apart in clusters of 4 or more tests, on slightly raised terrain or adjacent apparent swale channels. Shovel tests typically measured 35-40 cm on a side and reached a maximum depth of 65 cm. All excavated materials were screened through 6 mm mesh to examine matrices for cultural remains. Shovel test locations are shown on Figure 4, with information on excavated matrices and stratigraphy summarized in the Results section.

3.2 Preliminary Field Reconnaissance

A preliminary field reconnaissance (PFR) is undertaken to conduct an in-field review or ground-truthing of conditions that may enhance, alter or refine archaeological potential evaluations by noting the presence and extent of undocumented ground disturbances, terrain conditions or landforms not apparent on available terrain mapping (microterraces, floodplain swales, benches and so on. A field reconnaissance also provides the opportunity to visually survey the ground surface for readily apparent signatures of cultural activity, such as artifacts, fire-altered rock (a bi-product of food processing), anthropogenic sediment exposures, and so on.

In this case a full reconnaissance of the project area was not undertaken due to the presence of a mother bear with young cubs residing in the area and very dense vegetation which impeded foot survey, visibility, and safe movement through the area.

4.0 RESULTS - CULTURAL HERITAGE CONTEXT

4.1 Recorded Archaeological Sites

A total of sixteen archaeological sites are recorded within three kilometres of Coquitlam IR 2 (Figure 1). Area sites include ancient village sites, resource processing locales, fishing camps and fish weirs, subsurface perishable artifacts, well-preserved archaeological 'wet-site' (preserved organic materials) deposits and locations with stone tools and stone tool production debris. Most sites are situated along shoreline locales, but an increasing number of newly recorded sites away from main river tributaries highlight that inland locations that are underrepresented in the current archaeological site inventory (see DhRq-43, DhRq-86, DhRq-90, DhRq-91, Figure 1). Given the duration and intensity of aboriginal occupation in the area, we expect that many more archaeological sites remain undetected and undocumented.

Archaeological site DhRq 10 is in immediate vicinity to the Reeve Slough project area. Site boundaries have not been systematically documented west of the IR2 dike/trail but a site visit to the KFN cemetery by anthropologist Walter Kenyon and Coquitlam William in 1953 results in observations of surface archaeological materials at least in proximity to this area.

4.2 Reeve Slough Historic Vegetation and Landform Characteristics

Historic terrain and vegetation records drawn from Royal Engineer land surveyor notes of the mid to late 1800's show low lying areas of the project area covered in grass and areas of slightly raised elevation dominated by wet mixed coniferous forest characterized by Cedar, Douglas fir, Hemlock, and Spruce, with notable areas of Labrador tea, cranberry, and moss (Figure 2, North and Teversham 1984). Such ecosystem types along this major salmon bearing waterway would have provided a plentiful and reliable resource base from which to sustain the past Kwikwetlem community, and almost all of the Indigenous plant types found in the project area associate with known dietary, medicinal, and/or utilitarian uses for Indigenous peoples. It is this diversity of riverine, wetland, and dry scape resources that undoubtedly made the locale an important settlement locale for millennia.

Royal Engineer notes and maps also indicate that Reeve Slough was once an open backchannel that diverged from the main channel to form an island in Coquitlam River; a landform description that conforms with Kwikwetlem Elder memories of the area that describe a set of channels here that became silted in with historic flow pattern changes, attributed largely in community memory to changes in flow rates following the construction of the Coquitlam Dam.

4.3 Kwikwetlem Knowledge and Land Use

Kwikwetlem holds significant and detailed traditional knowledge of lands, waters, resource patterns, and cultural associations of the Project location. The historic KFN cemetery is situated to the immediate west of Reeve Slough although prior to colonial influence it is likely that ancestral interments once extended more broadly around the old village. Kwikwetlem community members resided on the floodplain on the west side of Reeve Slough (in raised post houses) at least until the

early 1940's. Evidence of these residences has been observed at least by Kwikwetlem members in the late 1990's.

4.4 Historic alternations of the Project Area

Historic land disturbance can be a mediating factor influencing the presence, preservation, and detection of archaeological resources. The Reeve Slough project area is relatively unaltered by historic disturbance. Notable alterations include a turn-of-the-century dike established along the east Coquitlam River shoreline (it is likely the dike berm is comprised of local area sediments). The historic dike was replaced and relocated in the early 1990's east of Reeve Slough through Coquitlam IR2 and is today referred to as the IR2 dike or Traboulay Poco – Colony Farm Trail. Installation of a municipal pump station at the head of the dike at Pitt River Road together with flow alterations and changing siltation patterns in the Coquitlam River in the historic period have led to an expansion of the Reeve Slough system and significant changes to the hydrologic pattern of groundwater, flooding, and back channel flows as reported by Kwikwetlem community members.

4.5 Subsurface Testing

Twenty-four shovel tests were placed in the vicinity of a potential proposed fish-rearing channel that extends west from the most a u-shaped bend of Reeve slough at its southern end (Figure 2). Sediments throughout the area can be summarized as a medium brown fine silt immediately underlying surface litter debris, between 20 to 35 cm thick. The underlying is a yellow grey fine silt often mottled with red or black staining that extended to the base of most shovel tests. Occasional lens of fine grey sand or black organic silts. No evidence of anthropogenic sediments or materials were observed.

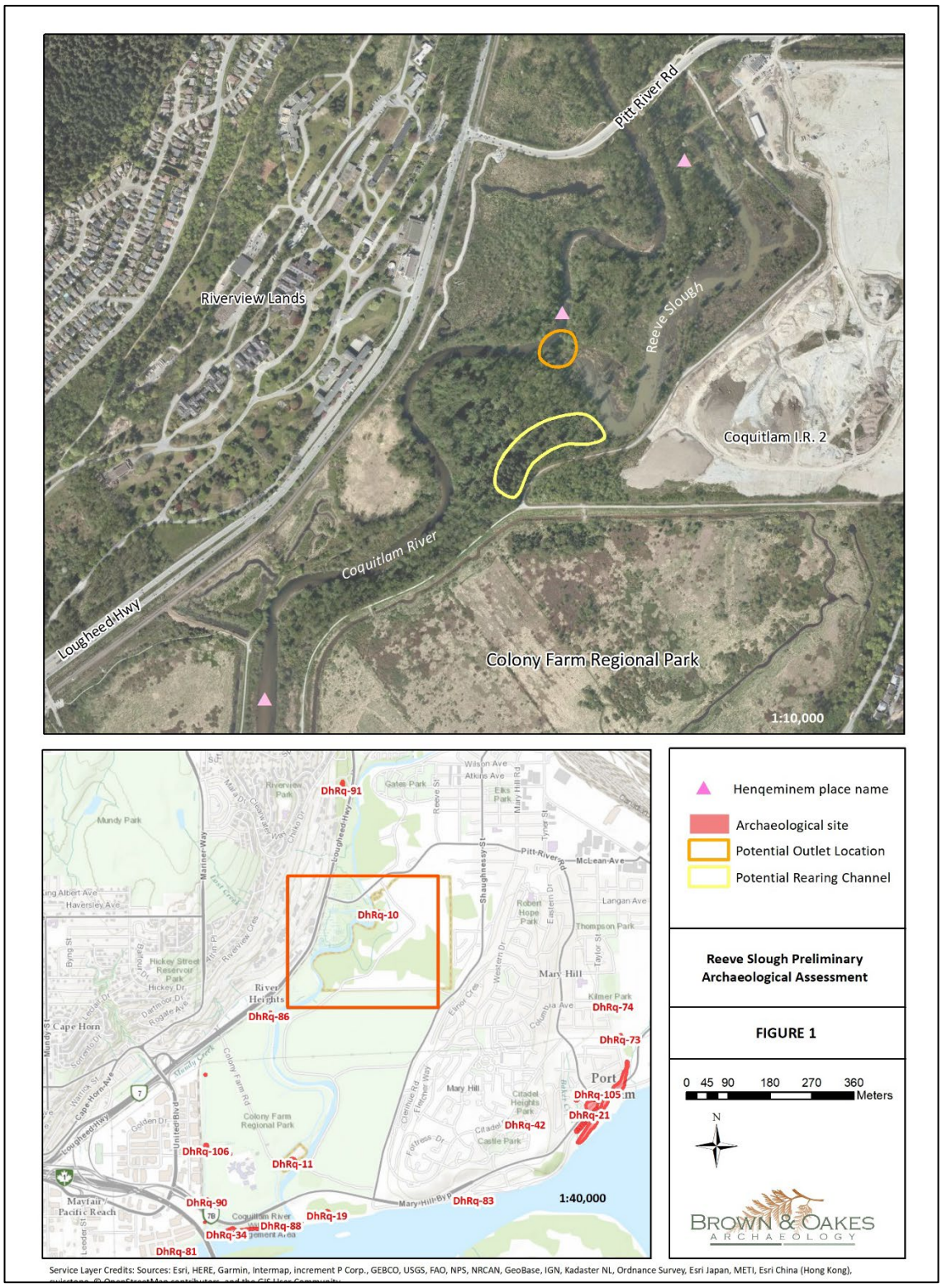

Figure 1. Reeve Slough Preliminary Archaeological Assessment.

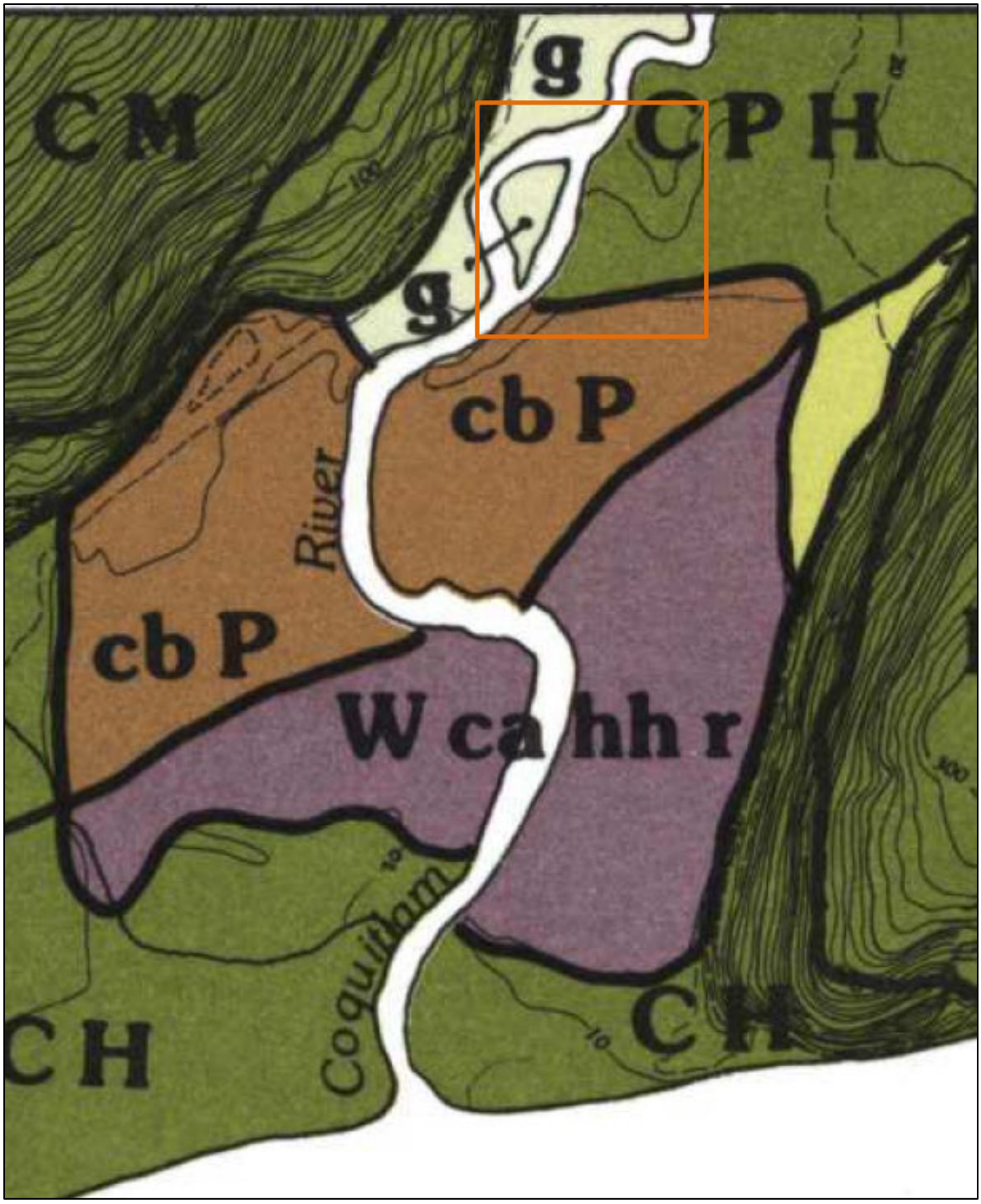

Figure 2. Section of historic vegetation mapping – 1858 to 1890 showing study area (orange polygon), North and Teversham 1984.

Figure 3. Historic 1938 air photo compilation (UBC, Geographic Information Centre).

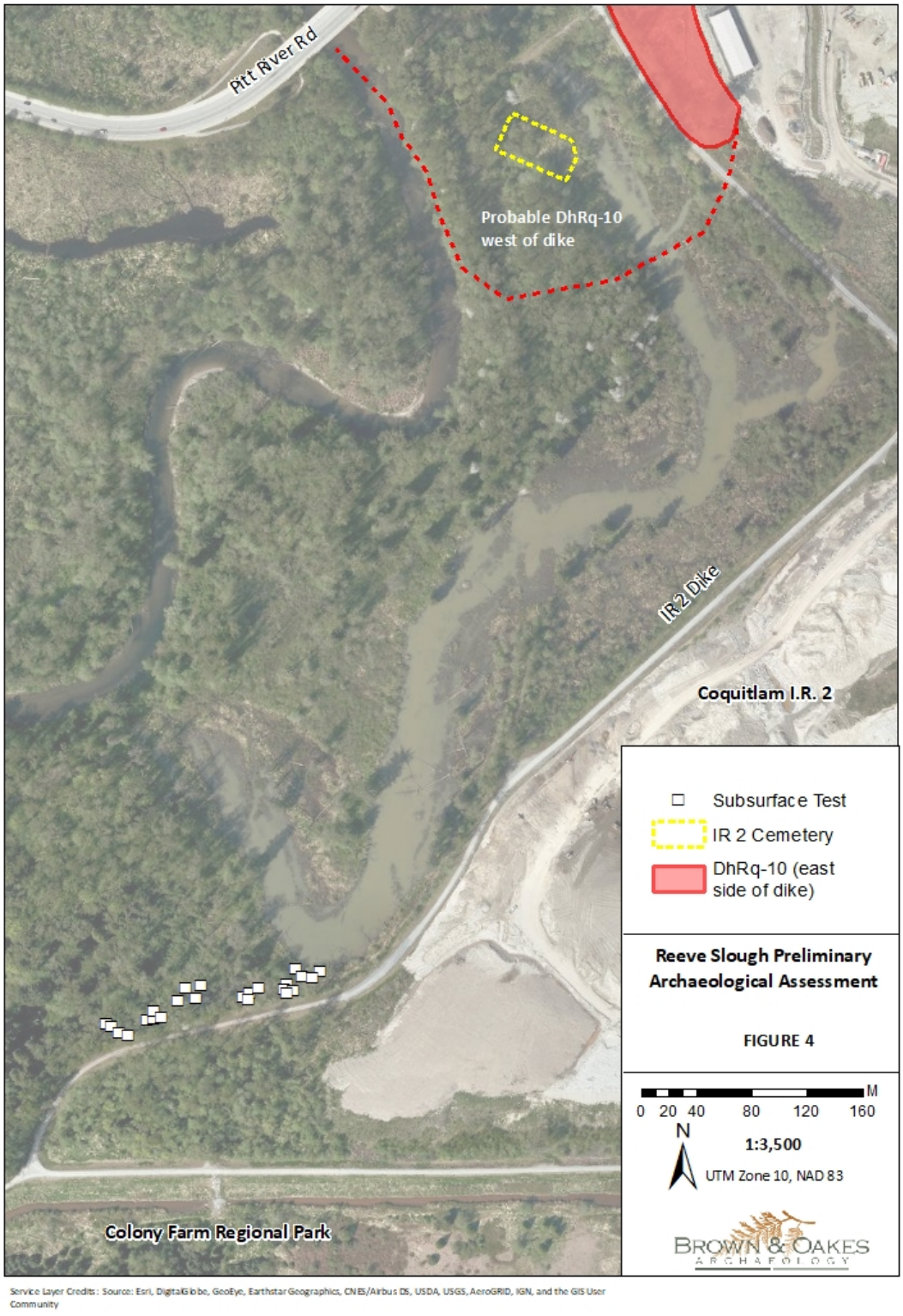

Figure 4. Reeve Slough subsurface test locations.

5.0 RECOMMENDATIONS

The Reeve Slough Feasibility Study is a high-level assessment to evaluate optimal fish habitat enhancement design while ensuring protection of area cultural heritage and ecosystem values.

The findings of this assessment conclude that all project areas associated with the Project Area have HIGH potential to encounter undocumented archaeological materials. In view of the archaeological potential of the study area and to assist future potential development activities, we provide the following recommendations:

1. Full systematic surface survey of all proposed impact areas and immediate surroundings should be undertaken PRIOR TO habitat developments. Survey should take place during a period of low vegetation (eg. Nov. to March) to maximize ground surface visibility.
2. Subsurface testing should be undertaken at all proposed habitat development areas with potential to lead to ground disturbance PRIOR TO construction initiation. Archaeological monitoring may be recommended by the archaeological team in select conditions, following the surface and subsurface assessment.
3. No further archaeological assessment is required in the proposed rearing channel project area, provided that development impacts do not extend beyond the archaeologically tested area.
4. Brown & Oakes will review all final design and construction plans to identify areas and/or activities that may result in meaningful ground disturbances and that may warrant assessment, for example, grubbing, tree stump removal, creation of temporary access routes, installation of erosion mitigation fixtures, and so on.

REFERENCES

North, M.E.A, and J.M Teversham

1984 The Vegetation of the Floodplain of the Fraser, Serpentine and Nicomekl Rivers, 1859 to 1890. Vancouver: University of British Columbia, Geographic Information Centre.

Appendix 3
Kwikwetlem First Nation Reeve Slough Ethnobotany Report

Reeve Slough Ethnobotany Report

KWIKWETLEM FIRST NATION

REEVE SLOUGH ETHNOBOTANY REPORT

OCTOBER 3, 2019

AUTHORS

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Cover Image: “Hairy Woodpecker” by Deanna MacKinnon

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1.0 PURPOSE OF THIS REPORT

This *Reeve Slough Ethnobotany Report* (RSER) provides a summary of preliminary findings and recommendations to help inform the Reeve Slough Feasibility Study 2019, which is investigating opportunities for enhancement of off-channel fish habitat on Kwikwetlem First Nation (KFN) land. The findings of this report are based on information provided by KFN on plants of cultural priority, and a preliminary survey of the proposed project area undertaken in August of 2019.

This RSER provides a general summary of ecological conditions and identifies plant species located in the proposed project area, including those used traditionally by KFN (for food, medicine, material, ceremonial or other purposes).

2.0 PROJECT BACKGROUND

Reeve Slough, located on Kwikwetlem First Nation land in Port Coquitlam, is the largest parcel of unrestored habitat remaining in the Coquitlam watershed. The project could potentially enhance 31,800 m^2 of fish habitat. The habitat enhancement project will provide productive rearing and refuge/overwintering habitat for salmonids, including chinook, chum, pink, coho, sockeye, steelhead, and cutthroat.

The project Feasibility Study includes tasks designed to improve the existing knowledge base and augment past reports prior to commencement of future habitat enhancement work. Specifically, this work will help determine what and how enhancement works can be undertaken to optimize fish habitat while ensuring that other values (such as the nearby KFN graveyard and existing ecosystems) are protected.

Tasks initiated as part of the Feasibility Study include completion of this ethnobotany report and a First Nations archaeological assessment, in addition to topographic surveys, bathymetric surveys, subsurface sediment sampling, water level monitoring, and species at risk surveys.

2.1 Project Boundaries

Due to the Reeve Slough fish habitat enhancement project only being at the conceptual stage at the time of survey, precise project boundaries were not established within which to conduct the survey. As such, it is anticipated that the actual disturbance boundaries may differ somewhat from the more generalized boundaries used as part of this preliminary ethnobotanical investigation.

The project area is located on the right (south) bank of the Coquitlam River, downstream of the Pitt River Road Red Bridge, and four kilometres upstream of the confluence with the Fraser River. The preliminary project boundaries (yellow boundary on Figure 1) encompass an area approximately 200 metres long and 20 metres wide. A dyke and trail (Traboulay Poco Trail – Colony Farm) border the south side of the project area, while Reeve Slough is adjacent to the east.

A secondary potential enhancement area was identified (see orange boundary on Figure 1); however, current efforts are focused on the primary enhancement area described within this report and no ethnobotanical surveys have been conducted elsewhere.

Figure 1: Primary (yellow) and secondary (orange) potential enhancement areas

3.0 RESULTS

An overview survey was undertaken within the preliminary project boundaries on August 30, 2019. Timing and scope limitations associated with this feasibility study precluded a more detailed survey. Other ecologically suitable plant species not listed in this report, including those used traditionally by KFN, may occur in the project area.

3.1 Biogeoclimatic Ecosystem Classification

Reeve Slough is located in the Coastal Western Hemlock dry maritime (CWHdm) subzone, according to the Biogeoclimatic Ecosystem Classification (BEC) of BC. The CWHdm occurs at low elevations on the British Columbia mainland and immediately adjacent islands. The CWHdm has long growing seasons with warm, relatively dry summers and moist, mild winters with little snowfall.

The project area appears to be located on a medium bench floodplain and is likely subject to periodic flooding at least every five years. Human disturbance (e.g. dyking, flood controls, tree clearing) has altered ecological conditions of the area; but approximate site series under BEC is CWHdm09 (black cottonwood – red-osier dogwood).

3.2 Site Description

The floodplain area is dominated by deciduous tree species (black cottonwood, red alder) with some minor occurrences of sitka spruce, western redcedar, paper birch, cherry, and cascara. Canopy height is approximately 30 metres; however, some sitka spruce grows to 40 metres. Numerous wildlife trees occur within the project area; these trees are typically small to medium sized deciduous snags.

The understory is dominated by shrubs (salmonberry, hardhack, black twinberry) and reed canary grass. Some invasive species (e.g., Himalayan blackberry) and exotics occur; however, they are located primarily along the dyke/trail.

View of forest stand looking east along dyke trail

Hardhack understory (middle of project area)

Wildlife tree (east side of project area)

Reed canary grass (east side of project area)

Topography is generally flat (<2% gradient) apart from the dyke itself. The project area encompasses what appears to be a dry, elevated channel bed that may contain water during periods of wet weather or periodic flooding. At its eastern most point, at the channel's confluence with Reeve slough, the channel bed was approximately 0.5 metres higher than the water surface in the slough.

Confluence of dry channel bed and Reeve slough

Reeve slough

Soil tests were not conducted as part of this assessment; however, soil in the dry channel appears to have a high sand content (sandy loam) with presence of rounded gravels and cobbles. These soil characteristics are indicative of fluvial (i.e., river or stream) processes.

Soil (texture) can influence the amount of water and nutrients that plants receive and should be fully considered as part of future habitat restoration, in terms of what plants can be best supported by the types of soils present.

Note: Separate soil tests have been conducted to help determine archaeological potential within the project area.

Rounded cobbles in substrate (west side of project area)

3.3 Plant Species

Plant species identified during the preliminary survey are listed in Table 1. Due to the timing and scope of the survey, the plant list is not considered definitive; additional plant species are likely present and a more intensive survey following best practices will be required to provide a more detailed species list. For example, timing (*i.e.*, flowering) windows to identify many herbaceous plants are April to June, and sedges and grasses in late July.

Table 1: Plants identified in preliminary project boundary

Vegetation Layer	Species	Common Name	Cover % (est.)	Comment
Tree	*Populus balsamifera* var. *trichocarpa*	Black cottonwood	50	KFN priority plant[#]
	Alnus rubra	Red alder	40	KFN priority plant[#]
	Thuja plicata	Western redcedar	<5	KFN priority plant[#]
	Picea sitchensis	Sitka spruce	<5	
	Rhamnus purshiana	Cascara	<5	KFN priority plant[#]
	Betula papyrifera	Paper birch	<5	
	Prunus sp.	Cherry	<5	
	Quercus sp.	Oak	<5	Exotic*
	Prunus laurocerasus	Cherry laurel	<5	Invasive[+]
Shrub	*Rubus spectabilis*	Salmonberry	30	KFN priority plant[#,++]
	Sambucus racemosa	Red elderberry	<5	KFN priority plant[#]
	Corylus cornuta var. *californica*	Beaked hazelnut	<5	KFN priority plant[#]
	Rubus parviflorus	Thimbleberry	<5	KFN priority plant[#]
	Oemleria cerasiformis	Indian-plum	10	KFN priority plant[#]
	Spirea douglasii ssp. *douglasii*	Hardhack	30	
	Cornus stolonifera	Red-osier dogwood	10	
	Acer circinatum	Vine maple	10	
	Lonicera involucrata	Black twinberry	10	
	Rubus ursinus	Trailing blackberry	<5	
	Sorbus sitchensis	Sitka mountain-ash	<5	
	Rubus discolor	Himalayan blackberry	<5	Invasive[+]
Herb/forb/grass	*Lysichiton americanum*	Skunk cabbage	<5	KFN priority plant[#]
	Polystichum munitum	Sword fern	<5	KFN priority plant[#]
	Polypodium glycyrrhiza	Licorice fern	<5	KFN priority plant[#]
	Athyrium filix-femina	Lady fern	<5	KFN priority plant[#]
	Solanum dulcamara	European bittersweet	<5	Exotic*
	Lathyrus latifolius	Broad-leaved peavine	<5	Exotic*
	Phalaris arundinacea	Reed canary grass	30	
	Carex sp.	Sedge	<5	
	Impatiens noli-tangere	Common Touch-me-not	<5	Exotic*
	Iris pseudacorus	Yellow-flag	<5	Exotic*
	Lotus corniculatus	Birds-foot trefoil	<5	Exotic*
	Nuphar polysepalum	Yellow pond-lily	-	Aquatic
	Polygonom sp.	Smartweed	-	Aquatic

KFN Preferred priority plant – Plants used by KFN for traditional purposes (e.g., food, medicine, material culture, ceremonial, or other)
*Exotic – species that occur outside of their natural range and were introduced either accidentally or on purpose, often due to human activities
+Invasive – when exotic species become established and reproduce (often due to lack of natural predators or other controls) and negatively affect natural ecosystems
++ Kwikwetlem often harvests salmonberry around the community; while a staple, the community feels it should not be prioritized at the expense of other less-available plants on this list

3.4 Invasive Plants

Invasive plants were identified in the project area. These include Himalayan blackberry and cherry laurel. Reed canary grass is also abundant; however, there is some debate as to whether reed canary grass is an invasive species[1]. Additionally, some large infestations of Japanese knotweed and policeman's helmet were also identified on the access dyke/trail east of the project area.

Invasive plants are typically aggressive, reproduce quickly, are difficult to control, and can outcompete other plants, thereby reducing biodiversity and affecting ecosystem health. Some species can also cause economic damage and impact human health. Invasive plants often colonize and establish in disturbed areas. The potential for the spreading of Japanese knotweed is of particular concern in riparian areas and areas prone to flooding, as they are easily transported by water.

Identification of invasive species and implementation of appropriate mitigation measures will be an important component of the more detailed project design and assessment phase. Effective mitigation measures can help to prevent establishment and spread of invasive plants in disturbed areas, which will protect the integrity of natural ecosystems, including plants of higher cultural and ecological value.

4.0 NEXT STEPS AND RECOMMENDATIONS

This *Reeve Slough Ethnobotany Report* (RSER) provides a summary of preliminary findings based on a limited field survey. General recommendations are provided below:

1. Include Kwikwetlem First Nation in future planning for habitat restoration. Kwikwetlem First Nation is in the process of compiling preferred replanting approaches for restoration projects that will include a focus on traditional plants. Community engagement with Kwikwetlem First Nation should continue beyond the conceptual stages to ensure KFN interests are fully considered as part of this restoration project. Future project costs should account for KFN involvement in restoration planning, including a more thorough ethnobotanical study and inclusion of traditional plants in planting palettes.

2. Complete detailed ethnobotanical surveys and ecological assessments. It is acknowledged that the timing and intensity of this preliminary survey precludes compilation of a definitive list of all plant species potentially located in the proposed project area, including traditional plants used by KFN.

Seasonal surveys are recommended to best detect plants as this method will capture the flowering periods of most plants. For example, timing windows for many herbaceous plants are April to June, and sedges and grasses in late July. Therefore, more detailed plant surveys using best practices will be required to

[1] E-Flora BC. 2019, September 9. Retrieved from http://linnet.geog.ubc.ca/Atlas/Atlas.aspx?sciname=Phalaris%20arundinacea.

identify plants that may occur within the project area. These plants may include traditionally used species, rare and endangered species, and other plants that may grow seasonally or in specific habitats.

Additionally, the project area boundaries have not been finalized, so it is likely that the survey area will need to be refined at future planning stages.

3. Limit disturbance to existing forest ecosystems. Minimize disturbance to vegetation and soil outside of channel area. In areas where disturbance cannot be avoided, implement measures to mitigate/limit soil and vegetation disturbance (e.g., establish tree root protection zones) and monitor/manage the spread of invasive plant species.

Include access management strategies to support restoration and help maintain KFN priority plant species.

4. Manage for biodiversity. Manage forest, riparian, and aquatic ecosystems to maintain or enhance biodiversity (e.g., maintain or enhance wildlife trees, coarse wood debris, understory diversity, tree species diversity. Implementation of specific mitigation measures for managing invasive plant species, as outlined in 3 above, will also assist in preserving biodiversity.

5. Implement a Monitoring Plan. Include KFN as part of a monitoring program to ensure restoration objectives are being met, including maintenance and establishment of priority plants.

Appendix 4
Reeve Slough Fish Habitat Enhancement Feasibility Assessments 2020

Reeve Slough

Fish Habitat Enhancement Feasibility Assessments

Prepared for:

Fisheries & Oceans Canada

& North Fraser Salmon Assistance Project Society.

Prepared by:

ENKON ENVIRONMENTAL LIMITED

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Project No.:1864-001

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Executive Summary

ENKON Environmental Limited (ENKON) has completed overview assessments to provide fish habitat restoration feasibility assessments to inform future detailed planning efforts for Reeve Slough, a relict side-channel habitat associated with the Coquitlam River.

The scope of assessments undertaken was limited to works defined in consultation with Fisheries and Oceans Canada and the North Fraser Salmon Assistance Project Society. The feasibility study components undertaken by ENKON included the following:

- Lidar acquisition and analysis including preliminary watershed modeling
- Qualified Environmental Professional (QEP) delineation of key topographic and ecological boundaries and coordination/acquisition of detailed topographic survey pickup at priority locations
- Bathymetric survey efforts of slough open-water habitat areas
- Preliminary analysis of organic sediments and interpretation of depth to underlying mineral substrate
- Implementation of long-term water level monitoring of river and slough to evaluate potential linkages and relationships
- Overview level Species-At-Risk reconnaissance surveys and habitat assessment

The feasibility assessments were initiated in June 2019 and continued through to April 2020 with the acquisition of the topographic surveys and summary reporting presented herein.

Key project findings include the verification of the seasonal and event specific hydrologic connectivity of Reeve Slough through a previously unmapped drainage connection through relict floodplain habitats originating from the northwesternmost end of the slough.

Preliminary analysis and field verifications suggests that there is no direct hydrologic connectivity between the Coquitlam River or the PoCo slough. Future fish habitat enhancement efforts would require the provision of potential fish access and the establishment of a water source to yield a 'flow through' hydrologic regime to benefit water quality hydrologic variability.

The presence of beaver and the prevalence of activity within and around Reeve Slough are concluded to pose the most significant challenge to the pursuit of drainage modifications to benefit fish access and alterations to the hydrologic regime. Explicit considerations for beaver management and flood risk management will be critical to address the fish access and rearing habitat objectives, and to avoid increasing the risks of flood inundation affecting the Kwikwetlem First Nation's cemetery site.

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1.0 INTRODUCTION

ENKON Environmental Limited (ENKON) was retained to provide feasibility assessments to support future project planning for fish habitat enhancements contemplated for Reeve Slough. The project included completion of specific studies identified as data gaps required to evaluate the feasibility of fish habitat enhancements.

The scope of studies have been defined by the Fish and Wildlife Compensation Program (FWCP) and in consultation with the North Fraser Salmon Assistance Project Society and Fisheries and Oceans Canada (DFO). Key considerations requiring evaluation included the assessment of the slough's hydro-dynamics and present-day connectivity with the Coquitlam River and an adjacent slough associated with the City of Port Coquitlam's Reeve Park drainage pump station.

Assessments also included a preliminary evaluation of wildlife habitat values with a focus on potential Species-at-Risk occurrences. Results from wildlife habitat assessments will help inform future project planning for ecosystem values beyond the immediate fish and fish habitat objectives.

1.1 Project Context

Reeve Slough is a relict channel of the Coquitlam River located on the east bank of the present-day mainstem channel (Figure 1). The location of the proposed fish habitat restoration project is located immediately downstream from the Pitt River Road bridge crossing of the Coquitlam River (the Red Bridge). It is isolated from the present-day stream channel mainstem and is characterized as an oxbow lake within the historic floodplain of the river (Photograph 1). The Coquitlam River is generally incised into Quaternary post-glacial sedimentary deposits, consisting of lowland and mountain stream marine deltaic and channel fill materials, characterized as coarse gravels and sands.

Photograph 1 - Upstream view of Reeve Slough from location of historic dyke crossing.

The slough is bound to the east by a dike constructed for flood protection (Photograph 2). A historic dike is located inboard of the present-day dike and is understood to have historically crossed the slough but was removed by members of the North Fraser Salmon Assistance Project. The historic dike serves as an access road generally parallel to the immediate left bank of the Coquitlam River and is interpreted to impound seasonally inundated floodplain habitats and exacerbate drainage concerns associated with the Kwikwetlem First Nation (KFN) cemetery.

The slough is isolated from known upstream water sources; however, the slough's upstream limit is immediately adjacent to a City of Port Coquitlam pump station and drainage channel that parallels Pitt River Road and discharges via a culvert and flap-gate to the Coquitlam River (Photograph 3). The potential relationship and hydrologic linkage between the pump station and drainage channel require further investigation as a potential source of 'flow-through' water supply in support of the restoration objectives.

The slough is located entirely within the KFN IR2 reserve lands. An important feature of the area is the Nation's cemetery, located to the east of the Coquitlam River and to the west of the slough, between the historic and present-day dike boundaries. The cemetery is accessed by a gravel road separating the upstream limits of the slough and the pump station drainage channel.

It is understood that groundwater levels affecting the cemetery have been too high to allow excavation for burials during much of the year. A major concern of the KFN with respect to potential fish habitat restoration efforts is to mitigate the risk of flooding or inundation affecting the cemetery. Mitigating flood risk will allow year round access and provide protection of ancestral burial grounds. As such, a key consideration of this project will be the hydrologic variables of the proposed fish habitat restoration. A major design consideration will be to improve the slough's drainage, and ensure the project does not exacerbate current groundwater levels or flood risks affecting the cemetery.

The KFN cemetery is also located immediately south from the Reeve Park Pumps Station and associated drainage channel. The drainage channel from the Reeve Park is a smaller slough feature that is conveyed to the Coquitlam River via an existing culvert with a flood-gate and a rip-rap armoured spillway providing drainage redundancy. This smaller slough feature has been observed to be regularly backwatered due to beaver activity and is discussed herein as the 'PoCo Slough' (Figure 1).

1.2 Fish Habitat Enhancement Objectives

The Reeve Slough site has been identified as a potential fish habitat enhancement project with the focus being the restoration and enhancement of viable off-channel rearing habitat for Chinook Salmon (*Oncorhynchus tshawytscha*).

The assessments completed under the scope of this assignment have been completed to support ongoing planning and design to establish the feasibility of the Reeve Slough fish habitat restoration objectives.

Legend

- BC Cadastral Boundary
- Slough Natural Boundary

Prepared by:
ENKON
Environmental Ltd.

Map Created: 2020-04-28
by: R. Preston
NAD 83, Zone 10N

Reeve Slough
Site Location
Map

Figure 1

Fisheries & Oceans Canada

2.0 METHODOLOGY

2.1 Terrain and Hydrologic Analysis

ENKON liaised with the City of Port Coquitlam's geomatics department staff and was provided with Light Detection and Ranging (LiDAR) datasets (year 2012) to support terrain and hydrologic analysis. Raw .las format files were provided which represented ground elevations.

A high resolution digital elevation model (DEM) surface was prepared utilizing ArcGIS V.10.6.1 and ETSpatialTechniques ETSurface software package. A DEM raster was prepared at a 0.5m grid cell resolution and formed the base for derivative raster analysis including hillshade, slope, flow direction, and flow accumulation raster datasets.

The terrain modeling was combined with available 2018 orthophotograph imagery obtained from the City of Coquitlam to support delineation of the approximate wetted perimeter/natural boundary of Reeve Slough and the adjacent Poco Slough.

Flow direction and flow accumulation datasets were analysed to model preferential surface flow pathways to inform targeted field investigations to assess for permanent or seasonal drainage connections between Reeve Slough and the Coquitlam River.

2.1.1 Field Verification

A targeted field assessment was undertaken in response to the period from January 30th through February 3rd, 2020 during which 182.25 mm of rainfall was recorded at the City of Coquitlam's Burke Mountain tipping bucket rain-gauge. Field assessments were conducted on February 03 and 06, 2020.

Further field assessments were conducted at the upstream limits of Reeve Slough for all site assessments completed, including assessments following extreme rain events to assess for the potential presence of a buried or obstructed culvert linking PoCo Slough to Reeve Slough.

2.2 Bathymetric Analysis

Bathymetric assessments were undertaken to develop an understanding of approximate slough depths. Initial bathymetric assessments were pursued with the field deployment of a SonarMite single-beam SEA1002 transducer obtained as a rental from Cansel.

The transducer and data collection equipment was mounted to a single person kayak. The kayak deployment was required due to the lack of access for any other form of boat launch due to the construction phase closure of the dike trail associated with the adjacent KFN business park development. Furthermore, initial field reconnaissance surveys identified a number of downed trees and shallow water conditions that would preclude typical boat access. The small recreational kayak deployment allowed for easy access with a 2-person field crew and access to the full extent of the seasonally wetted areas of Reeve Slough.

The SEA1002 transducer was mounted to a custom fabricated wood platform and deployed below the static water surface to record depth to substrate. Transducer deployment included the sensor GPS receiver set at a height above water surface of 1.3 m and the transducer set at 0.4m below water surface per manufacturer's requirements and instructions from the equipment supplier (Cansel). The transducer was paired to a Trimble Geo Series GPS unit for data collection and export to support GIS analysis and interpretation of results.

Dataset interpretation was accomplished following export of the spatial data files and attribute information utilizing ArcGIS V.10.6.1.

2.2.1 Manual Bathymetric Analysis

Shallow water levels and the prevalence of aquatic weeds limited the effectiveness of the bathymetric instrumentation. A relatively 'low-tech' approach was pursued utilizing a calibrated rod and field measurements of depths to substrate to further inform bathymetric analysis.

A 3 m graduated metal rod was prepared and deployed by kayak to assess depth to substrate. A total of 69 sampling stations were recorded and mapped utilizing a Trimble R1 GNSS receiver paired to ArcCollector utilizing a field tablet computer.

2.2.2 Substrate Assessment

An analysis of substrate was undertaken following discussion with DFO representatives to inform the potential value of slough excavations to potentially benefit increased groundwater or hyporheic zone connections.

Coincident with the manual bathymetric analysis, an approximation of the depth of substrate was undertaken utilizing the 3 m calibrated rod. The depth to substrate was recorded (D1) and then manually inserted to refusal to estimate the depth of unconsolidated substrate (D2).

A qualitative interpretation of underlying material was recorded based on tactile and auditory interpretation of the interface at refusal. Manipulation of the metal rod along consolidated benthic material was completed to facilitate an interpretation of texture. Generally, interpretation of texture was limited to an identification of fines (e.g. hard packed clay) or obvious sands or gravels.

2.3 Water Level Monitoring

ENKON has sourced and deployed water level monitoring instrumentation (Solinst instrumentation) to assess the relative water level fluctuations and potential hydrologic linkages.

Three (3) Solinst model 3001 Levelogger Edge data loggers were purchased and deployed to support the feasibility assessments. One (1) barometric data logger, a Solinst Barologger Edge datalogger, was purchased and deployed to facilitate barometric compensation.

The Levelogger Edge measures absolute pressure (water pressure + atmospheric pressure) and has been deployed to measure water level in meters. The most accurate method of obtaining

changes in water level is to compensate for atmospheric pressure fluctuations using a Barologger Edge, avoiding time lag in the compensation.

The Barologger has been deployed onsite and secured to a mature conifer within the study area at an elevation well above the potential risk of flood inundation and at a location that mitigates the risk of vandalization. One Barologger is used to compensate Leveloggers deployed for the Reeve Slough project. All data loggers were set to sample continuously at 15 minute intervals.

Data logger deployment sites are located and named as summarized in Table 1.

Table 1 – Water Level Monitoring Instrumentation

Site ID	Description	UTM Easting	UTM Northing
Coquitlam River	Left bank of Coquitlam River at confluence of Poco-slough, downstream from historic dike culvert crossing	E 514847.13	N 5455329.31
Poco Slough	Left bank of PoCo slough – accessed from KFN cemetery access road	E 514906.73	N 5455361.03
Reeve Slough	Right bank of Reeve Slough. Accessed from west terminus of historic dike/road	E 514888.74	N 5454962.66
Barometric Compensation	Proximal to Reeve Slough levelogger site	E 514883.83	N 5454983.60

Figure 2 illustrates the location and naming convention for the Leveloggers.

Data acquisition has been completed via manual downloading of the data loggers utilizing specialized equipment provided by ENKON. ENKON has been deploying the use of a Solinst direct read to optical adapter paired with a Levelogger App Interface unit to facilitate blue-tooth data collection to smart device (Appendix A).

In future, data downloads and operations not completed by ENKON will require the acquisition of specialized cable connections or optical reading equipment available from Solinst. Acquisition of physical equipment to facilitate the long-term operation of the level loggers by DFO or the North Fraser Salmon Assistance Project Society will be required and were originally purchased through Hoskins Scientific (www.hoskins.ca). Equipment options include the use of direct read cables with field computers and Solinst software, or direct read to optical adapters paired with the Levelogger App Interface (and available App), or the DataGrabber products.

Pitt River Road

PoCo Slough

KFN Cemetery

Coquitlam River

Old Dike Road

Barometric logger mounted to large spruce tree

Existing Dike Road

Reeve Slough

N

0 25 50 100 150 200 Meters

Legend

- Level_Logger
- Slough Natural Boundary
- Access (Road Surface)
- Foot access route

Prepared by: ENKON Environmental Ltd.

Map Created: 2020-02-03
by: R. Preston
NAD 83, Zone 10N

Reeve Slough Level Logger Locations

Figure 2

Fisheries & Oceans Canada

2.4 Species at Risk

ENKON staff completed assessments for Species at Risk Act (SARA) wildlife species at Reeve Slough. The assessments included both desktop and field based assessments to assess wildlife habitat suitability with a focus on SARA species. A reconnaissance level review of terrestrial and aquatic vegetation communities was also conducted during Species at Risk assessments.

2.4.1 Desktop Review

The following online resources and literature were reviewed to facilitate the planning and identification of potential environmentally sensitive areas:

- BC Conservation Data Centre – CDC iMap 2019. URL: http://maps.gov.bc.ca/ess/sv/cdc/
- BC Ministry of Forests, Biogeoclimatic Zone and associated habitat information: http://www.for.gov.bc.ca/hre/becweb/index.html & imapBC (http://maps.gov.bc.ca/ess/sv/imapbc/);
- Federal Species at Risk Act (SARA) Public Registry Species List: http://www.speciesatrisk.gc.ca/default_e.cfm

The CDC database stores information on species of conservation concern within the vicinity of the study area. A review of publicly available mapping from the Province of BC's Conservation Data Centre (CDC) mapping service was conducted to assess species occurrences within approximately 2.5 km of the project area.

Appendix B includes the results of the CDC report based on the study area boundary. BC's Species and Ecosystem Explorer was used to generate a list of federally and provincially listed species that have the potential to occur within or near the study area. Suitable habitat requirements for species found from the analysis were considered in the field assessment.

A review of posted Critical Habitat polygons based on Environment and Climate Change Canada (ECCC) was also completed.

2.4.2 Wildlife Habitat Field Assessment

Encounter (foot) surveys and kayak based field assessments were conducted within the study area to assess for wildlife and habitat suitability. Potential wildlife was categorized into ecological and taxonomic groups (species groups) which have shared generalized habitat requirements. Species groups considered include land (raptors and passerines) and water birds (waterfowl and waders); small mammals, ungulates, large carnivores; herpetofauna and gastropods. Habitat values and suitability for each species groups based on the availability of their specific habitat requirements within Reeve Slough were considered in the field assessment. The wildlife field assessments also included consideration of the availability and suitability of the habitat requirements of wildlife and plant species of conservation concern that were found from CDC analysis and the Species and Ecosystem Explorer.

The field assessment included searches for nests as evidence of onsite breeding activity for raptors and passerine birds including woodpeckers and hummingbirds. Tree canopies were scoped to search for conspicuous breeding raptors such as Red-Tailed Hawk (*Buteo jamaicensis*) and Cooper's Hawk (*Accipeter cooperi*). Tree trunks were searched for the presence of large cavities that might provide nest sites for inconspicuous breeding raptors such as owls. Raptor activity signs in the form of faecal wash; prey remains, such as bones and plucked feathers; and regurgitated pellets were also searched. Non-raptorial bird use was evaluated by searching for and documenting old and recent nests and tree cavities used either for nesting or foraging, Attention was considered for birds' nests protected year-round by BC's *Wildlife Act* Section 34(b) during the surveys. Year-round nest protection and surrounding buffer vegetation is accorded for eagles, osprey, gyrfalcon, peregrine, burrowing owl and heron colonies.

Auditory and visual observations of all wildlife encountered during the field surveys were documented. Incidental wildlife observations of all commonly occurring wildlife, from large to small animals and signs of habitat use, were documented when encountered during the terrestrial, aquatic, and riparian surveys. Wildlife activity within the development site was described by documenting the presence of dens, burrows, browse, tree scratches, scat, tracks, and game trails.

Field notes were taken and supplemented by photographic documentation. A GPS track was recorded into a handheld GPS unit. No small mammal trapping surveys were conducted in support of the field assessment. Surveys focused on searching for available habitat that can provide cover from predators and thermal refuges such as coarse woody debris and low lying vegetation.

Suitable amphibian and reptile habitat that could provide breeding pools, thermal refuges and hibernacula were searched. Habitat features targeted were patches with dense layers of deciduous leaf litter, rotting stumps and nurse logs, ponds and rock piles that could provide potential hibernacula for herpetofauna. Gastropods share the same habitat requirements as amphibians with their need for moisture. Habitat that is suitable for amphibians would also be considered suitable gastropod habitat. Due to the overview nature of the project scope and associated budgetary and time constraints, formal surveys that follow recommended Resources Inventory Standards Committee (RISC) methodologies were not conducted.

2.5 Topographic Surveys

ENKON sub-contracted Target Land Surveying to complete a formal topographic survey of key control points determined to be relevant to future drainage modifications to achieve the fish habitat restoration objectives. Key control points included the topographic break-lines and natural boundaries associated with PoCo Slough, including both the historic dike crossing and associated culvert, and the KFN cemetery access roadway.

Downstream survey locations included the northwestern terminus of the slough, topographic break-lines and natural boundary conditions at Reeve Slough, the Coquitlam River, the anthropogenic ditch drainage, and identified high water discharge points associated with the seasonal drainage pathway through the floodplain habitat. The point of confluence from the confirmed seasonal flow path and the left bank of the Coquitlam River was also surveyed. Field surveys at the downstream controls included pickup of field delineations of ecological boundaries established by ENKON.

3.0 RESULTS AND DISCUSSION

3.1 Terrain & Hydrologic Analysis

A high resolution DEM was prepared to support terrain and hydrologic analysis. The DEM was analyzed and used to prepare derivative products to assess previously unmapped drainage connections or floodplain inundation areas under potential high water scenarios.

Flow direction and flow accumulation algorithms were employed to interpolate the preferential flow-path (e.g. drainage network) from the 0.5m DEM surface. The drainage network analysis yielded a drainage flow-path through the floodplain with connectivity to the Coquitlam Rivers left bank located approximately 400m from the slough boundary (Figure 3).

Flood inundations levels based on modeling completed by Kerr Wood Leidal for the City of Coquitlam was summarized in an email provided by KFN representatives and is understood to be estimated at 4.7m elevation at the downstream face of the Pitt River Road crossing. A simple analysis, notwithstanding the consideration of the longitudinal profile of the river and relative elevation of the Coquitlam River along the transect parallel to Reeve Slough suggests full floodplain inundation, inclusive of the full extent of Reeve Slough, under a 1:2 year (e.g. bankfull) flow event achieving 4.7m elevation.

3.1.1 Field Verification

Field transect surveys were conducted to assess the validity of the modeled flow path. Preliminary assessments confirmed the presence of a continuous topographic depression with evidence of inundation and rafted organics. However, a well-defined flow path under dry seasonal conditions was not conclusive.

Field surveys conducted following extreme rain events in early February 2020 confirmed significantly elevated water levels and a sustained flow path draining the slough along the approximate alignment of the modeled drainage pathway (Photographs 2 and 3). Contiguous surface flows demonstrate connectivity to the Coquitlam River mainstem. However, the location of the flow path confluence deviated slightly to the south from the modeled drainage pathway. The field-verified confluence was physically flagged to inform the location for future survey pickup.

The outflow channel assessment included three (3) channel cross section assessments to characterize the significance of the watercourse and are summarized in Table 2.

Table 2: Outflow Channel Measurements

Location	Wetted width (m)	Bankfull width (m)	Wetted depth (m)	Bankfull depth (m)
Station 1	2.67	3.17	0.21	0.31
Station 2	3.8	5.1	0.35	0.5
Station 3	2.26	2.77	0.24	0.31
Average	2.91	3.68	0.267	0.373

Photograph 2 – Upstream view of Reeve Slough drainage channel along approximate alignment of the LiDAR modeled flow path following Feb 2020 storm event.

Photograph 3 – Reeve Slough drainage channel nearing confluence with Coquitlam River left bank following Feb 2020 storm event.

Field assessments coinciding with the early February 2020 storm event confirmed direct evidence of floodplain inundation with a ubiquitous veneer of sand deposits on the immediate floodplain surfaces confirming the direct inundation of the northwestern areas of Reeve Slough (Photograph 4 & 5).

Photograph 4 - Veneer of sand deposited as a result of flood event in early February 2020 confirms overbank flooding and direct hydrologic connection between Coquitlam River and Reeve Slough.

Photograph 5 - Illustration of visible floodplain inundation at NW limit of Reeve Slough illustrating slough water level, floodplain sand veneer, and visible staining on Cedar stem indicating recent flood inundation. Note nominal beaver dam obstruction at edge.

A secondary drainage feature was originally identified as a potential drainage outlet. The identification of a discrete linear drainage feature is evident from terrain modeling results and was verified during dry weather field reconnaissance (Photograph 6). The linearity of the feature suggests a potential anthropogenic origin. Drainage function was confirmed during high water conditions (Photograph 7). However, the ditch feature is concluded to be insignificant in comparison to the main flow path mapped from the northwest terminus of the slough as discussed above. The ditch connection does not interface with the main open water boundary of the slough and drains a limited volume flow and would not afford potential fish access.

Photograph 6 – Upstream view of dry linear channel connecting Reeve Slough to Coquitlam River (July 2019)

Photograph 7 – Upstream view of nominal drainage function through recently deposited floodplain sand veneer following February peak flows.

Upstream connections have not been identified between PoCo Slough and Reeve Slough. Despite the apparent southern linear extension of PoCo slough, no visible subsurface connections have been identified during any of the field surveys. Anecdotal information and field observations; however, suggest periodic inundation of the KFN cemetery access road surface under high water conditions.

3.1.2 Topographic Survey

The results of field reconnaissance surveys informed the scope of formal BCLS survey pickup. The survey locations were defined by ENKON based on interpretation of key physical controls pertinent to future drainage modifications to benefit fish habitat enhancements (e.g. establishment of surface flow connectivity and establishment of fish access).

Four (4) discrete survey locations were identified as key physical controls to any future fish habitat enhancement opportunities. Field delineation of ecosystem boundaries was completed by ENKON to inform survey pickup. BCLS survey pickup included key topographic break-lines and natural boundary/high water mark conditions at the following locations:

1. Poco Slough culvert crossing of historic dike road
2. KFN Cemetery access road separating PoCo Slough and Reeve Slough
3. Northwest terminus of Reeve Slough at interface with left bank of Coquitlam River, including linear drainage ditch feature
4. Seasonal drainage channel confluence linking Reeve Slough outflow with Coquitlam River left bank.

The results of the BCLS survey have been provided as a PDF graphic (Appendix C) and a CAD dataset (.dwg format) to support future detailed design and feasibility studies. Datasets have been provided in a UTM Zone 10N, NAD83 projection in the horizontal plane for mapping purposes. All elevations are true ground level geodetic elevations that are not scaled.

Key physical variables that relevant to the potential establishment of flow connections and fish access to Reeve Slough include the following:

1. Outlet controls from PoCo Slough at the historic dike road crossing include a 1750mm culvert with invert set at between 0.99m and 1.04m elevation;
2. The invert of the rip-rap armoured overflow spillway at the historic dike road is 2.99m elevation;
3. ToB controls at the overflow spillway at the historic dike road is approximately 4.2m elevation;
4. The ToB control at the KFN cemetery road is approximately 3.89m elevation at the boundary with PoCo Slough;
5. The ToB control at the KFN cemetery road is approximately 3.6m elevation at the boundary with Reeve Slough;
6. The NW outlet controls at Reeve Slough area approximately 2.2m elevation;

7. The point of confluence between the seasonal flow path and Coquitlam River is approximately 1m elevation.

Copies of the survey datasets will be provided as project deliverables to DFO and the North Fraser Salmon Assistance Project Society.

Pitt River Road

Lougheed Highway

KFN Cemetery

Coquitlam River

Old Dike Road

Minor OUtflow Ditch

Verified Channel Confluence

0 25 50 100 150 200 Meters

N

Legend

- Side channel location
- Channel X-Section
- Verified Seasonal Channel
- Beaver dam
- Hydrologic Model - Flow path
- Slough Natural Boundary

Prepared by: ENKON Environmental Ltd.

Map Created: 2020-02-25
by: N. Lamarche
NAD 83, Zone 10N

Reeve Slough
Outflow Channel Mapping

Figure 3

Fisheries & Oceans Canada

3.2 Bathymetric Surveys

The instrumentation approach included the mounting of the transducer and GNSS data collector to a single-person kayak (Photograph 8). The transducer based bathymetric survey results provided poor spatial coverage of the wetland and no useable information with respect to a typical bathymetric map to understand the subsurface profile of Reeve Slough. The significant variability of the bed of the slough coupled with the manufacturers requirement for a minimum 0.4 m depth of insertion for the SonarMite transducer, coupled with the significant density of aquatic weeds (Photograph 9) precluded assessment of all but the central portion of the slough (Figure 4).

Photograph 8 – Bathymetric survey transducer and GNSS equipment mounted to a kayak at Reeve Slough

Photograph 9 - Illustration of typical transducer fouling resulting from extensive aquatic weed presence within Reeve Slough.

Results of the bathymetric instrumentation was the interpretation of maximum slough depth which was recorded as 1.92m with an average of 0.7m for the accessible areas of the slough. The spatial coverage limitations and frequency of nul results due to fouling precluded any possibility of the development of bathymetric mapping. Any future detailed bathymetry requirements should be pursued only under winter high water conditions. Even then, the expectation of detailed bathymetric datasets should be tempered to due the prevalence of obstructions, aquatic weed fouling, and relatively shallow depths.

3.2.1 Manual Assessment

The manual 'low-tech' bathymetric analysis yielded increased spatial coverage due to the removal of the transducer set at 0.4 m below water surface. Increased access by kayak facilitated the sampling of a larger surface area during the assessment completed October 2, 2019. A total of 69 stations were sampled throughout Reeve Slough (Figure 3). The depth to benthic surface material ranged from 0.4 to 2.1 m with an average slough depth of 1.28 m (Table 2).

3.2.2 Depth of Substrate

In association with the manual bathymetric assessment the approximate depth of unconsolidated substrate was assessed. The depth of the unconsolidated benthic mud ranged from 0.02m to 1.88m with an average mud depth of 0.77m. Two locations (RS37 and RS53) had depths to the benthic material over 3 m, so the depth of unconsolidated benthic materials could not be determined based on the sampling methodology and equipment limitations.

The analysis included a qualitative interpretation of the underlying substrate (e.g. mineral materials below organic substrate). Some areas resulted in clear evidence of a coarse sand or gravel substrate which may suggest presence of historic alluvium and potential for enhancement of groundwater or hyporheic zone interactions.

Table 3 summarizes the depth of substrate and the relative characterization of underlying materials.

Table 3 – Manual bathymetric and substrate assessment

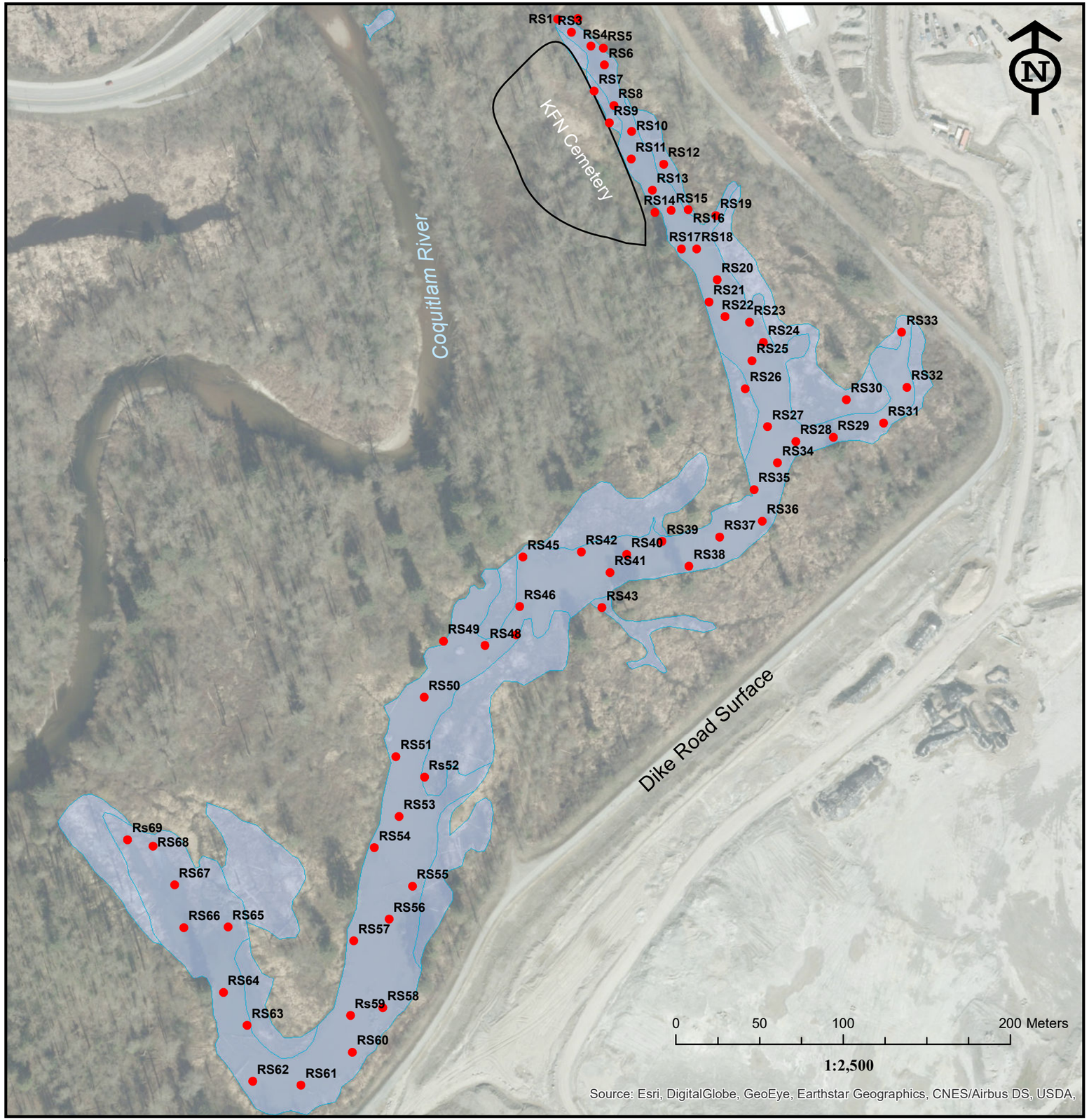
Station	**D1** (m)	**D2** (m)	**Mud Depth** (m)	**Substrate Interpretation**
RS1	0.9	1.4	0.5	hard packed clay
RS2	0.42	0.9	0.48	hard packed clay
RS3	0.88	1.2	0.32	hard packed clay
RS4	1.26	2.1	0.84	hard packed clay
RS5	0.76	1.52	0.76	hard packed clay
RS6	0.8	1.76	0.96	hard packed clay
RS7	0.44	1.6	1.16	hard packed clay
RS8	1.04	1.6	0.56	gravel/coarse sand
RS9	0.8	1.22	0.42	hard packed clay, some sand
RS10	1.02	1.76	0.74	hard packed clay
RS11	1.36	2.08	0.72	hard packed clay
RS12	0.94	1.6	0.66	hard packed clay

Station	D1 (m)	D2 (m)	Mud Depth (m)	Substrate Interpretation
RS13	1.8	2.24	0.44	gravel/coarse sand
RS14	1.06	2.02	0.96	hard packed clay
RS15	1.2	2.1	0.9	gravel/coarse sand
RS16	0.74	1.78	1.04	hard packed clay, some sand
RS17	1.3	2.06	0.76	hard packed clay
RS18	1.52	1.9	0.38	hard packed clay
RS19	0.82	1.5	0.68	hard packed clay
RS20	1.52	2.2	0.68	hard packed clay
RS21	1.56	2.14	0.58	hard packed clay
RS22	1.66	2.28	0.62	coarse sand
RS23	0.82	1.86	1.04	hard packed clay
RS24	0.66	1.86	1.2	hard packed clay, some sand
RS25	1.78	2.52	0.74	hard packed clay
RS26	1.3	1.94	0.64	hard packed clay
RS27	2.1	2.8	0.7	hard packed clay, some sand
RS28	1.74	2.4	0.66	hard packed clay, some sand
RS29	1.34	2.86	1.52	hard packed clay, some sand
RS30	0.66	1.34	0.68	hard packed clay
RS31	1.56	1.74	0.18	hard packed clay, some sand
RS32	0.96	1.64	0.68	hard packed clay
RS33	1	1.86	0.86	hard packed clay, some sand
RS34	1.22	2.9	1.68	Cobble
RS35	1.94	2.8	0.86	hard packed clay
RS36	1.7	2.64	0.94	hard packed clay
RS37	2.06	>3	N/A	N/A
RS38	1.7	2.96	1.26	hard packed clay

Station	D1 (m)	D2 (m)	Mud Depth (m)	Substrate Interpretation
RS39	1.28	2.14	0.86	hard packed clay
RS40	1.82	2.74	0.92	hard packed clay
RS41	1.82	2.74	0.92	hard packed clay
RS42	1.36	2.26	0.9	hard packed clay
RS43	1.42	1.86	0.44	hard packed clay
RS44	1.24	1.4	0.16	gravel/coarse sand
RS45	1.28	1.3	0.02	Gravel
RS46	1.2	1.9	0.7	gravel/coarse sand
RS47	1.12	1.6	0.48	coarse sand
RS48	1.24	2.2	0.96	hard packed clay
RS49	1.26	2.36	1.1	hard packed clay
RS50	2.1	2.94	0.84	hard packed clay
RS51	1.74	2.32	0.58	hard packed clay
RS52	1.1	1.92	0.82	hard packed clay
RS53	1.72	>3	N/A	N/A
RS54	0.82	1.98	1.16	hard packed clay
RS55	1.2	1.36	0.16	gravel/coarse sand
RS56	1.48	2.4	0.92	hard packed clay
RS57	1.4	2.04	0.64	hard packed clay
RS58	1.44	2.16	0.72	hard packed clay
RS59	1.7	2.32	0.62	hard packed clay
RS60	1.46	2.36	0.9	hard packed clay
RS61	1.54	2.46	0.92	hard packed clay
RS62	1.72	2.82	1.1	hard packed clay
RS63	1.48	2.4	0.92	hard packed clay
RS64	1.2	1.8	0.6	hard packed clay

Station	**D1** (m)	**D2** (m)	**Mud Depth** (m)	**Substrate Interpretation**
RS65	1.1	2.98	1.88	hard packed clay
RS66	1.02	1.54	0.52	hard packed clay, some sand
RS67	1.16	1.76	0.6	hard packed clay
RS68	0.8	1.4	0.6	hard packed clay
RS69	0.86	1.96	1.1	hard packed clay

Station	Mud Depth (m)	Station (Cont.)	Mud Depth (m) (Cont.)
RS1	0.50	RS35	0.86
RS2	0.48	RS36	0.94
RS3	0.32	RS37	>1
RS4	0.84	RS38	1.26
RS5	0.76	RS39	0.86
RS6	0.96	RS40	0.92
RS7	1.16	RS41	0.92
RS8	0.56	RS42	0.90
RS9	0.42	RS43	0.44
RS10	0.74	RS44	0.16
RS11	0.72	RS45	0.02
RS12	0.66	RS46	0.70
RS13	0.44	RS47	0.48
RS14	0.96	RS48	0.96
RS15	0.90	RS49	1.10
RS16	1.04	RS50	0.84
RS17	0.76	RS51	0.58
RS18	0.38	RS52	0.82
RS19	0.68	RS53	>1
RS20	0.68	RS54	1.16
RS21	0.58	RS55	0.16
RS22	0.62	RS56	0.92
RS23	1.04	RS57	0.64
RS24	1.20	RS58	0.72
RS25	0.74	RS59	0.62
RS26	0.64	RS60	0.90
RS27	0.70	RS61	0.92
RS28	0.66	RS62	1.10
RS29	1.52	RS63	0.92
RS30	0.68	RS64	0.60
RS31	0.18	RS65	1.88
RS32	0.68	RS66	0.52
RS33	0.86	RS67	0.60
RS34	1.68	RS68	0.60
RS35	0.86	RS69	1.10



Reeve Slough Water Depth & Substrate Depth Assessment

Fisheries & Oceans Canada

Legend

- Depth Station
- Cemetery
- Slough HWM
- Slough Natural Boundary

Figure 4

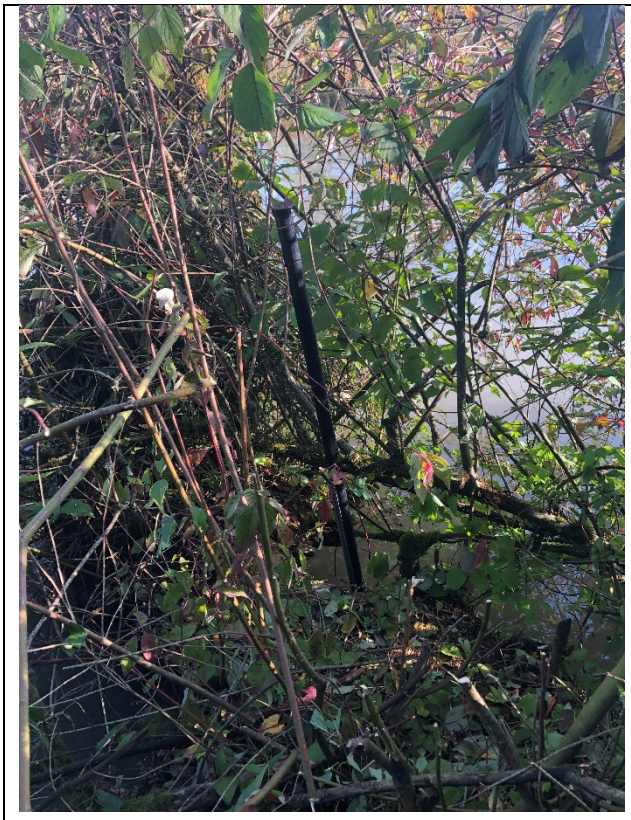
Map Created: N. LaMarche
February 2020
Projection: NAD 83, UTM Zone 10

Prepared by:
ENKON
Environmental Ltd.

3.3 Water Level Monitoring

Water level monitoring instrumentation was purchased and installed to support the feasibility assessments and longer term project monitoring. The initial installation of the Solinst Leveloggers and a barometric compensation unit have been deployed within the slough and the surrounding waterbodies to facilitate the interpretation of the relative water level fluctuations and potential hydrologic linkages between Reeve Slough, the Coquitlam River, and the PoCo Slough – notably in response to the variable hydrologic dynamics related to the operation of the Reeve Park pump station.

The Leveloggers and barometric compensation units were deployed at locations illustrated in Figure 2 and summarized in Table 1 above. The instrumentation was installed September 19, 2019 (Photographs 10 & 11).



Photograph 10 – PVC deployment for Levelogger at Reeve Slough.

Photograph 11 – Barometric datalogger deployment installed above limits of potential floodplain inundation.

Two (2) dataset downloads have been completed to facilitate the initial analysis of water level data. The initial download was completed February 3, 2020 and revealed a significant data anomaly attributed to fouling of the barometric compensation deployment. Two discrete spikes in barometric pressure were noted in the raw data analysis and were manually removed from the dataset as anomalies (Figure 5).

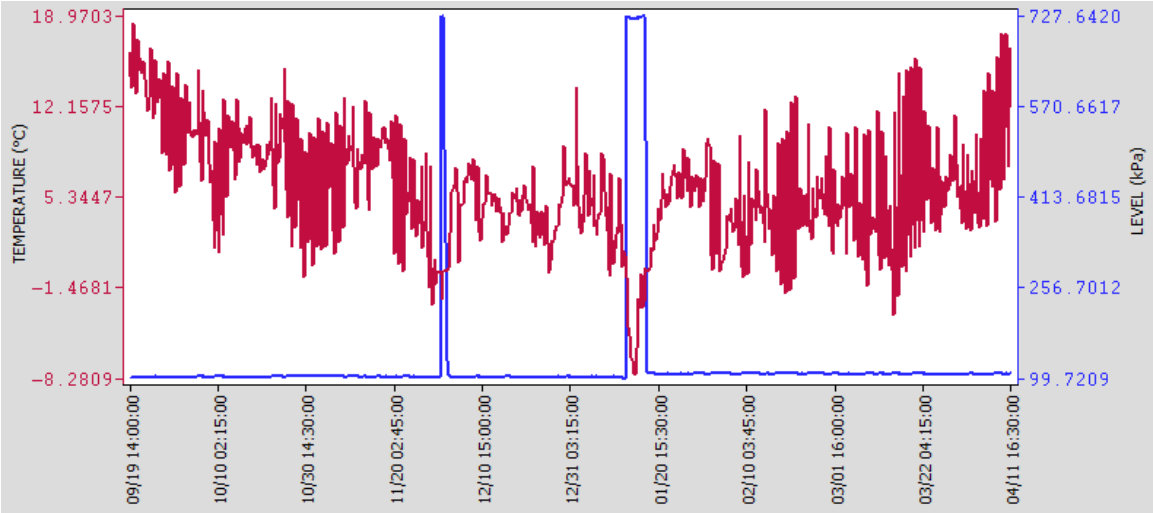


Figure 5 – Reeve Slough Barometric Compensation Unit Raw Data

Notwithstanding the removal of obvious anomalies from the barometric dataset, the transition to the second deployment yields a notable discontinuity from approximately January 12 to 18, 2020. Subsequent barometric readings have been systematically higher. The reason for the spike is uncertain; however, modifications to the barometric logger housing were modified to provide increased drainage ports and transmissivity in an effort to avoid future variability.

The resulting discrepancy in the apparent pressure band applicable to the pre January 12 period and post January 21 require interpretation of the water level datasets as discrete time periods.

Figure 6 illustrates the modified and consolidated barometric dataset illustrates the relative discontinuity of approximately 8KPa. As the intent of the initial water level monitoring was to establish relative water level fluctuations and potential linkages between Reeve Slough and offsite water sources, the dataset challenges are considered insignificant.

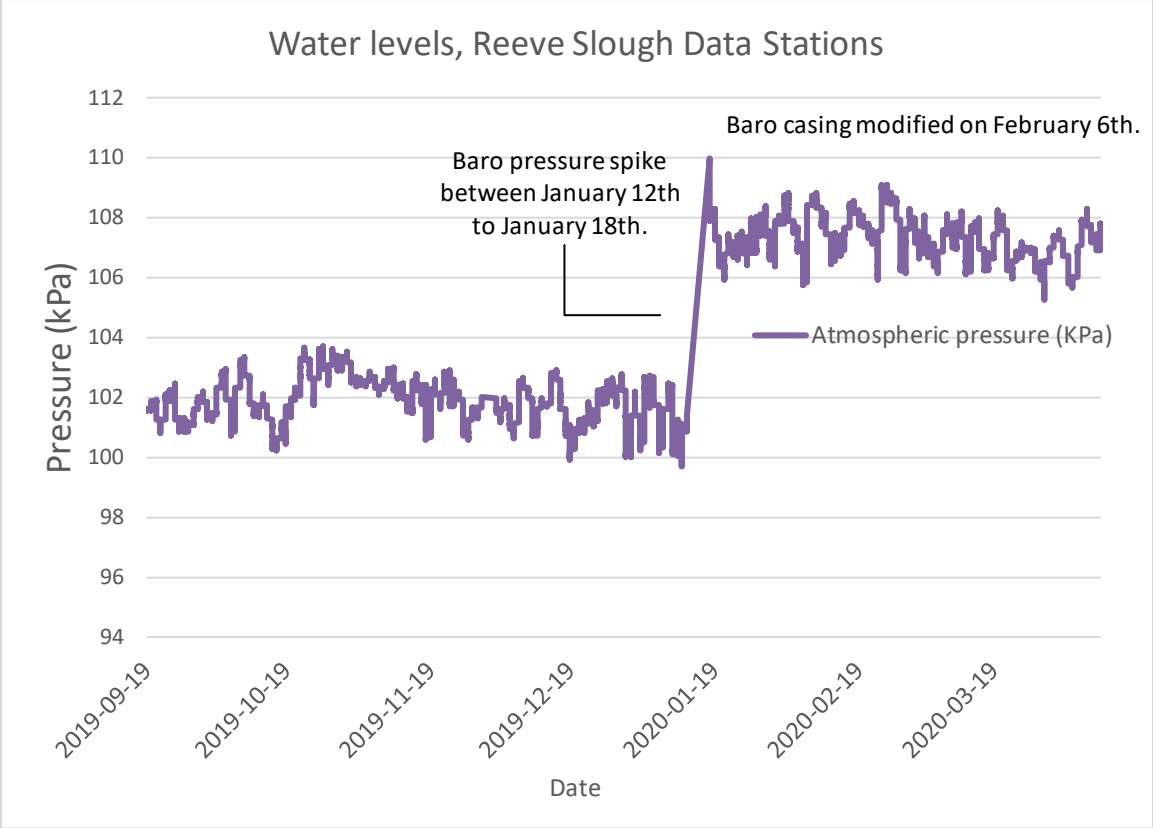


Figure 6 – Consolidated barometric compensation dataset

Figures 7 and 8 illustrate the combined water level monitoring datasets to facilitate the relative comparisons between the Leveloggers for the periods prior to January 13 and following the January 21 period, respectively.

Both the Coquitlam River and PoCo Slough Leveloggers recorded a curious and coincident drop in water levels on or around February 5th, 2020. A review of the Water Survey of Canada dataset for the Coquitlam River at Port Coquitlam station, located upstream at Kingsway Avenue (Station ID 08MH002) corroborates the drop. The relative water level drop is assumed to reflect a change in discharge to the Coquitlam River associated with the BC Hydro dam.

3.3.1 Levelogger Redeployment

The Leveloggers and barometric compensation unit remain in operation. The parameters are set such that the data loggers will ultimately over-write the original data. Data collection remains set at 15 minute intervals and may be adjusted to reduce the frequency of data collection and extend the data collection period between data retrieval events.

Future data retrieval will require the ongoing engagement of ENKON to utilize existing data acquisition equipment or purchase of the equipment by the project proponents.

Recent field data collection has highlighted that under low water conditions the Coquitlam River and Poco Slough Leveloggers are exposed above the low-water line (Photographs 12 & 13). While the PoCo Slough Levelogger exposed as a result of the culvert maintenance at the old dyke, the exposure of the Coquitlam River site suggests that the fluctuating water levels in the river and low tide conditions may regularly expose the equipment.

Relocation of the Coquitlam River Levelogger is recommended. Assuming that the culvert remains cleared, water level fluctuations in the Coquitlam River will backwater the PoCo Slough and provide a reasonable characterization of the potential water source for the purposes of the Reeve Slough enhancement project.

Relocation of the PoCo Slough will be required based on the negligible flows observed at the left bank of the slough following the culvert maintenance by City of Port Coquitlam operations staff (Photograph 14). A significant change in water levels appears to have occurred following the February 5, 2020 event. As a result the left slough Levelogger deployment is elevated above the PoCo slough low-flow channel and will only register water levels under high flow events and potentially high tide conditions.

Photograph 12 – Illustration of observed April 2020 conditions at Coquitlam River Levelogger deployment illustrating equipment above low water level.

Photograph 13 – Illustration of PoCo Slough Levelogger conditions following Coquitlam River flow reduction and dyke culvert maintenance.

Photograph 14 - Upstream view of PoCo Slough illustrating channel thalweg vs. left bank conditions at location of Levelogger deployment – arrow indicates original deployment site under prior inundation conditions.

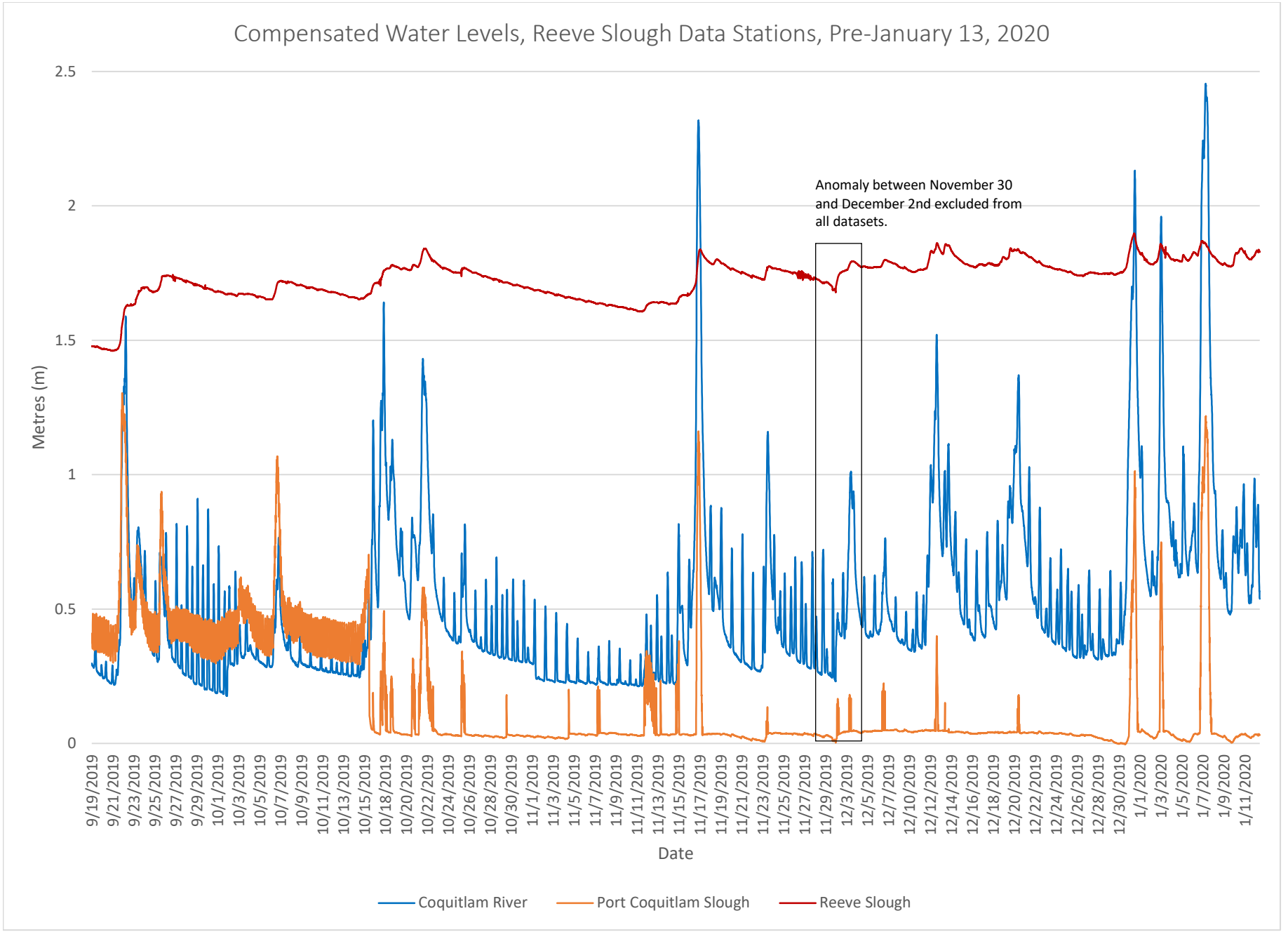


Figure 7 - Combined Water Level Results - Pre Jan 13 Baro Correction

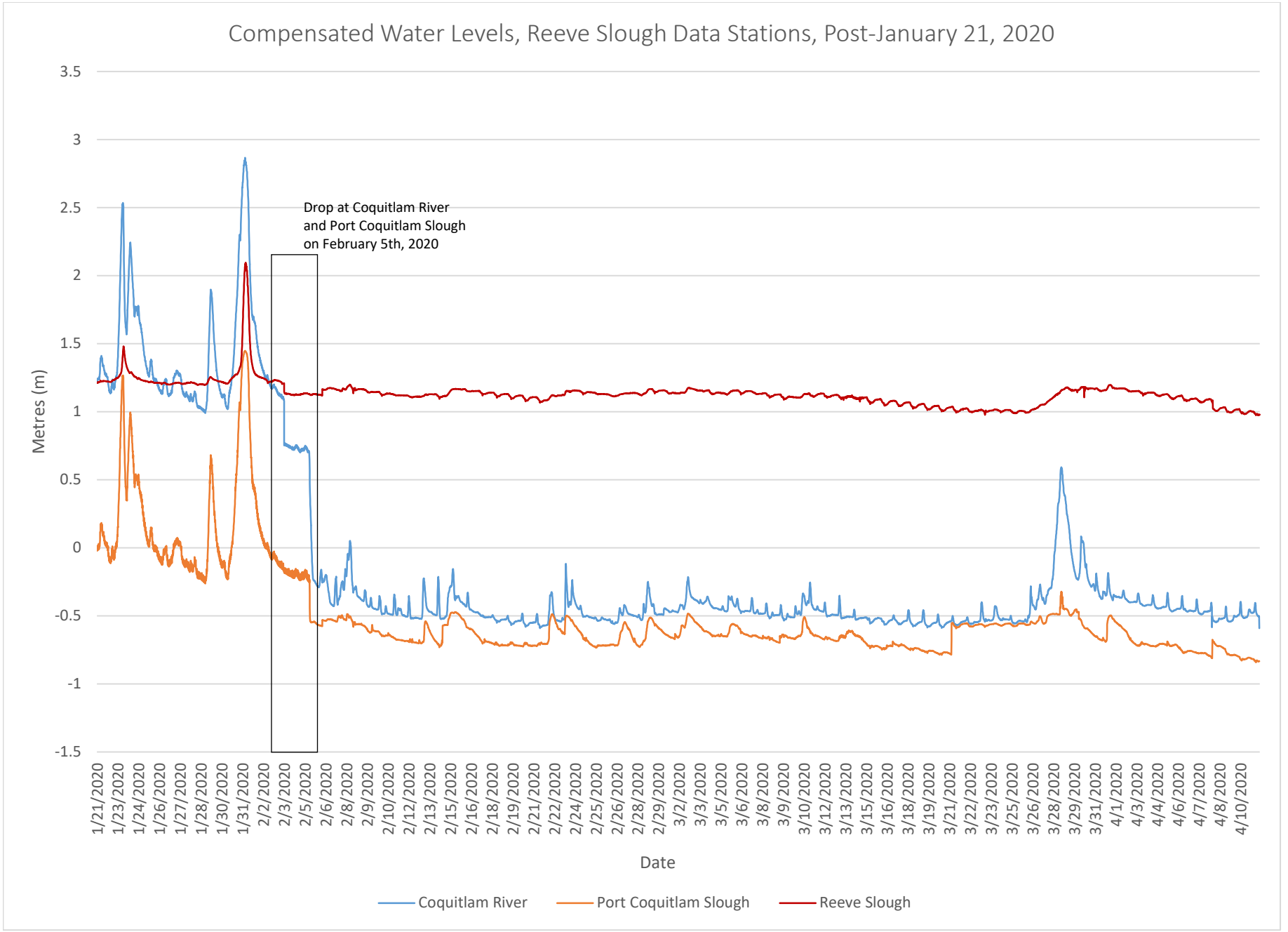


Figure 8 - Combined Water Level Results - Post January 21 Baro Correction

3.4 Species at Risk Assessment

Wildlife field assessments were conducted on September 18th, 23rd and October 2nd, 2019. Water smartweed (*Polygonum amphibium*) was a common aquatic plant observed throughout the slough. Where the water is visibly clear it is indicative of suitable pond-breeding amphibian habitat. Northern Red-Legged Frog and the non-natives Green Frog and American Bullfrog are all pond-breeders. These amphibians would be preyed upon by the Great Blue and Green Heron which were frequently observed in Reeve Slough.

Wildlife trees were present across the wetland. They provide nesting habitat for birds and lookout points for insectivorous and piscivorous birds. Wildlife trees were also present in the forest to provide nest sites for cavity-nesting birds, squirrels and bat roost sites. CWD is available in the forest to provide cover for rodents and other small animals.

Birds are known to use Reeve Slough for breeding habitat. Inactive nests were observed in the forest and along the edge of the slough. A Bald Eagle's nest in a cottonwood was observed in the forest (Photograph 15) (See Figure 1). Its proximity to Coquitlam River and the slough is ideal given the availability of fish, waterfowl, herons and beavers as prey. Its presence may have deterred Great Blue Herons from selecting Reeve Slough as a potential breeding colony; otherwise the forest habitat and prevalence of large cottonwood trees at Reeve Slough would provide an ideal location for a heron colony if it were not for the eagles' nest.

Photograph 15 - Bald eagle nest located within floodplain habitat between Reeve Slough and left bank of Coquitlam River.

Reeve Slough is large enough to host the five (5) beaver lodges observed during field surveys. The slough itself and associated wetland and floodplain habitats provide high suitability as Pacific Water Shrew (*Sorex bendirii*) habitat. The full extent of the study area is within a designated Critical Habitat polygon for Western painted turtle (*Chrysemys picta*). The presence of sandy and granular materials underlying local soils provides potentially suitable nesting substrate for Western painted turtle; however, no observations of turtles were documented during the formal wildlife surveys or any other of the field assessments.

There were areas where the water turbidity was very high. This was most apparent at the south end of the slough's east tributary and culvert connection with offsite earthworks and grading activities beyond the dyke. Turbid water is known to impact fish, but it would also impact aquatic amphibians and can also affect the hunting success of fish-eating birds which rely primarily on vision.

3.4.1 Incidental Wildlife Observations

Incidental wildlife observations recorded during the reconnaissance level field assessment are summarized in Table 4.

Table 4 - Incidental Wildlife Observations

Common Name	Scientific Name	Observation
Birds		
Pied-Billed Grebe	*Podilymbus podiceps*	Visual
Green Heron	*Butorides virescens*	Visual
Great Blue Heron	*Ardea herodias*	Visual
Red-Tailed Hawk	*Buteo jamaicensis*	Visual
Canada Goose	*Branta canadensis*	Visual
American Widgeon	*Mareca americana*	Visual
Mallard	*Anas platyrhyncos*	Visual
Wood Duck	*Aix sponsa*	Visual
Belted Kingfisher	*Megaceryle alcyon*	Visual
Northern Flicker	*Colaptes auratus*	Visual/Auditory
Anna's Hummingbird	*Calypte anna*	Auditory
Northwestern Crow	*Corvus caurinus*	Visual
Steller's Jay	*Cyanocitta stelleri*	Auditory
Black-Capped Chickadee	*Poecile atricapillus*	Auditory
American Robin	*Turdus migratorius*	Auditory

Common Name	Scientific Name	Observation
Song Sparrow	*Melospiza melodies*	Visual/Auditory
White-Crowned Sparrow	*Zonotrichia leucophrys*	Visual
Spotted Towhee	*Pipilo maculatus*	Visual/Auditory
Dark-Eyed Junco	*Junco hyemalis*	Visual
Mammals		
Coast Mole	*Scapanus orarius*	Mounds
Beaver	*Castor canadensis*	Lodges/ Chewed timbers
Douglas Squirrel	*Tamiasciurus douglassi*	Visual/Auditory
Gray Squirrel	*Sciurus carolinensis*	Visual
Coyote	*Canis latrans*	Scat
Black Bear	*Ursus americanus*	Scat
Gastropods		
Banana Slug	*Ariolimax columbianus*	Visual
Pacific Sideband	*Monodenia fidelis*	Visual

3.4.2 Vegetation Community Assessment

The study area is located within the Coastal Western Hemlock, dry maritime biogeoclimatic zone. The site series would generally be classified as a CWHdm/05 – Western Red Cedar-Sword Fern ecosystem. However, the immediate study area is characterized as floodplain habitat. Based on evidence of sand lenses within the immediate banks at the Coquitlam River and prevalence of red-osier dogwood (*Cornus stolonifera*), the site is interpreted as transitional between a middle and high bench floodplain system (CWHdm/09 and CWHdm/08, respectively).

Reeve Slough is characterized as a shallow open water and marsh wetland ecosystem complex. Characteristic wetland vegetation includes native willow (*Salix spp*), hardhack (*Spiraea douglasii*), common cattail (*Typha latifolia*), rushes (*Juncus spp*.), and sedges (*Carex spp*). Invasive reed canarygrass (*Phalaris arundinaceae*) and yellow flag-iris (*Iris pseudacorus*) along with an abundance of aquatic weeds are also present within the littoral and open water habitats.

The area west of the slough is characterized as a deciduous forest, dominated by black cottonwood (*Populus balsamifera*). Red alder (*Alnus rubra*), paper birch (*Betula papyrifera*), and bigleaf maple (*Acer macrophyllum*) are also present throughout. Infrequent occurrences of coniferous species include Sitka Spruce (*Picea sitchensis*), western redcedar (*Thuja plicata*) and western hemlock (*Tsuga heterophylla*). The shrub community is well developed and includes

species like red-osier dogwood, red elderberry (*Sambucus racemosa*), salmonberry (*Rubus spectabilis*), vine maple (*Acer circinatum*), beaked hazelnut (*Corylus cornuta*) and Hardhack.

Himalayan Blackberry (*Rubus armeniacus*) was prevalent in the edge of the forest along the slough's western perimeter along with Japanese knotweed (*Fallopia japonica*) in association with the historic ditch outlet channel.

3.4.3 Wildlife Habitat Evaluation

Reeve Slough provides high wildlife habitat value to many species groups. The aquatic and wetland ecosystems provide habitat for aquatic invertebrates, fish and amphibians. It supports herons, ducks and eagles. The riparian vegetation and floodplain forest habitats provide habitat for deer, bears, coyote and other large wildlife.

The Reeve Slough site is concluded to provide high suitability as Pacific Water Shrew habitat. Furthermore, the site is associated with Western painted turtle critical habitat as an important migration corridor and potential nesting habitat.

Beavers are resident in the slough; therefore, any contemplated changes to the inflow and outflow connections to the slough in the interests of fish access and hydrologic modifications will require significant monitoring and maintenance efforts to prevent obstructions due to beaver activity. Trapping and removal of beavers is not recommended and would likely be unsuccessful.

The slough provides suitable breeding habitat for Red-legged frog. Enhancement efforts for the purposes of fish habitat may negatively affect habitat values for amphibians due to increased predation of tadpoles. However, other wildlife including otters, herons and Bald Eagles can be expected to benefit from fish habitat enhancements and the presence of salmonids

Numerous bird species are confirmed to use Reeve Slough as breeding habitat. Any future habitat enhancement works needing vegetation removals will require explicit consideration of the potential presence of wildlife species, notably breeding birds (passerines, raptors and waterfowl) to ensure compliance with Section 34(a) and (b) of the *Wildlife Act* and the federal *Migratory Bird Conventions Act*.

Reeve Slough is located in Nesting Zone A1. Figure 9 illustrates the relative percentage of bird species nesting in Zone A1's forested habitats with increases from mid-March and then declining numbers towards mid-August.

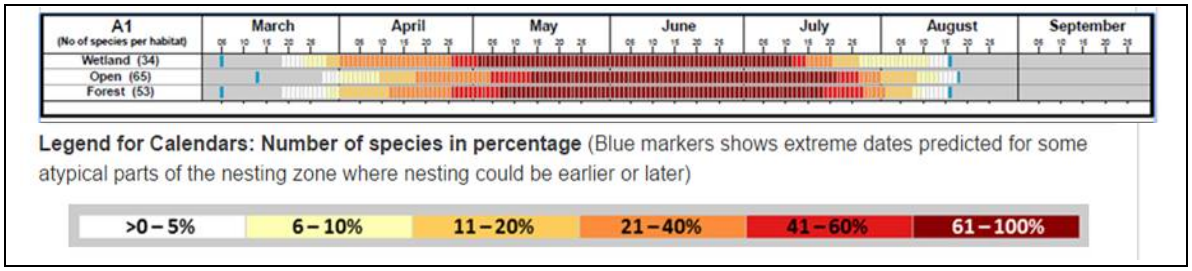


Figure 9: Calendar for Nesting Zone A1.

The presence of a Bald Eagle nest at Reeve Slough will require the development of an eagle nest management plan that considers vegetation management zones and breeding season noise buffers. Future assessments are recommended to confirm the status of the nest to determine if the nest is active or an alternate or abandoned nest site. Habitat enhancement activity and particularly the operation of machinery including power saws will require regular monitoring to ensure the eagle nest is not abandoned while it is active.

Turbid water quality in the slough appears is attributed to both offsite anthropogenic activity and biological activity. Significant sediment plumes adversely affecting water quality within the slough are confirmed to be directly related to earthworks and grading occurring to the east of the dike. Culvert drainage connections to the slough remain functional. Mitigation measures and implementation of offsite erosion and sediment control plans will be important to mitigate the risk of adverse water quality impacts affecting fish habitat values, amphibian habitat values, and more broadly the influence on hunting success of fish-eating birds which rely primarily on vision to catch fish.

Regarding species of conservation concern identified in the immediate area through CDC analysis and Species and Ecosystem explorer, Great Blue Heron is confirmed to utilize Reeve Slough. Oregon Forestsnail would be least impacted in association with potential fish habitat enhancements and access improvements, because dense Stinging Nettle growth was not detected along the banks of the slough's outflow path. Pacific Water Shrew habitat is present at both the seasonal flow path and ditch drainages from the slough, in addition to the entirety of the slough itself.

An observation of lupine species located at the historic dike road surface at the slough boundary will require further assessment and evaluation. The substrate at the old road alignment characterized as a coarse sand and is considered suitable as potential habitat for the red-listed Streambank Lupine.

There are other species that have the potential to occur in Reeve Slough based on past project experience in the City of Coquitlam and found from a list generated by the BC Species and Ecosystem Explorer. Species confirmed to be present or highly likely to be present as full-time or seasonal residents of Reeve Slough project area due to close proximity to confirmed observations in Colony Farm Regional Park include the following:

- American Bittern,
- Band-Tailed Pigeon,
- Barn Swallow,
- Pacific Sideband,
- Purple Martin and
- Northern Red-Legged Frog.

Species that have the potential to occur in Reeve Slough based on suitable habitat availability include the following:

- Pacific Watershrew,
- Olive-Sided Flycatcher Western Toad,
- Trowbridge's Shrew,
- Western Painted Turtle,
- Western Screech-Owl.

Species that may benefit from habitat enhancement efforts through the installation of nest and roost boxes include Barn Owl and Townsend's Big-Eared Bat. Habitat enhancement at Reeve Slough can provide the opportunity to establish additional breeding populations for these species of special conservation concern.

4.0 SUMMARY & RECOMMENDATIONS

4.1 Slough Outflow Considerations

The results of the preliminary feasibility assessments have confirmed the lack of a direct or sustained surface water connection between offsite water supplies and Reeve Slough; however, the LiDAR based hydrologic model and field assessments have confirmed the periodic flood inundation of the Slough. Overbank flood inundation appears to connect the northwest limit of the slough with the Coquitlam River and activate a previously unmapped seasonal channel connection.

Summer assessments suggest that the outlet drainage channel is inactive with the exception of high flow events, and potentially only under conditions of floodplain inundation during high flow events within the Coquitlam River. Further long-term assessment and monitoring of the periodicity of the outlet channel is recommended. Relocation of the Coquitlam River Levelogger to the outlet channel is recommended as the datasets and field conditions suggest that the PoCo slough logger reflects a direct hydrologic condition and backwater effect due to the lack of a flap-gate on the historic dyke culvert crossing.

Despite the apparent significance of the outlet channel under high water events, the potential for this drainage connection to facilitate upstream fish access is likely limited. Further evaluation recommended to establish the hydrologic periodicity of the confirmed seasonal outlet flow path. Fish sampling within the seasonal channel is recommended to establish existing fish usage.

Clarification of the project objectives to provide off-channel rearing habitat values for wild vs. hatchery Chinook will be required by DFO. It is assumed that stocking of Reeve Slough with juvenile hatchery stock Chinook would limit the significance of the periodicity of the natural outlet channel and that possible drainage modifications to the Coquitlam River via a constructed spillway may better facilitate the out-migration of smolts from the slough.

Options to connect Reeve Slough with River for outmigration and drainage functions will require the aforementioned evaluation of periodicity and fish usage of the natural flow path or the benefits of an alternative flow pathway. The close proximity of the terminus of the open water portion of the slough to the left bank of the Coquitlam River suggests that a relatively short channel or spillway may be possible; however, considerations of a constructed spillway would require explicit considerations of the risks posed by beaver activity and challenges related to construction phase access and long-term maintenance and monitoring. Notwithstanding the access, operations, and maintenance challenges, a potential steep gradient spillway from the northern terminus of the slough directly north to the Coquitlam River would be possible.

Analysis of the topographic survey datasets and interpretations of High Water Mark/Natural Boundary suggests a direct connection to the Coquitlam River would yield channel gradients between 7% and 14% depending on location. Gradients providing connection to low water conditions would yield steeper channel gradients and challenges with the maintenance of stable base-level controls.

An alternate drainage connection may be considered parallel to the toe of dyke where physical construction, monitoring, and operational requirements would not face prohibitive access constraints, and the scale of potential construction phase and access impacts would be reduced.

Field assessments suggest that portions of the floodplain along the toe of dyke may already be inundated under high water conditions and or function as vernal ponds and that relatively limited earthworks and channelization may be required to establish a more formal defined channel for the purposes of controlled drainage and fish out-migration. Further detailed survey of the areas along the toe of dyke between the Reeve Slough natural boundary and Coquitlam River is recommended to evaluate the viability of this potential alternate drainage outlet. Preliminary analysis of LiDAR based contour and terrain modeling suggests a nominal height of land is present that would not be prohibitive to overcoming; however, diversion of naturally occurring seasonal drainage channels and flow-pathways would not be desirable.

4.2 Slough Inflow Considerations

Further study is recommended to evaluate the viability of establishing a formal streamflow connection into Reeve Slough. The land-bridge resulting from the road access to the KFN Cemetery includes a discrete side channel area that suggests the location of a historic connection; however, field investigations revealed no evidence of any drainage connectivity. The installation of a simple culvert connection with beaver management measures may provide a significant and relatively persistent baseflow contribution to benefit water quality and connectivity through Reeve Slough.

The establishment of a formal drainage connection into the slough; however, would require the explicit consideration of the risks posed by beaver and potential impoundments exacerbating drainage and flood concerns related to the cemetery. Establishment of a formal drainage outlet that is subject to regular inspection and maintenance to yield a consistent slough base-level control (e.g. outlet rim elevation) would yield no significant increase of risks to the inundation of the slough or surrounding floodplain habitats from the conveyance of sustained flows from the Reeve Park pump station discharges as a water source establishing formal streamflow connectivity – link baseflows and flushing flows through Reeve Slough to increase existing aquatic habitat values of Reeve Slough. Establishment of a drainage connection into Reeve Slough is anticipated to yield very little difference to conditions observed through the majority of the study period wherein the existing culvert and flap gate at the historic dyke crossing was largely blocked by beaver activity. The maintenance of the existing culvert and spillway as a redundancy for extreme flows with prioritization of baseflows conveyed to Reeve Slough could be easily accomplished with a simple constructed weir upstream from the existing 1750mm culvert inlet to surcharge the PoCo slough to levels similar to those observed prior to the beaver dam removals.

Further detailed survey of the Poco Slough inverts and Reeve Slough inverts under low water conditions is recommended to inform detailed design of a potential formalized drainage connection and consideration of beaver management techniques (e.g. long-length 'beaver deceiver' devices).

Figure 9 illustrates the location and general drainage considerations recommended for further evaluation in support of establishing a water supply to Reeve Slough

4.3 Water Quality

The scope of feasibility assessments did not include assessment of water quality variables; however, it is understood that some level of biophysical assessments and water quality monitoring may have been completed by BCIT student projects. Clarification of water quality evaluations, particularly with respect to summer temperature and dissolved oxygen (DO) levels will be required by DFO. In the absence of information, longer term monitoring of seasonal DO variability is recommended. Temperature data for the single Reeve Slough Levelogger is available from September 2019 and illustrate a maximum and minimum of 17.8°C and 5.4°C, respectively over the initial monitoring period. Additional temperature monitoring providing a more representative spatial distribution through the slough to evaluate temperature (and DO) variability is recommended to evaluate against lethal temperature ranges for Chinook summarized in Bjorn & Reisser[1] (1991) (lower lethal: 0.8°C; upper lethal: 26°C; preferred range: 12-14°C).

Significant water quality impacts attributed to offsite construction and earthworks have been observed during multiple site assessments. The source of turbidity has been confirmed as a culvert connection across the current dyke and drainage connections to the adjacent fill site behind the dike. Mitigation of sediment erosion and sediment control risks will be increasingly important prior to the establishment of juvenile fish stocking efforts and more formalized and consistent drainage connections to the Coquitlam River.

4.4 Beaver Management

The projects most significant constraints to the establishment of both a fish accessible downstream connection between the Coquitlam River and Reeve Slough, or the upstream water supply to the slough, will be the prevalence of beaver activity. Restoration recommendations will need to consider ongoing maintenance and removal of beaver dams to allow for intended flow paths to function and convey water, and mitigate the risk of flood inundation of the KFN cemetery lands. Multiple active beaver dens and dam structures are present within the slough. Relatively recent dam construction at the NW terminus of the slough appear to define the present-day base level control and restrict the frequency with which the outlet channel flow path is activated (Photograph 16).

[1] Bjornn, T.C., and D.W. Reiser. 1991. Habitat requirements of salmonids in streams. American Fisheries Society Special Publication 19: 83-138. URL: https://www.for.gov.bc.ca/hfd/library/ffip/Bjornn_TC1991.pdf

Photograph 16 - Upstream view of minor beaver dams defining base-level control at NW outlet channel.

4.5 Invasive Species Considerations

Japanese knotweed is present in locations. Prior to any formal construction access in relation to drainage improvements, a detailed survey for noxious weeds, particularly Schedule 1 noxious weeds pursuant to the BC Weed Control Act is recommended.

Future construction activities will require explicit consideration of noxious weeds and other invasive species, and the risks of potential spread in association with construction activities.

4.6 Regulatory Considerations

Notwithstanding the location of Reeve Slough within the Kwikwetlem First Nation's IR2 lands, the proposed scope of work will likely involve diversions of natural or modified 'streams' regulated under the Province of BC's *Water Sustainability Act* (WSA). Approvals for 'Changes in and About a Stream' pursuant to Section 11 of the WSA will be required for any alterations below the bed and banks of affected waterbodies.

Authorization for the 'Use of Water' pursuant to Section 6 of the WSA, and Section 9 – Licenses, is anticipated to be required for a potential diversion, subject to the detailed project design details, to support the recommendation for the establishment of upstream flow connections into Reeve Slough. The diversion of water into the slough is anticipated to be considered a water use for a designated 'conservation purpose' to achieve the fish habitat restoration objectives.

The presence of an Eagles Nest will require compliance with the Province of BC's *Wildlife Act*. Specifically, Section 34(b) prohibits the disturbance of the eagles nest, with guidelines published for the establishment of vegetation protection zones and breeding season quiet zones that may affect construction phase activities associated with fish habitat enhancement. Future development plans will require the development of a project specific eagle nest management plan.

The location of Reeve Slough within the posted Western painted turtle critical habitat polygon is furthermore anticipated to require further assessment and evaluation of the habitat use by the species and development of an impact mitigation plan with respect to the future construction activities.

Clarification will be required by DFO representatives, as a project proponent, as to whether the project will require formal authorization under the *Fisheries Act* based on the likelihood of works occurring within the wetted perimeter of the Slough and anticipated direct connections to the Coquitlam River and the fish accessible portion of the PoCo Slough.

5.0 SUMMARY & CLOSURE

The Reeve Slough feasibility assessments completed based on the scope of services requested by DFO and the North Fraser Salmon Assistance Project Society have been presented herein. The studies were undertaken to support future detailed planning and evaluation of the potential fish habitat enhancements to achieve suitable Chinook off-channel rearing habitat within the relict channel of the Coquitlam River.

The results of the assessment suggest that there is no persistent water supply sustaining a perennial 'flow-through' hydrologic regime at Reeve Slough. The offsite Reeve Park Pump Station and associated drainage flows provide a unique opportunity to establish an upstream water supply with the ultimate downstream connection remaining the Coquitlam River as the receiving environment.

The establishment of a water source will require the formalization of a defined outlet control that can be accessed, monitored, and maintained as the risks of beaver impoundment are significant and the project must consider the existing flood concerns associated with the KFN Cemetery which is located on the immediate right bank of Reeve Slough at its head, and between the slough, the offsite PoCo Slough, and the Coquitlam River. Notwithstanding the potential for potential water source flow connections, the flooding concerns affecting the cemetery are assumed to be significant due to the ongoing beaver activity and observed floodplain connectivity between the Coquitlam River and Reeve Slough. Beaver activity within Reeve Slough is significant. The present-day hydrologic controls are the direct result of beaver activity at the northwest terminus of the slough.

The project has confirmed the presence of a previously unmapped seasonal drainage channel connecting Reeve Slough with the Coquitlam River. The drainage channel flows through floodplain habitats and yields a continuous stream channel for an undetermined period of the year.

Ongoing water level monitoring is recommended between Reeve Slough and the PoCo slough; however, redeployment of the existing water level recording equipment is required to establish the potential benefits of a direct drainage connection. Changes to the drainage conditions at PoCo slough have compromised the function of the monitoring equipment. Furthermore, a notable reduction in water levels within the Coquitlam River suggest that the water level monitoring equipment originally placed at the left bank of the river would be better repurposed to assess the flow periodicity of the mapped natural drainage channel.

The Reeve Slough site provides a unique opportunity for fish habitat enhancement as a significant and intact off-channel habitat feature is present with close proximity to the Coquitlam River. The potential to provide fish access to benefit Chinook salmon off-channel rearing habitat at the scale afforded by Reeve Slough is uncommon and warrants further consideration to achieve a viable rearing habitat enhancement project for this important keystone fish species.

APPENDIX A

Solinst LeveLogger 3001 Product Summary

ENKON

Levelogger® Edge

Model 3001

The Levelogger Edge records highly accurate groundwater and surface water level and temperature measurements. It combines a pressure sensor, temperature detector, 10-year lithium battery, and datalogger, sealed within a 7/8" x 6.25" (22 mm x 159 mm) stainless steel housing with Titanium based PVD coating.

The Levelogger Edge measures absolute pressure using a Hastelloy pressure sensor, offering excellent durability and reliability. Combined with the Titanium based PVD coating, both elements have high corrosion resistance in harsh environments, allowing stable readings in extreme pressure and temperature conditions. The Hastelloy sensor can withstand 2 times over-pressure without permanent damage.

The Levelogger Edge features a wide temperature compensated pressure range (0 to 50°C, -10 to 50°C for Barologger Edge), and rapid thermal response time. The Levelogger Edge has high resolution and an accuracy of 0.05% FS. The convenient Barologger Edge provides the easiest and most accurate method of barometric compensation.

Applications

- Aquifer characterization: pumping tests, slug tests, etc.
- Watershed, drainage basin and recharge monitoring
- Stream gauging, lake and reservoir management
- Harbour and tidal fluctuation measurement
- Wetlands and stormwater run-off monitoring
- Water supply and tank level measurement
- Mine water and landfill leachate management
- Long-term water level monitoring in wells, surface water bodies and seawater environments

Fast communication and downloading speeds with a high speed Optical Reader

Get Quote | More Info

Features

- 0.05% FS Accuracy
- Corrosion resistant Titanium based PVD coating
- Robust Hastelloy pressure sensor
- Accurate temperature compensation
- Memory for up to 120,000 readings
- Basic and advanced data compensation options

The Levelogger Edge has a battery life of 10 years based on a 1-minute sampling rate. It has FRAM memory for 40,000 sets of data points - or up to 120,000 using the compressed linear sampling option.

The Levelogger Edge uses a Faraday cage design, which protects against power surges or electrical spikes caused by lightning. Its durable maintenance-free design, high accuracy and stability, make the Levelogger Edge the most reliable instrument for long-term, continuous water level recording.

Flexible Communication

Levelogger PC Software is streamlined, making it easy to program dataloggers, and to view and compensate data, in the office or in the field. The software has useful programming options, including compressed and repeat sampling, and future start/stop. Data compensation has been simplified, and allows multiple data files to be barometrically compensated at once.

The extremely intuitive Solinst Levelogger App, and Levelogger App Interface on your in-field Leveloggers, creates a Bluetooth® connection between your Leveloggers and smart device. Also an option, the DataGrabber is a field-ready, USB data transfer unit designed specifically for the Levelogger Series.

For remote monitoring, options include STS Telemetry Systems and RRL Remote Radio Link. In addition, Levelogger Edge Series dataloggers are SDI-12 compatible.

Levelogger Setup

Programming Leveloggers is extremely intuitive. Simply connect to a PC using an Optical Reader or PC Interface Cable. All in one screen fill in your project information and sampling regime. Templates of settings can be saved for easy re-use.

The Levelogger time may be synchronized to the computer clock. There are options for immediate start or future start and stop times. The percentage battery life remaining and the amount of free memory are indicated on the settings screen.

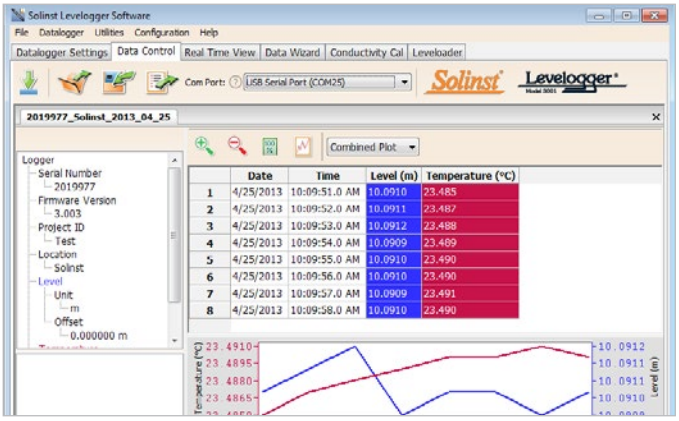
Leveloggers can also be programmed with a sampling regime and start/stop times using the Solinst Levelogger App on your smart device.

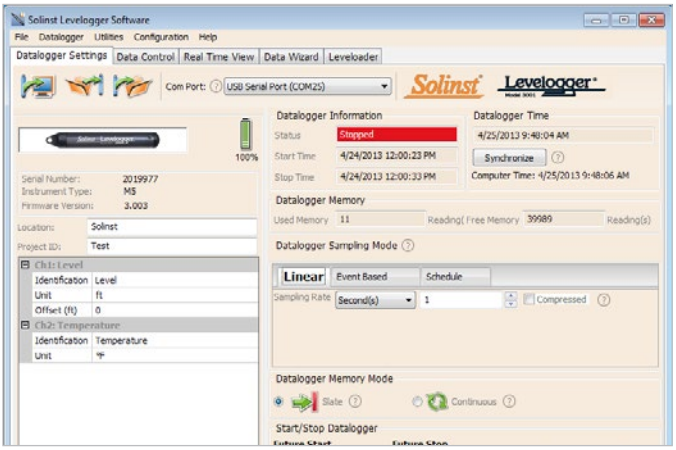
Convenient Sampling Options

Leveloggers can be programmed with linear, event-based, or a user-selectable sampling schedule. Linear sampling can be set from 1/8 second to 99 hours. The Levelogger Edge can be programmed with compressed linear sampling, which increases memory from 40,000 to up to 120,000 readings.

Event-based sampling can be set to record when the level changes by a selected threshold. Readings are checked at the selected time interval, but only recorded in memory if the condition has been met. A default reading is taken every 24 hours if no "event" occurs.

The Schedule option allows up to 30 schedule items, each with its own sampling rate and duration. For convenience, there is an option to automatically repeat the schedule.





Levelogger Edge Settings Software Windows

Data Download, Viewing and Export

Data is downloaded to a PC with the click of a screen icon. There are multiple options for downloading data, including 'Append Data' and 'All Data'. The software also allows immediate viewing of the data in graph or table format using the 'Real Time View' tab.

The level data is automatically compensated for temperature, and the temperature data is also downloaded. Barometric compensation of Levelogger data is performed using the Data Wizard, which can also be used to input manual data adjustments, elevation, offsets, density, and adjust for Barometric efficiency.

The software allows easy export of the data into a spreadsheet or database for further processing.

The Solinst Levelogger App also allows you to view and save real-time, or logged data right on your smart device.

Helpful Utilities

The 'Self-Test Diagnostic Utility' can be used in case of an unexpected problem. It checks the functioning of the program, calibration, backup and logging memories, the pressure transducer, temperature sensor and battery voltage, as well as enabling a complete Memory Dump, if required.

A firmware upgrade will be available from time to time, to allow upgrading of the Levelogger Edge, as new features are added.

Solinst Levelogger App & Levelogger App Interface

The Levelogger App Interface uses Bluetooth® technology to connect your Levelogger to your smart device. With the Solinst Levelogger App, you can download data, view real-time data, and program your Leveloggers. Data can be e-mailed from your smart device directly to your office (see Model 3001 Levelogger App & Interface data sheets).

Download on the App Store

GET IT ON Google play

Standard Cable Deployment

Leveloggers may be suspended on a stainless steel wireline or Kevlar® cord. This is a very inexpensive method of deployment, and if in a well, allows the Levelogger to be easily locked out of sight and inaccessible. Solinst offers stainless steel wireline assemblies and Kevlar cord assemblies in a variety of lengths.

Solinst 3001 Well Cap Assembly

The 2" Locking Well Caps are designed for both standard and Direct Read Cable deployment options.

The well cap has a convenient eyelet for suspending Leveloggers using wireline or Kevlar cord. The Well Cap insert has two openings to accommodate Direct Read Cables for both a Levelogger and Barologger. Adaptors are available to fit 4" wells.

The cap is vented to equalize atmospheric pressure in the well. It slips over the casing, and the cap can be secured using a lock with a 3/8" (9.5 mm) shackle diameter.

Levelogger 2" Locking Well Cap Installations (see Well Caps data sheet for more details)

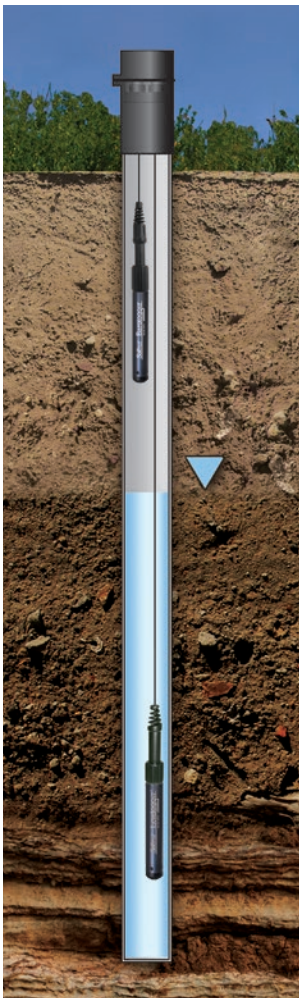
Direct Read Cables

When it is desired to get real-time data and communicate with Leveloggers without removal from the water, they can be deployed using Direct Read Cables. This allows viewing of the data, downloading and/or programming in the field using a portable computer, DataGrabber, or the Solinst Levelogger App and Interface.

Leveloggers can also be connected to an SDI-12 datalogger using the Solinst SDI-12 Interface Cable attached to a Direct Read Cable.

Cable Specifications

Direct Read Cables are available for attachment to any Levelogger in lengths up to 1500 ft. The 1/8" dia. (3.175 mm) coaxial cable has an outer polyethylene (MDPE) jacket for strength and durability. The stranded stainless steel conductor gives non-stretch accuracy.



Barologger and Levelogger installed in Well Using Direct Read Cables

Accurate Barometric Compensation

The Levelogger Edge measures absolute pressure (water pressure + atmospheric pressure) expressed in feet, meters, centimeters, psi, kPa, or bar.

The most accurate method of obtaining changes in water level is to compensate for atmospheric pressure fluctuations using a Barologger Edge, avoiding time lag in the compensation.

The Barologger is set above high water level in one location on site. One Barologger can be used to compensate all Leveloggers in a 20 mile (30 km) radius and/or with every 1000 ft. (300 m) change in elevation.

The Levelogger Software Data Compensation Wizard automatically produces compensated data files using the synchronized data files from the Barologger and Leveloggers on site.

The Barologger Edge uses pressure algorithms based on air rather than water pressure, giving superior accuracy.

The recorded barometric information can also be very useful to help determine barometric lag and/or barometric efficiency of the monitored aquifer.

The Barologger Edge records atmospheric pressure in psi, kPa, or mbar. When compensating submerged Levelogger Edge, Gold or Junior data, Levelogger Software Version 4 can recognize the type of Levelogger and compensate using the same units found in the submerged data file (Levelogger Gold and Junior measure in feet, meters, or centimeters). This makes the Barologger Edge backwards compatible.

Synchronize & Streamline Your Barometric Compensation Efforts, Across Your Entire Site

® *Kevlar is a registered trademark of DuPont Corp.*

Levelogger Edge Specifications

Level Sensor:	Piezoresistive Silicon with Hastelloy Sensor
Accuracy:	± 0.05% FS (Barologger Edge: ± 0.05 kPa)
Stability of Readings:	Superior, low noise
Units of Measure:	m, cm, ft., psi, kPa, bar, °C. °F (Barologger Edge: psi, kPa, mbar, °C, °F)
Normalization:	Automatic Temperature Compensation
Temp. Comp. Range:	0° to 50°C (Barologger Edge: -10 to +50°C)
Temperature Sensor:	Platinum Resistance Temperature Detector (RTD)
Temp. Sensor Accuracy:	± 0.05°C
Temp. Sensor Resolution:	0.003°C
Battery Life:	10 Years - based on 1 reading/minute
Clock Accuracy:	± 1 minute/year (-20°C to 80°C)
Operating Temperature:	-20°C to 80°C
Maximum # Readings:	40,000 readings FRAM memory, or up to 120,000 using linear data compression
Memory:	Slate and Continuous
Communication:	Optical Infrared Interface. Conversion to RS-232, USB, SDI-12. Serial at 19,200 bps, 38,400 bps with USB
Size:	7/8" x 6.25" (22 mm x 159 mm)
Weight:	4.6 oz. (129 grams)
Corrosion Resistance:	Titanium based PVD coating
Other Wetted Materials:	Delrin®, Viton®, 316L stainless steel, Hastelloy, Titanium based PVD coating
Sampling Modes:	Linear, Event & User-Selectable with Repeat Mode, Future Start, Future Stop, Real-Time View
Measurement Rates:	1/8 sec to 99 hrs
Barometric Compensation:	Software Wizard and one Barologger in local area (approx. 20 miles/30 km radius)

Models	Full Scale (FS)	Accuracy
Barologger	Air only	± 0.05 kPa
F15, M5	16.4 ft., 5 m	± 0.010 ft., 0.3 cm
F30, M10	32.8 ft., 10 m	± 0.016 ft., 0.5 cm
F65, M20	65.6 ft., 20 m	± 0.032 ft., 1 cm
F100, M30	98.4 ft., 30 m	± 0.064 ft., 1.5 cm
F300, M100	328.1 ft., 100 m	± 0.164 ft., 5 cm
F600, M200	656.2 ft., 200 m	± 0.328 ft., 10 cm

Levelogger Junior Edge: See Levelogger Junior Edge Data Sheet.
Conductivity: See Model 3001 LTC Levelogger Junior Data Sheet

DataGrabber

The DataGrabber is a field-ready data transfer device that allows you to copy data from a Levelogger, onto a USB flash drive key.

The DataGrabber is compact and very easy to transport. It connects to the top end of a Levelogger's Direct Read Cable, or an Adaptor is available to allow direct connection to a Levelogger.

One push-button is used to download all of the data in a Levelogger's memory to a USB device plugged into the DataGrabber. A convenient LED light indicates the operation of the DataGrabber. The data in the Levelogger memory is not erased, and logging is not interrupted if the Levelogger is still running. The DataGrabber uses its own replaceable 9V battery.

STS Telemetry

The STS Telemetry System provides an economical and efficient method to send Levelogger data from the field to your desktop. Built for Leveloggers, the system combines high quality dataloggers, intuitive software, and wireless communication, to create a remote monitoring solution.

Communication options give the flexibility to suit any project. Systems are suitable for both small to large networks. STS Systems are designed to save costs by enabling the self-management of data. Alarm notification, remote firmware upgrades and diagnostic reporting make system maintenance simple (see Model 9100/9200 data sheet).

RRL Telemetry

The inexpensive RRL Remote Radio Link is ideal for short range applications up to 20 miles or 30 km; distances can be increased by using some radios as relay stations. Ideal for creating closed-loop monitoring networks using Leveloggers (see Model 9100/9200 data sheet).

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APPENDIX B

Conservation Data Centre Summary Report – Reeve Slough

ENKON

BC Conservation Data Centre: Species Occurrence Report
Shape ID: 57643

Scientific Name: *Allogona townsendiana*
English Name: Oregon Forestsnail

Identifiers

Occurrence ID: 8847
Shape ID: 57643
Taxonomic Class: gastropods
Element Group: Invertebrate Animal

Status

Provincial Rank: S2
BC List: Red
Global Rank: G3G4
COSEWIC: E (APR 2013)
SARA Schedule: 1

Locators

Survey Site: COQUITLAM RIVER, WEST OF
Directions: West of the Coquitlam River in Colony Farm Regional Park along Colony Farm Road and Lougheed Highway. Capture location was Wilson Farm North, tide gate pond, Coquitlam, BC; Segment 2 of the Port Mann Highway 1 (PMH1) project. The relocation location was Wilson Farm South, near silo, Coquitlam, BC; Segment 2 of the Port Mann Highway 1 (PMH1) project (A. Conover, pers. comm. 2011).
Biogeoclimatic Zone:
Ecosection: FRL

Area Description

General Description:

Colony Farm Regional Park is predominantly open fields and wetland complexes, colonized by dense stinging nettle, shrubs and tall grass, with only a few scattered deciduous trees. The Coquitlam River meanders north to south through this park to meet the Fraser River with dykes on either side, and some side channels divide the fields. It is possible that some seasonal flooding occurs within the park (Parkinson and Heron 2010).

Vegetation Zone:

Min. Elevation (m): **Max. Elevation (m):**

Habitat: PALUSTRINE: Shrub Wetland

Occurrence Information

First Observation Date: 2010-05-20 **Last Observation Date:** 2015-05-10

Occurrence Data:

2015: over 200 Oregon Forestsnails were found (L. Andrusiak, pers. comm. 2015). 2011: twenty four snails were captured at Wilson Farm North and relocated approximately 600 m east to Wilson Farm South (A. Conover, pers. comm. 2011). 2010: At least 670 snails observed (Parkinson and Heron 2010).

Occurrence Rank and Occurrence Rank Factors

Rank: B : Good estimated viability

Rank Date: 2011-08-24

Rank Comments:

Rank was A when the EO was many snails within a protected area. Lowered to B to reflect the relocation of 24 individuals and alteration of habitat within the now larger EO.

Condition of Occurrence:

The eastern portion of this occurrence has experienced habitat alteration. Oregon Forestsnails at the site of habitat alteration were relocated to an area of suitable habitat further east (A. Conover, pers. comm. 2011). This occurrence is found within a regional park. Oregon Forestsnail was observed laying eggs in the grass directly adjacent (>1 metre) to the path. The stinging nettle is concentrated at the west side of Mundy Creek Trail, and extends only about 200 metres south along Colony Farm Road Trail. The habitat along the railroad, north of Mundy Creek Trail and the park appeared to be marginal in comparison with the latter; the substrate was rocky and a narrow strip of Himalayan blackberry and horsetails was immediately adjacent to the railroad track, beyond which was stinging nettle. Few, if any, non-native Grovesnail were observed on the Mundy Creek Trail, but they were commonly observed on the Colony Farm Road Trail and along the south edge of the railroad track. Chocolate Arion were observed in all areas of the park surveyed (Parkinson and Heron 2010).

Size of Occurrence:

More than 670 snails observed in 2010 (Parkinson and Heron 2010).

Landscape Context:

Highway 7A and 7B are adjacent to the north and south borders of the park. Colony Farm Road divides the park north to south on the west side. The south end of the park borders the Fraser River. This is a very urban park surrounded by the City of Coquitlam (Parkinson and Heron 2010).

Version

Version Date: 2018-01-25

Version Author: Shepard, M.G.

Mapping Information

Estimated Representation Accuracy: Medium

Estimated Representation Accuracy Comments:

Confident that full extent is represented by Occurrence: N

Confidence Extent Definition: Confident full extent of EO is NOT known

Additional Inventory Needed: Y

Inventory Comments:

Documentation

References:

Andrusiak, Lorraine. Personal Communication.

Conover, Abigail. Personal Communication. Kiewit Flatiron General Partnership.

Klinkenberg, Brian (Editor). ND. E-Fauna BC: Electronic Atlas of the Fauna of British Columbia [www.efauna.bc.ca]. Lab for Advanced Spatial Analysis, Department of Geography, University of British Columbia, Vancouver.

Paetow, Andrea. Personal Communication.

Parkinson, L. and J. Heron. 2010. Surveys for two invertebrate species at risk in southwestern British Columbia: Audouin's Night-stalking Tiger Beetle (Omus audouini) and Oregon Forestsnail (Allogona townsendiana). B.C. Ministry of Environment, Terrestrial Conservation Science Section, Vancouver, B.C.

Specimen:

Suggested Citation:

B.C. Conservation Data Centre. 2014. Occurrence Report Summary, Shape ID: 57643, Oregon Forestsnail. B.C. Ministry of Environment. Available: http://maps.gov.bc.ca/ess/hm/cdc, (accessed Sep 13, 2019).

BC Conservation Data Centre: Species Occurrence Report
Shape ID: 7984

Scientific Name: *Ardea herodias fannini*

English Name: Great Blue Heron, *fannini* subspecies

Identifiers

Occurrence ID: 1127

Shape ID: 7984

Taxonomic Class: birds

Element Group: Vertebrate Animal

Status

Provincial Rank: S2S3B,S4N

BC List: Blue

Global Rank: G5T4

COSEWIC: SC (MAR 2008)

SARA Schedule: 1

Locators

Survey Site: PORT COQUITLAM

Directions: <u>H208-005 Mary Hill</u>: Southwest of the intersection of Mary Hill Road and Mary Hill Bypass (Port Coquitlam). Colony is on the southeast shore of the mouth of the Coquitlam River (Moul 1998). New Westminster Land District, Plan 70578. <u>Bothwell Park </u>(Surrey):
on 168th Street, south of 96th Ave, north of 92A Ave

Biogeoclimatic Zone:

Ecosection: FRL

Area Description

General Description:

Mary Hill: Large black cottonwood stand near the mouth of the Coquitlam River.

Vegetation Zone:

Min. Elevation (m): 2 **Max. Elevation (m):**

Habitat: TERRESTRIAL: Forest Broadleaf; RIVERINE: Riparian

Occurrence Information

First Observation Date: 1992 **Last Observation Date:** 2010

Occurrence Data:

<u>H208-005</u><u> Mary Hill</u>: The increase in numbers at this site may be due to the abandonment of the Debouville Slough colony (H208-011). 2004: 118 active nests, 10 of 10 nests surveyed were successful (Chatwin 2015). 2002: 101 active nests (Chatwin 2015). 2001-02: over 100 active nests (Moul 2002). 2000: 79 active nests (Moul 2001). 1998-99: over 100 active nests but only 35 or less successful (Vennesland 2000). 1997: 62 nests observed and some activity, but no successful nests (Moul 1998). 1994: 35 active nests, 54 nest structures counted in November after leaf fall. 1993: 22 active nests. 1992: 12 out of 16 nests active, 11 contained up to 4 chicks (Gebauer 1995).
<u>Bothwell Park</u>: new rookery reported by a private individual in 2010, unknown number of nests or individuals. Site may be abandoned (K. Welstead, pers. comm. 2013).

Occurrence Rank and Occurrence Rank Factors

Rank: E : Verified extant (viability not assessed)

Rank Date: 2010

Rank Comments:

Condition of Occurrence:

Mary Hill probably impacted by Port Mann bridge expansion project. Bothwell Park may be abandoned (K. Welstead, pers. comm. 2013).

Size of Occurrence:

H208-005 Mary Hill: Over 118 active nests in 2004 (Chatwin 2015).

Landscape Context:

Version

Version Date: 2015-03-11

Version Author: Davis, H.

Mapping Information

Estimated Representation Accuracy: Medium

Estimated Representation Accuracy Comments:

Confident that full extent is represented by Occurrence: N

Confidence Extent Definition: Confident full extent of EO is NOT known

Additional Inventory Needed: Y

Inventory Comments: No idea if Bothwell Park site is active or how many nests there are.

Documentation

References:

Chatwin, T. 2015. Electronic database of Great Blue Heron (fannini subspecies) records. BC Ministry of Forests, Lands and Natural Resource Operations, Nanaimo, BC.

Gebauer, M.B. 1995. Status, reproductive success and habitat requirements of greater sandhill cranes (Grus canadensis tabida) in the Lower Fraser River delta in 1993 and 1994. Unpubl. rep. submitted to Wildl. Program, B.C. Environ., Surrey, BC. 70pp.

McClaren, E., and T. Chatwin. 2003. Database for Great Blue Heron colonies in British Columbia from 1920 through 2003. B.C. Minist. Sustainable Resour. Manage., Nanaimo.

Moul, I.E. 1998. The location and status of heron colonies around the Strait of Georgia: Region 2, Lower Fraser Valley, Sunshine Coast and the Powell River Area. Unpubl. contract rep. B.C. Minist. Environ., Lands and Parks, Nanaimo, BC. 146pp.

Moul, I.E. 2001. Database for Great Blue Heron colonies in British Columbia from 1920 through 2000. Compiled for K. Morrison, B.C. Minist. Sustainable Resour. Manage., Nanaimo.

Moul, I.E. 2002. Database for Great Blue Heron colonies in British Columbia from 1920 through 2001. Compiled for K. Morrison, B.C. Minist. Sustainable Resour. Manage., Nanaimo, BC.

Moul, I.E., R.G. Vennesland, M.L. Harris, and R.W. Butler. 2001. Standardizing and interpreting nesting records for Great Blue Herons in British Columbia. Can. Wildl. Serv. Prog. Note No. 217, June 2001. Environ. Can. 31pp.

Vennesland, R.G. 2000. The effects of disturbance from humans and predators on the breeding decisions and productivity of the Great Blue Heron in south-coastal British Columbia. M.Sc. Thesis, Simon Fraser Univ., Dep. Biol. Sci. 109pp.

Welstead, K. Personal communication. Species at Risk Biologist. Ministry of Environment. Surrey, BC.

Specimen:

Suggested Citation:

B.C. Conservation Data Centre. 2014. Occurrence Report Summary, Shape ID: 7984, Great Blue Heron, fannini subspecies. B.C. Ministry of Environment. Available: http://maps.gov.bc.ca/ess/hm/cdc, (accessed Sep 13, 2019).

BC Conservation Data Centre: Species Occurrence Report
Shape ID: 8546

Scientific Name: *Acipenser transmontanus* pop. 4

English Name: White Sturgeon (Lower Fraser River Population)

Identifiers

Occurrence ID: 1543

Shape ID: 8546

Taxonomic Class: ray-finned fishes

Element Group: Vertebrate Animal

Status

Provincial Rank: S1S2

BC List: Red

Global Rank: G4T2

COSEWIC: T (NOV 2012)

SARA Schedule:

Locators

Survey Site: FRASER RIVER, MOUTH TO HELL'S GATE

Directions: From the mouth of the Fraser River to Hell's Gate.

Biogeoclimatic Zone:

Ecosection: EPR;SPR;HOR;SOG;FRL

Area Description

General Description:

Habitat varies from a broad, shallow channel with cobble/gravel bars and islands, tight meanders within a broad valley with moderate velocities and depths, confined narrow channels with high velocities and turbulent, upwelling flows with exposed substrate, large boulders and rapids, lower velocity sections where depositional areas and large channel meanders predominate, to the lower section which has a low gradient braided channel with a prevalence of sidechannels, marshes and backwater sloughs (R.L. & L. Environmental Services 2000). In the lower section of the river Perrin et al. (1999, 2000) found evidence of spawning in sidechannels with substrates of gravel, cobble and sand; in the mainstem site boulder and cobble predominated; flows were mainly laminar with near-bed velocities averaging 1.7 m/s. Most eggs and larvae were collected at water depths between 3.0 and 4.5 m and at velocities of > 1.5 m/s for eggs, and 0.5 to 1.5 m/s for larvae. Juveniles (< 1 m in length) are often found in the lower reaches of tributaries, large backwaters, sidechannels and sloughs.

Vegetation Zone:

Min. Elevation (m): **Max. Elevation (m):**

Habitat: RIVERINE: Big River; High Gradient; Low Gradient; Moderate Gradient; ESTUARINE: River Mouth; Tidal Flat

Occurrence Information

First Observation Date: 1866-PRE **Last Observation Date:** 2004

Occurrence Data:

2004 population estimated at approximately 60,000 fish between 40 cm and 220 cm with evidence of an increasing population over the 2000-2004 study period. Walters et al. (2005) indicates that the minimum estimate of abundance of 60 cm+ sturgeon is between 40,000 and 60,0000 individuals. Number of individuals of reproductive age (140 cm or larger) is estimated at about 9,000 based on continued mark-recapture studies (Nelson et al. 2004). Age and size composition data suggest relatively healthy numbers of older fish in the population that is either stable or increasing (Walters et al. 2005).

Estimate of decline in abundance over the last 100 years, is over 50% (COSEWIC 2003). Sturgeon provided an important commercial fishery in the late 1800s and early 1900's; the annual harvest peaked at 517 tonnes and collapsed to 20 tonnes in 1905 due to overharvest (Echols 1995). The impact of the historical fishery varies depending on the interpretation of data available for the commercial sturgeon fishery (only total weight of landings was recorded). Under some scenarios using stock reduction analysis, Walters et al. (2005) were able to show that the numbers of fish removed may have been higher between 1960-80 due to interception in the commercial chinook gill net fishery; this is based on the assumption that the average size of the fish harvested in the early fishery was much greater than it was for those intercepted in the later salmon fishery.

Occurrence Rank and Occurrence Rank Factors

Rank: BC : Good or fair estimated viability

Rank Date: 2004

Rank Comments:

Relatively large abundance that may be increasing as it recovers from over-harvest. However, this area is undergoing rapid growth and development.

Condition of Occurrence:

Estimate of decline in abundance over the last 100 years, is over 50% (COSEWIC 2003). Sturgeon provided an important commercial fishery in the late 1800s and early 1900's; the annual harvest peaked at 517 tonnes and collapsed to 20 tonnes in 1905 due to overharvest (Echols 1995). The impact of the historical fishery varies depending on the interpretation of data available for the commercial sturgeon fishery (only total weight of landings was recorded). Under some scenarios using stock reduction analysis, Walters et al. (2005) were able to show that the numbers of fish removed may have been higher between 1960-80 due to interception in the commercial chinook gill net fishery; this is based on the assumption that the average size of the fish harvested in the early fishery was much greater than it was for those intercepted in the later salmon fishery. Catch data suggest the abundance of small fish (1-7 years) has been rapidly increasing since 2000; age and size composition data suggest relatively healthy numbers of older fish in the population that is either stable or increasing (Walters et al. 2005).

Major threats include: over-fishing; loss or degradation of habitat from the elimination of wetlands, dyking, channelization, dredging, gravel mining and contamination; poaching and by-catch in other fisheries. The emerging commercial aquaculture industry could have impacts, if it is not managed appropriately (concerns include facility placement and containment, security, access to wild broodstock or the importation of non-native stocks, and the possibility of masking and enhancing the market for illegally caught wild fish or their products (COSEWIC 2003). There is no direct evidence from the mark-recapture study of cumulative mortality due to repeated catch and release associated with the recreational fishery (Walters et al. 2005).

Size of Occurrence:

2004 population estimated at approximately 60,000 fish between 40 cm and 220 cm with evidence of an increasing population over the 2000-2004 study period. Number of individuals of reproductive age (140 cm or larger) is estimated at about 9,000 (Maximum Likelihood Estimate) based on continued mark-recapture studies (Nelson et al. 2004). Walters et al. (2005) indicates that the minimum estimate of abundance of 60 cm+ sturgeon is between 40,000 and 60,0000 individuals.

Area of Occupancy about 500 km2; Linear Distance of Occupancy about 211 km (COSEWIC 2003).

Landscape Context:

The surrounding area in the lower Fraser Valley is undergoing rapid growth and development.

Version

Version Date: 2007-07-11

Version Author: Westereng, L.K.

Mapping Information

Estimated Representation Accuracy: Low

Estimated Representation Accuracy Comments:

Confident that full extent is represented by Occurrence: N

Confidence Extent Definition: Confident full extent of EO is NOT known

Additional Inventory Needed: Y

Inventory Comments: Regular population monitoring is needed to inform management practices.

Additional information on life-history traits (including anadromy), habitat use and catch-and-release mortality studies are required to determine appropriate management strategies. The importance of the declines in forage species populations to recruitment should be determined. Information is required on the influence of abiotic and biotic factors on spawning and subsequent recruitment success.

Documentation

References:

Brown, J.R., A.T. Beckenbach, and M.J. Smith. 1992. Influence of Pleistocene glaciations and human intervention upon mitochondrial DNA diversity in white sturgeon (Acipenser transmontanus) populations. Can. J. Fish. Aquat. Sci. 49:358-367.

COSEWIC. 2003e. COSEWIC assessment and update status report on the white sturgeon Acipenser transmontanus in Canada. Comm. on the Status of Endangered Wildl. in Can. Ottawa. vii+51pp.

Lane, E.D. Personal communication. Malaspina College, Nanaimo, BC.

Perrin, C.J., A. Heaton, and M.A. Laynes. 1999. White sturgeon (Acipenser transmontanus) spawning habitat in the lower Fraser River, 1998. Report prepared by Limnotek Research and Development Inc. for BC Fisheries, Victoria, B.C. 53 pp.

Perrin, C.J., A. Heaton, and M.A. Laynes. 2000. White sturgeon (Acipenser transmontanus) spawning habitat in the lower Fraser River, 1999. Report prepared by Limnotek Research and Development Inc. for BC Fisheries, Victoria, B.C. 72 pp.

Pollard, S. 2000. Fraser River white sturgeon genetic results - Implications to stock structure. Unpubl. rep. prepared for B.C. Fish., Conserv. Sect., Victoria, BC. 4pp.

R. L. & L. Environmental Services Ltd. 2000b. Fraser River white sturgeon monitoring program region 7 (Omineca-Peace) 1999 data report. Prepared for B.C. Fish., Ministry of Environment, Lands and Parks. 32pp. +append.

Rosenau, M. Personal communication.

Semakula, S.N., and P.A. Larkin. 1968. Age, growth, food, and yield of the white sturgeon (Acipenser transmontanus) of the Fraser River, British Columbia. J. Fish. Res. Board Can. 25:2589-2602.

Swiatkiewicz, V.J. 1989. Lower Fraser River white sturgeon (Acipenser transmontanus) studies from 1985-1987. Reg.l Fish. Rep. No. LM209, B.C. Minist. Environ., Surrey.

University of British Columbia. Dep. Bot., Dep. Zool., Biol. Sci. Bldg., 6270 Univ. Blvd., Vancouver, BC.

Specimen: S59MIL59-586UBBCCA; S62SEM631096UBBCCA; S62SEM631095UBBCCA; S60BAK528T03UBBCCA; S62SEM631093UBBCCA; S57XXX72-57-UBBCCA; S61STE61-275UBBCCA; S62SEM631094UBBCCA; S61STE61-276UBBCCA; S59MIL59-59UBBCCA; S59LAN61-27UBBCCA

Suggested Citation:

B.C. Conservation Data Centre. 2014. Occurrence Report Summary, Shape ID: 8546, White Sturgeon (Lower Fraser River Population). B.C. Ministry of Environment. Available: http://maps.gov.bc.ca/ess/hm/cdc, (accessed Sep 13, 2019).

BC Conservation Data Centre: Species Occurrence Report
Shape ID: 14929

Scientific Name: *Sorex bendirii*
English Name: Pacific Water Shrew

Identifiers

Occurrence ID: 5743
Shape ID: 14929
Taxonomic Class: mammals
Element Group: Vertebrate Animal

Status

Provincial Rank: S2?
BC List: Red
Global Rank: G4
COSEWIC: E (APR 2016)
SARA Schedule: 1

Locators

Survey Site: COQUITLAM, "LOST LAKE"
Directions: East of Mundy Lake on the east side of Mundy Park. The lake does not have a gazetteered name.
Biogeoclimatic Zone:
Ecosection: FRL

Area Description

General Description:

Small lake with a beaver channel running in, riparian habitat of birch, cascara, saskatoon, redcedar, western hemlock, sphagnum moss and sundews (G. Ryder, pers. comm.).

Vegetation Zone:

Min. Elevation (m): **Max. Elevation (m):**

Habitat: LACUSTRINE; RIPARIAN

Occurrence Information

First Observation Date: 2000-07-12 **Last Observation Date:** 2000-07-12

Occurrence Data:

One observation in 2000 in suitable habitat (G. Ryder, pers. comm.; Wilson 2003).

Occurrence Rank and Occurrence Rank Factors

Rank: E : Verified extant (viability not assessed)

Rank Date: 2000-07-12

Rank Comments:

Notes written by G. Ryder describe the habitat as "just what this species needs" and does provide a habitat description that does sound like good protected habitat.

Condition of Occurrence:

Size of Occurrence:

Landscape Context:

Version

Version Date: 2002-11-12

Version Author: Ramsay, L.

Mapping Information

Estimated Representation Accuracy: High

Estimated Representation Accuracy Comments:

Confident that full extent is represented by Occurrence: N

Confidence Extent Definition: Confident full extent of EO is NOT known

Additional Inventory Needed: Y

Inventory Comments:

Documentation

References:

Ryder, G. Personal communication.

Wilson, S. 2003. Electronic database containing Sorex bendirii records up until 2002.

Specimen:

Suggested Citation:

B.C. Conservation Data Centre. 2014. Occurrence Report Summary, Shape ID: 14929, Pacific Water Shrew. B.C. Ministry of Environment. Available: http://maps.gov.bc.ca/ess/hm/cdc, (accessed Sep 13, 2019).

BC Conservation Data Centre: Species Occurrence Report
Shape ID: 3054

Scientific Name: *Lupinus rivularis*
English Name: streambank lupine

Identifiers

Occurrence ID: 4459
Shape ID: 3054
Taxonomic Class: dicots
Element Group: Vascular Plant

Status

Provincial Rank: S1
BC List: Red
Global Rank: G2G4
COSEWIC: E (NOV 2002)
SARA Schedule: 1

Locators

Survey Site: COQUITLAM RIVER, 130M EAST OF
Directions: Railroad tracks on north side of Kingsway Avenue.
Biogeoclimatic Zone:
Ecosection: FRL

Area Description

General Description:

Vegetation Zone: Lowland
Min. Elevation (m): 13
Max. Elevation (m):
Habitat: TERRESTRIAL: Roadside

Occurrence Information

First Observation Date: 1993-10-16 **Last Observation Date:** 2013-07

Occurrence Data:

2013-07: More than 107 flowering plants and more than 116 seedlings/juveniles. South subpopulation is a roadside partly within fenced area in a sand and silt area. North subpopulation is a roadside and railway right-of-way with coarse gravel, sand and silt (T. Mcintosh, pers. comm. 2013).

2010: 2 flowering plants (Streambank Lupine Recovery Team 2014). Approximately 356 flowering plants and approximately 184 seedlings/juveniles (T. Mcintosh, pers. comm. 2013).

2009: No plants seen (Streambank Lupine Recovery Strategy, 2012). Many flowering plants and seedlings/juveniles noted in the southern subpopulation; no plants observed in north subpopulation (T. Mcintosh, pers. comm. 2013).

2005: No plants observed, seedbank only (T. Mcintosh, pers. comm. 2013).

2001-05-07: Mesic grassy roadside verge adjacent to tracks, mowed area or maintained "lawn". Lupines grow inside and outside a fence along the railway tracks extending from the river's edge (University of British Columbia herbarium; R. Klinkenberg, pers. comm. 2013).

2001: 100 flowering plants and > 200 seedlings/juveniles (Streambank Lupine Recovery Team 2014).

1998-05-29: Abundant in large patch along fence in gravel railroad track fill (UBC herbarium).

1993-10-16: Many plants along railroad tracks, persisting for many years (F. Lomer, pers. comm. 1993).

Occurrence Rank and Occurrence Rank Factors

Rank: C : Fair estimated viability

Rank Date: 2010

Rank Comments:

Condition of Occurrence:

2001: Flowering plants and seedlings/juveniles present (Streambank Lupine Recovery Team 2014). 2009, 2010 and 2013: Flowering plants and seedlings/juveniles present (T. Mcintosh, pers. comm. 2013). Seed bank could be extensive as many seedlings were present in years the population was visited (R. Klinkenberg, pers. comm. 2013).

Size of Occurrence:

2001: 100 plants over at least 12 square m (R. Klinkenberg, pers. comm. 2013). 2005: No plants (T. Mcintosh, pers. comm. 2013). 2009: Many plants (T. Mcintosh, pers. comm. 2013). 2010: 356 plants (T. Mcintosh, pers. comm. 2013). 2013: At least 107 plants (T. McIntosh, pers. comm. 2013).

Landscape Context:

Threats to this population include mowing, spraying and railway track maintenance. Also, election signs have been placed on top plants outside the fencing, areas were dug up for utilities work and soil was dumped from an adjacent construction site (R. Klinkenberg, pers. comm. 2013). 2001: Flowers outside the fence were mowed continuously, but often flowered, despite persisting as tiny chopped off plants . Mowing may have reduced competition, but it was recommended that it be rescheduled until after plants had flowered. Some plants within the fence were up to 3 feet tall, but most were much smaller. When topsoil from outside the fence and along the road edge was dumped across the road and fenced, dozens of small Lupinus rivularis plants geminated and bloomed (R. Klinkenberg, pers. comm. 2013). 2010: Tracks were periodically sprayed and all

Version

Version Date: 2014-03-11

Version Author: Donovan, M. and V. Prigmore

Mapping Information

Estimated Representation Accuracy: High

Estimated Representation Accuracy Comments:

Confident that full extent is represented by Occurrence: Y

Confidence Extent Definition: Confident full extent of EO is known

Additional Inventory Needed: N

Inventory Comments:

Documentation

References:

Klinkenberg, R. Personal communication.

McIntosh, Terry T. Personal communication. Biospherics Environmental Inc., Vancouver, British Columbia.

Royal British Columbia Museum. 675 Belleville Street, Victoria, BC. V8V 1X4.

Streambank Lupine Recovery Team. 2014. Recovery strategy for streambank lupine (Lupinus rivularis) in British Columbia. Prepared for the B.C. Ministry of Environment, Victoria, BC. 24pp.

University of British Columbia. Dep. Bot., Dep. Zool., Biol. Sci. Bldg., 6270 Univ. Blvd., Vancouver, BC.

Specimen: Lomer, F. (98-67). 1998. V233849. V.; Klinkenberg, B. and R. (01-01). 2001. #V218382. UBC.

Suggested Citation:

B.C. Conservation Data Centre. 2014. Occurrence Report Summary, Shape ID: 3054, streambank lupine. B.C. Ministry of Environment. Available: http://maps.gov.bc.ca/ess/hm/cdc, (accessed Sep 13, 2019).

APPENDIX C

Topographic Survey Results

Target Land Surveying

ENKON

TOPOGRAPHIC SITE PLAN OVER A PORTION OF THE COQUITLAM RIVER

SCALE 1 : 2000

20 0 40 80

ALL DISTANCES ARE IN METRES

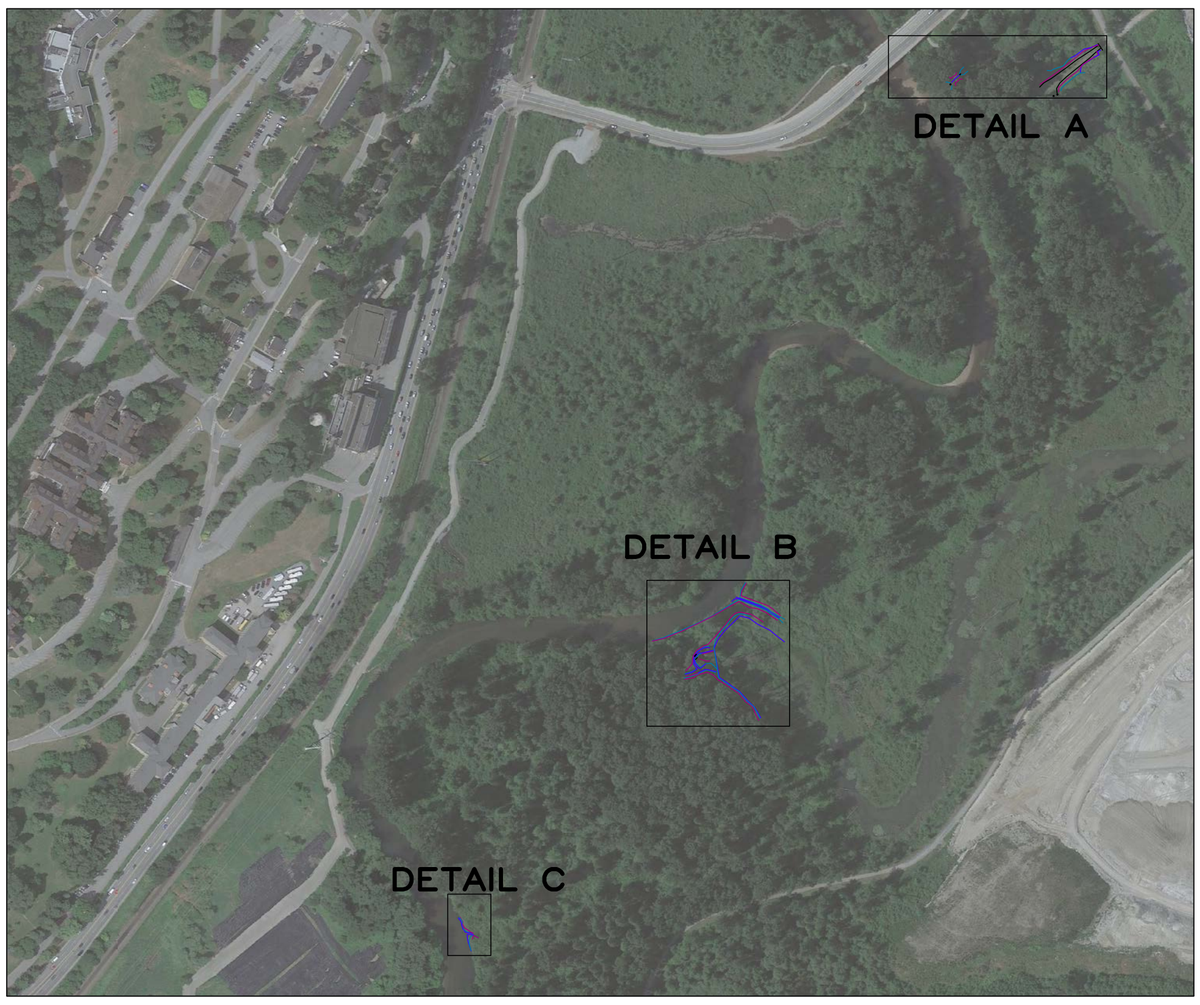
The intended plot size of this plan is 560mm in width by 864mm in height (D size) when plotted at a scale of 1:2000.

Address: Near intersection of Highway 7 and Pitt River Road
Port Coquitlam

Survey Date: March 13 2020

KEY PLAN

(Airphoto is for information purposes and is approximate only)



DETAIL A

SCALE 1 : 400

4 0 8 16 24

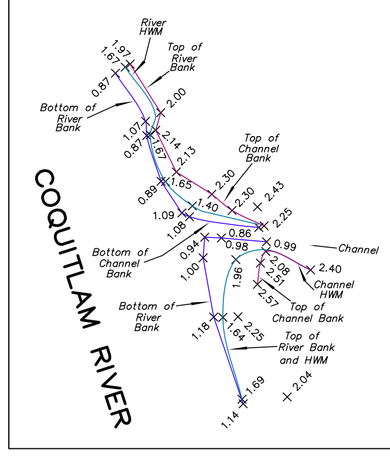
ALL DISTANCES ARE IN METRES

DETAIL C

SCALE 1 : 400

4 0 8 16 24

ALL DISTANCES ARE IN METRES

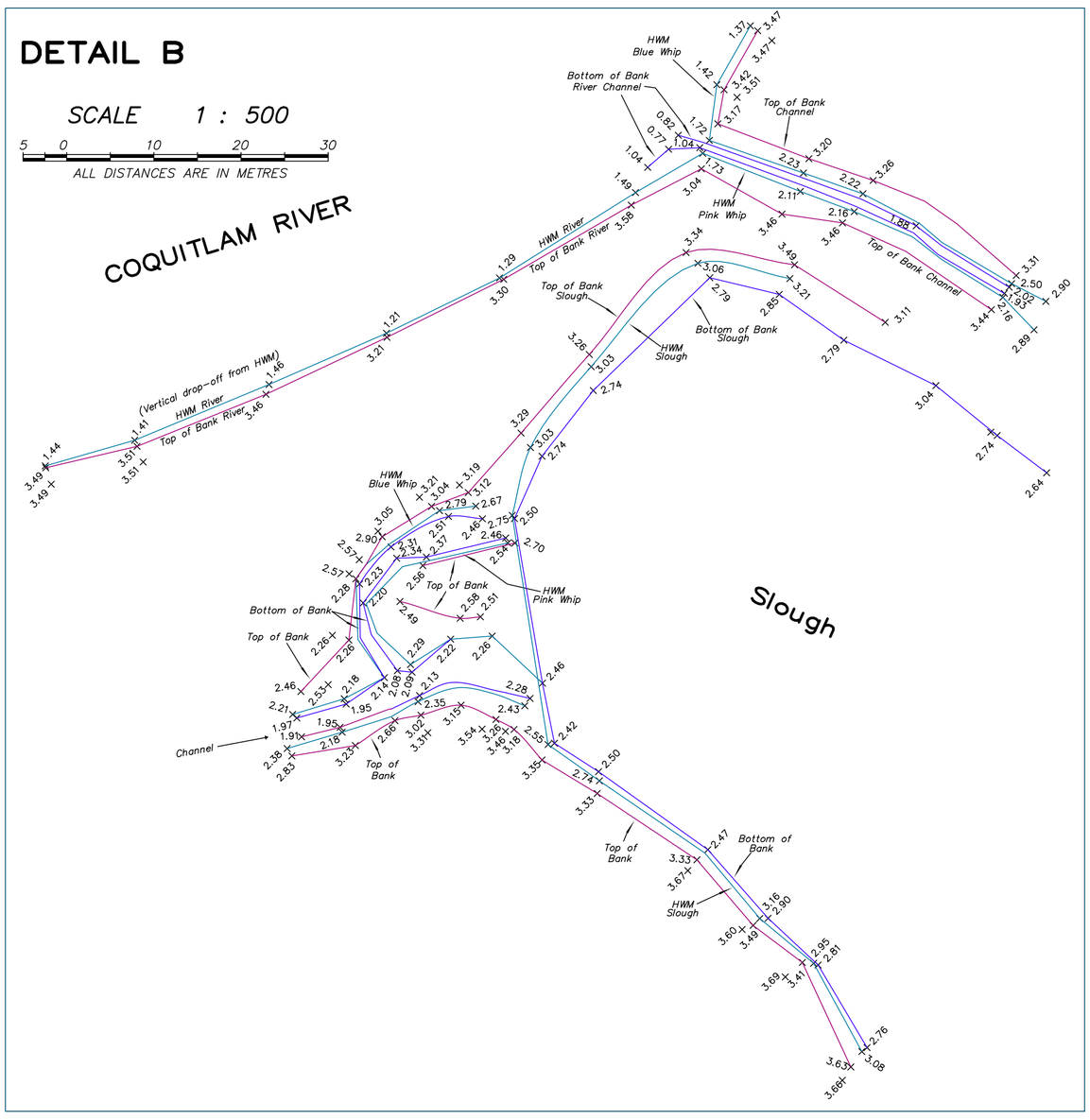


DETAIL B

SCALE 1 : 500

5 0 10 20 30

ALL DISTANCES ARE IN METRES



LEGEND

HWM	DENOTES HIGH WATER MARK
ø	DENOTES DIAMETER
×##.##	DENOTES GROUND ELEVATION

NOTES:

No charges or property lines are shown on this plan.

This plan shows orientation and grid distances in UTM Zone 10 coordinates. To calculate ground distances, multiply grid distances by the average combined factor of 1.0004040

Elevations are Geodetic (CVD28 GVRD–2018 – IN METERS)
Derived from Control Monument 94H1655
located in the sidewalk at the SW intersection of Alouette Dr. and Canim Ave.
Elevation = 90.494m

If this plan is used in digital form, Target Land Surveying (NW) Ltd will only assume responsibility for information content shown on original unaltered drawing.

This Plan was prepared for preliminary design and servicing purposes, and is for the exclusive use of our client. Target Land Surveying (NW) Ltd accepts no responsibility or liability for any damages that may be suffered by a third party as a result of reproduction, transmission or alteration to this document without consent.

TARGET LAND SURVEYING

www.targetlandsurveying.ca

FILE: N4021–TOPO–R2

Appendix 5
Restoration Plan for Reeve Slough, 2020 BCIT

Restoration Plan for Reeve Slough, Coquitlam, British Columbia

Anna Bondartchouk
Jessie Chestnut
Sonia Waiz

Project Supervisors: Kim Ives, BCIT and Lisa Henault, BCIT
Project Sponsor: Murray Manson, DFO
Applied Research Project – RENR 8303
25 May 2020

A report submitted in partial fulfillment of the requirements for the Bachelor of Science in Ecological Restoration
BRITISH COLUMBIA INSTITUTE OF TECHNOLOGY

Executive Summary

The Coquitlam River is located in the Fraser River watershed, British Columbia (B.C.), Canada, and its floodplain includes important habitat for salmonid species. Reeve Slough is located adjacent to the Coquitlam River and within Kwikwetlem First Nation (KFN) Indian Reserve #2. In recent years, Reeve Slough has become disconnected from the mainstem of the Coquitlam River, and because of this, many species such as juvenile coho (*Oncorhynchus kisutch)* and stream-type chinook (*Oncorhynchus tshawytscha*), have been cut off from valuable off-channel habitat. Fisheries and Oceans Canada (DFO) is interested in reconnecting Reeve Slough to the Coquitlam River, which has helped drive the goals of this restoration plan. Our restoration plan aims to improve ecological conditions in Reeve Slough before reconnecting it to the mainstem of the Coquitlam River.

To determine the ecological condition of Reeve Slough, we conducted a site assessment that revealed the existence of invasive fish and plants. Most water quality parameters were within suitable limits for salmonid survival. We found some measurements that were below the recommended dissolved oxygen (DO) levels for juvenile salmonid growth.

To improve juvenile salmonid habitat invasive fish species should be removed through intensive trapping sessions and electrofishing. These efforts will be conducted between the fall of 2020 through to 2025. Catch-per-unit-effort (CPUE) measurements will be used to approximate fish populations in Reeve Slough. Invasive plants will be brushcut and removed by hand pulling, or with tools. Native vegetation will be planted around Reeve Slough after invasive plant removals begin in 2020 and these plants will provide solar cover and predation cover for fish in Reeve Slough.

The monitoring plan includes surveys of invasive fish, plants, and water quality. Invasive fish will be monitored by estimating population size with CPUE while invasive plants will be monitored using vegetation surveys. Water quality will be monitored and compared to a reference site to document changes over time. Monitoring will be carried out for 5 years and data will be compared across years.

Maintenance treatments are based on the data collected during the monitoring plan, which will include ongoing invasive fish and plant management. Maintenance may be carried out by future BCIT students and KFN volunteers. Public access to the site is limited, so public outreach will consist mainly of signage informing the public of the costs of introducing invasive fish and plants to local watersheds.

Acknowledgments

This project was a collaborative effort among many participants. The authors wish to express their gratitude to the following for their input, support, and guidance over the course of developing the Reeve Slough Restoration Plan. Your dedication was invaluable, and we couldn't have completed our work without you. Thank you.

Murray Manson, M.Sc., R.P. Bio., DFO
Dave Nanson, Eng. Tech., DFO
Kim Ives, M.Sc., R.P. Bio., BCIT
Lisa Henault, B.Ed., M.Sc., BCIT
Eric Anderson, M.Sc., Ph.D., BCIT
Geric Coutts, T. Dipl., BCIT
Tony Matahlija, NFSAS
Tyler Thibault, T.Dipl., Blueback Consulting

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Figure 1. Reeve Slough project site in Coquitlam, B.C. Reeve Slough is located on Indian Reserve #2, next to a KFN cemetery, and a KFN industrial lot currently under construction (2020). Reeve Creek is indicated by the dashed line and it remains connected to the Coquitlam River, indicated by the solid blue line. Reeve Slough is represented by the polygon and the KFN cemetery is indicated in red. 3

Figure 2. 1963 aerial photograph from (Flight Path #6 - BC 5062:15) of Reeve Slough and the Coquitlam River. The red arrow indicates the most recent evidence of a connection and fish access to the Coquitlam river (City of Coquitlam Archives 2017). 6

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Error! Reference source not found. Project Overview

The Coquitlam River is part of a 253 km^2 watershed in Coquitlam, B.C., Canada, which is part of the larger Fraser River watershed (FWCP 2017). Similar to other natural floodplains of large river systems, this area has experienced extensive human impacts over the past 200 years. Restoration of aquatic systems has become increasingly important in the region as salmon populations decline, and human populations continue to grow. Added stressors, such as damming and logging have contributed to these declines in salmonid species.

The Coquitlam Dam was constructed in the 1900s as a source of hydropower and water for Metro Vancouver (CRWR 2019). The dam altered the river's flow regime, which reduced inundation frequency and the extent of flooding into the floodplain; this change has resulted in decreased habitat for salmonids and the need for restoration. Originally the Coquitlam River was home to all five Pacific salmon species (*Oncorhynchus spp.)* as well as steelhead (*Oncorhynchus mykiss*), Dolly Varden char (*Salvelinus malma*), cutthroat trout (*Oncorhynchus clarkii*), and rainbow trout (*Oncorhynchus mykiss*) (Douglas 2007). Declines have been observed in all species, with the complete extirpation of sockeye (*Oncorhynchus nerka*) from the Coquitlam River watershed (Koop 2011).

Reeve Slough is found within the KFN Indian Reserve #2, which is an 81.9 ha parcel of land located within the Coquitlam River floodplain (Figure 1). A 41 ha lot on the Reserve #2 to the east of Reeve Slough is under development by the KFN for commercial purposes. There is also a cemetery located 5 m to the west of the restoration site that is actively used by the KFN and experiences flood inundation during high flow events. Reeve Creek is located north of Reeve Slough and is known to host salmonid species. This creek has been used for baseline reference conditions to inform the restoration of Reeve Slough.

Approximately 60 years ago, Reeve Slough was a part of the mainstem of the Coquitlam River. However, through time and anthropogenic influence, the channel was cut off and has remained a slough in the floodplain, maintained primarily through groundwater and sporadic inundation during high peak flow events. As a result, fish species cannot access Reeve Slough from the Coquitlam River except during overland flooding events. The long term goal of our sponsor, DFO, is to reconnect Reeve Slough to the Coquitlam River to provide off-channel habitat for overwintering juvenile coho salmon and summer-

rearing chinook because off-channel habitat is likely a limiting factor for salmonids (Nickelson et al. 2011).

Our restoration plan will focus on improving ecological conditions for juvenile salmonids within Reeve Slough by reducing the abundance of invasive fish and invasive plants. We will remove invasive fish species to reduce resource competition and direct predation on juvenile salmonids. We will replace invasive plant species with native vegetation, which will overhang Reeve Slough and provide shade during summer months, increasing DO levels and reducing water temperature. Once these ecological conditions are improved, we suggest conducting a feasibility study for reconnecting Reeve Slough to the Coquitlam River.

Following our study, the proposed reconnection project will be jointly managed by the KFN, DFO, and the North Fraser Salmon Assistance Society (NFSAS). Funding for the Reeve Slough reconnection project is provided by B.C. Hydro's Fish and Wildlife Compensation Project (FWCP). The FWCP funds projects in watersheds that have been impacted by B.C. Hydro dam facilities. DFO and KFN will provide project management and design, along with environmental monitoring during restoration.

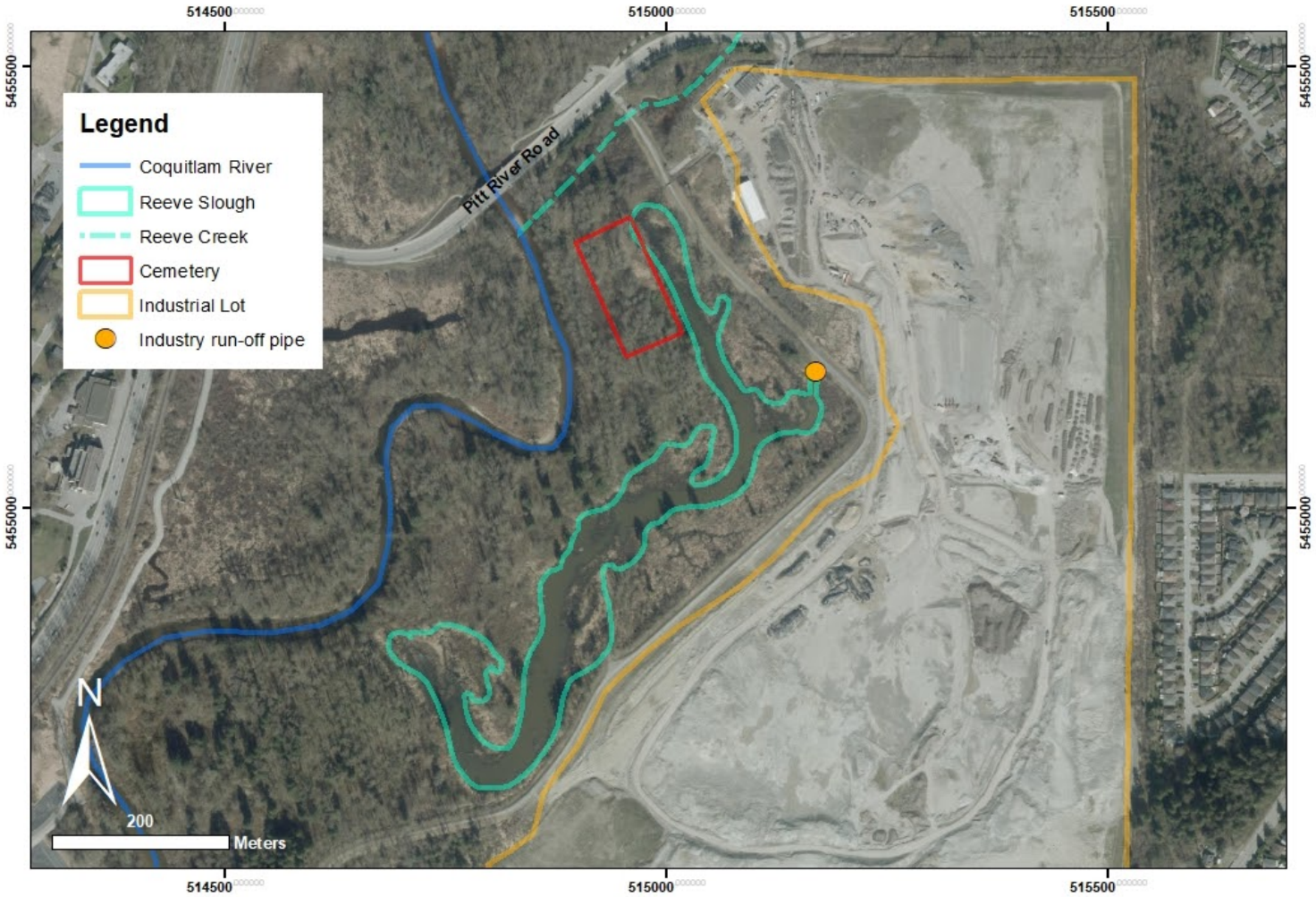

Figure 1. Reeve Slough project site in Coquitlam, B.C. Reeve Slough is located on Indian Reserve #2, next to a KFN cemetery, and a KFN industrial lot currently under construction (2020). Reeve Creek is indicated by the dashed line and it remains connected to the Coquitlam River, indicated by the solid blue line. Reeve Slough is represented by the polygon and the KFN cemetery is indicated in red.

2 Site Conditions

2.1 Coquitlam River Watershed

The Coquitlam River watershed has over 30 tributaries including major tributaries such as Or Creek, Hoy Creek, Scott Creek, and Pinnacle Creek (Houghton 2008). The Coquitlam River originates in the Coast Mountains at Disappointment Lake and flows south through the Coast Mountains into Coquitlam Lake. From the Coquitlam Dam, the river continues southward through Coquitlam and Port Coquitlam until its confluence with the Fraser River.

2.1.1 Glacial History

The Coquitlam River tributaries have been heavily influenced by the advance and retreat of glaciers between 10,000 and 12,000 years ago (Cannings and Cannings 2015). The remaining material is basal and ablation till that is predominantly sandy material which contribute to the present-day drainage characteristics of the Coquitlam River tributaries (Pike et al. 2010).

2.1.2 Recent History

In the 1800s, the human population sharply increased in the Coquitlam area because of the booming lumber industry (CRWR 2019), which led to a higher demand for power. In response, the Coquitlam Dam was constructed on the Coquitlam River from 1904 to 1905 (CRWR 2019). Design and construction of the dam did not incorporate measures for salmon passage, which resulted in salmon no longer being able to access spawning grounds upstream of the dam and the complete extirpation of sockeye (FWCP 2017). The building of the Coquitlam Dam altered large woody debris and sediment recruitment and transport in the watershed below the dam (FWCP 2017).

Few historical records exist that document the abundance of spawning salmon in the Coquitlam River. However, anecdotal witnesses were recorded describing return numbers in the thousands (Koop 2011). A Water Management Study from the B.C. Ministry of Environment estimated that there was a 92% decrease in spawning salmon in the Coquitlam River between 1951 and 1957 (MoE 1978). This decline coincided with a surge in development in both Coquitlam and Port Coquitlam. In addition, gravel removal in the Coquitlam River watershed was conducted by industry and government in the 1950s to mid-1960s, which has led to a severe reduction in suitable salmon spawning grounds (FWCP 2017).

Bank erosion and increased sediment in the streams associated with poor logging practices in the 1960s and 1970s further degraded salmonid habitat (Houghton 2008). Additional stress from the continued development and urbanization of the watershed had widespread impacts on the streams, including altered flow regimes and polluted stormwater entering the stream system (Houghton 2008).

2.2.3 Reeve Slough History

Reeve Slough has had limited inundation from the mainstem of the Coquitlam River since the construction of the Coquitlam Dam. A 1963 aerial photograph shows that the southern end of Reeve Slough appeared to have a connection to the Coquitlam River which would have allowed fish access (Figure 2). Since that time, the southern connection has become cut off and overland flooding is the only way fish are able to access Reeve Slough from the Coquitlam River. Currently, during overland flooding a connection to the Coquitlam River is formed only if water levels rise by 2 m (Douglas 2007).

Further development around Reeve Slough includes a dike that runs along the east side which separates it from the KFN industrial lot. Construction of the dike began in 1993 and was completed in 1994. Development of the industrial lot began in 1995 and a run-off pipe was constructed which directed stormwater into Reeve Slough.

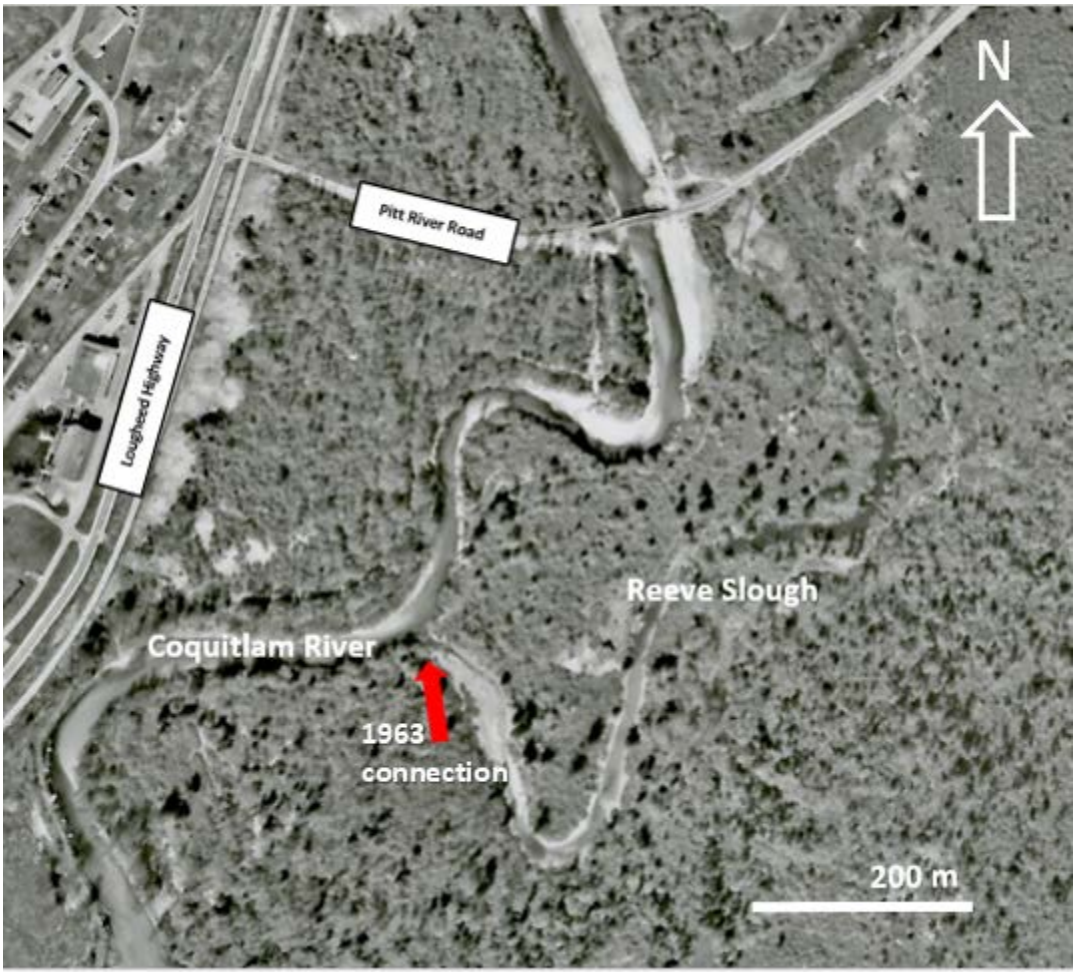

Figure 2. 1963 aerial photograph from (Flight Path #6 - BC 5062:15) of Reeve Slough and the Coquitlam River. The red arrow indicates the most recent evidence of a connection and fish access to the Coquitlam River (City of Coquitlam Archives 2017).

2.3 Current Conditions

2.3.1 Coquitlam River Flow Conditions

The Coquitlam River is supplied by glacial melt, snow melt, and rain. In the upper watershed, water is captured by the Coquitlam Reservoir and the Coquitlam Dam spillway controls the outflow. Because of the coastal influence causing increased rainfall events in fall and winter, peak flows in the Coquitlam River occur between October and January (FWCP 2017). According to Douglas (2007) peak flow events are one of the only times when fish are able to access Reeve Slough. This is due to high discharge values from the dam (over 140 m^2/s) and overflow from a nearby stormwater drain in Port Coquitlam. In such instances, the KFN cemetery adjacent to Reeve Slough is also flooded (Douglas 2007).

2.3.2 Fish Assessment Methods and Results

Reeve Creek has been chosen as a baseline reference site because it is able to be accessed by fishes easily. Reeve Creek has water quality conditions that would be suitable and that allow the presence of native fish species, including salmonids (M. Manson, DFO, pers. comm.). The parameters we wish to replicate in Reeve Slough are DO, temperature, pH, and turbidity.

DFO conducted fish sampling in Reeve Creek and Reeve Slough on 22 March 2019. Twenty-five Gee minnow traps were soaked for 24 hours and DFO found native species in Reeve Creek and found only invasive species in Reeve Slough (Table 1) (Appendix A).

We conducted additional fish sampling on 19 October 2019 and 10 March 2020 using 19 Gee minnow traps; 11 traps were set 1 m from shore and the rest were set 5 m from shore using a small rowboat in Reeve Slough. Traps in Reeve Creek were set from the bank. We baited traps with cat food and soaked them for 24 hours (Appendix B). Our sampling revealed several native species in all 6 traps in Reeve Creek whereas we found only invasive species in Reeve Slough (Table 1) (Appendix C).

Table 1. Comparison of DFO fish sampling data from 22 March 2019 and BCIT fish sampling data from 19 October 2019 and 10 March 2020 in Reeve Creek and Reeve Slough.

Reeve Creek	**Invasive (I) or Native (N)**	**DFO**	**BCIT Fall**	**BCIT Spring**
American bullfrog (tadpole) (*Lithobates catesbeianus)*	I	0	3	0
Coho (*Oncorhynchus kisutch*)	N	8	0	0
Largescale sucker (*Catostomus macrocheilus*)	N	2	20	2
Prickly sculpin (*Cottus asper)*	N	1	2	0
Pumpkinseed (*Lepomis gibbosus*)	I	1	0	0
Threespine stickleback (*Gasterosteus aculeatus*)	N	100	76	32
Reeve Slough				
American bullfrog (tadpole) (*Lithobates catesbeianus)*	I	0	1	2
Black crappie (*Pomoxis nigromaculatus*)	I	1	1	0
Brown bullhead (*Ameiurus nebulosus*)	I	1	27	1
Chinese weather loach (*Misgurnus angullicaudatus*)	I	8	12	1
Crayfish (*Pacifastacus leniusculus*)	N	0	1	0
Pumpkinseed (*Lepomis gibbosus*)	I	46	4	0

2.3.3 Water Quality Methods and Results

Water quality was assessed in Reeve Creek and Reeve Slough using a handheld YSI multiparameter meter on 18 October 2019, 29 January 2020, and 10 March 2020 for a total of seven stations (Table 2) (Appendix D). We selected stations in Coquitlam River, Reeve Creek, and several locations in Reeve Slough. Reeve Creek and the Coquitlam River were chosen to assess conditions in areas currently used by salmonids, while Reeve Slough stations were chosen to examine water quality within the restoration site. Previous water temperature data exist from a preliminary study encompassing Reeve Slough; Fernhill Consulting measured water temperature on 22 August 2007 and recorded 22°C in Reeve Slough (Douglas 2007).

Table 2. Water quality data collected on 18 October 2019, 29 January 2020 and 10 March 2020 in Reeve Creek (RC) (reference site; wq01 and 02), Reeve Slough (RS) (treatment site; wq03) and the Coquitlam River (CR) (reference site wq04 to 06).

		October 2019			January 2020			March 2020		
Station	**Location**	**DO (mg/L)**	**pH**	**Temp (℃)**	**DO (mg/L)**	**pH**	**Temp (℃)**	**DO (mg/L)**	**pH**	**Temp (℃)**
wq01	RC	5.4	6.4	11.9	6.6	6.4	9.7	9.4	6.9	8.6
wq02	RC	2.2	6.1	12.8	7.8	6.3	9.9	4.8	6.7	9.2
wq03	CR	*	6.6	9.3	13.2	6.1	5.2	14.2	7.0	4.6
wq04	RS	4.9	6.4	9.5	7.9	6.6	6.3	8.1	6.9	7.3
wq05	RS	7.9	7.8	9.9	7.3	9.6	6.9	5.5	7.3	6.1
wq06	RS	5.5	6.6	10.1	5.7	8.8	6.5	5.7	6.8	4.8
wq07	RS	5.1	7.0	10.3	6.3	8.2	6.4	8.5	6.8	7.3

* This measurement is absent due to user/equipment error.

2.3.3.1 Water Quality Discussion

In our sampling there were measurements that were outside optimal ranges for juvenile salmonid growth and survival including high pH following a storm event, high summer temperatures, and some less-than-optimal DO measurements (Table 2) (Appendix E) (Brett 1952).

On 29 January 2020 after a storm event that resulted in increased runoff, we found increased pH levels near the industrial run-off pipe with 9.6 being the highest measurement. This measurement of pH is potentially harmful to salmonids since a pH of above 10 is considered lethal for most fish species (EIFAC 1969)

The measurement taken on 22 August 2007 of 22.0 °C in Reeve Slough is stressful because the lethal limit is 26.0 °C for coho and 25.1°C for chinook (Brett 1952, Amour 1991, McCullough 1999). This suggests that Reeve Slough is not suitable off-channel summer habitat for juvenile chinook as the high temperature would cause stress.

We found DO to be suboptimal in 12 measurements during our sampling sessions in October, January, and March (Table 2). Growth rate and food conversion efficiency for juvenile coho is optimal at DO

concentrations of above 5.0 mg/L (Herrmann et al. 2011, McMahon 1983). Swimming speeds can decrease at DO concentrations lower than 6.0 mg/L which can make juvenile salmonids more susceptible to predation (McMahon 1983).

2.3.4 Vegetation Assessment Methods and Results

We conducted a vegetation survey on 19 October 2019. We used a 30 m zone for the riparian vegetation survey, as this represents the area influenced by the aquatic ecosystem (Ackerman 2001). We surveyed along 10 m by 1 m transects in the near-shore (0 m), mid-shore (15 m from shoreline), and far-shore (30 m from shoreline) (Appendix F) (Figure 3). We had 10 survey transects in total; 4 near-shore, 4 mid-shore, and 2 far-shore transects. The location of each transect was randomly selected. Each plant species was given a rating based on abundance in the transect, designated as low (L), abundant (A), or dominant (D). One species per transect was assigned as dominant.

Figure 3. An example of near-shore, mid-shore, and far-shore distances used during our vegetation sampling at Reeve Slough on 19 October 2019. For the survey our 10 transect locations were at randomly selected locations around Reeve Slough.

We documented a total of 49 plant species around Reeve Slough (Appendix G). Of the 19 plant species assigned abundant and dominant ratings, 5 were invasive species (Appendix H). The invasive species found along our transects included reed canary grass (RCG) (*Phalaris arundinacea)*, yellow iris (*Iris pseudacorus),* Himalayan blackberry (*Rubus ameniacus)* and purple loosestrife (*Lythrum salicaria)* (Table 3). The data from each transect can be found in Appendix I.

Table 3. Dominant and abundant plant species found during our vegetation survey on 19 October 2019 around Reeve Slough. The percentages show in how many of the transects the species was dominant or abundant.

Species	**Near-shore**	**Mid-shore**	**Far-shore**
Reed canary grass	75%	100%	0%
Himalayan blackberry	0%	10%	10%
Yellow iris	50%	25%	0%
Purple loosestrife	10%	10%	5%

2.4 Stressors and Impacts

Reeve Slough is in an urbanized area of Coquitlam with major roadways (Lougheed Highway and Pitt River Road), dense residential areas and frequent active construction. Current stressors of Reeve Slough include the surrounding industrial activity, impervious surfaces, and invasive plant and fish species.

2.4.1 Impervious Surfaces

Surrounding impervious surfaces contribute to increased stormwater run-off that often contains heavy metals and other pollutants that impact the growth and survival of fish (Johnson et al. 2011). Observable symptoms of nonpoint source pollution in fish include erratic swimming patterns, loss of equilibrium, and disorientation (McCarthy et al. 2008). Impervious surfaces have limited water storage capacity and do not filter or take in water. Upslope impervious surfaces generate high run-off, which erodes downslope soil surfaces causing more sediment to enter the
water body (Pappas et al. 2008, Jennings and Jarnagin 2002). This erosion and the consequent increase in sedimentation and turbidity, create water quality concerns, specifically for fish. Increased sedimentation can decrease the feeding efficiency of salmon through darker water column conditions, damaged gills, and decreased DO levels because of increased surface area for bacteria growth, and

increased pollutants (Luo et al. 2018, Thompson and Larson 2004). A complete shift in species has been noted in some watersheds as a result of urbanization (Steffy and Kilham 2006).

2.4.2 Invasive Species

2.4.2.1 Invasive Fish

We captured invasive species (brown bullhead, pumpkinseed, and black crappie) that prey on juvenile salmon (E-Fauna B.C. 2019 a,b,c). We also captured Chinese weather loaches, which are tolerant of low oxygen levels and low temperatures. Salmonids have a narrower tolerance to fluctuating water quality parameters and thus, invasive fish species are more likely to outcompete salmonids. Chinese weather loaches are also known to carry parasites that can be transferred to native species, as well as birnavirus (LV1) that is related to salmonid infectious pancreatic necrosis virus (IPNV) (Hanke 2015). IPNV affects primarily juvenile salmonids and can alter growth and feeding patterns, reducing their fitness and likelihood of survival (Damsgard et al. 1998, Multoloki et al. 2016).

2.4.2.2 Invasive Plants

RCG, yellow iris and purple loosestrife can alter the hydrology of a stream or river by constricting waterways and trapping silt (WRCGMW 2009). Yellow iris and purple loosestrife have dense root systems that can also alter waterways by physically blocking water movement and subsurface flow throughout a system. They also create drier conditions for competing native species by using more water than most native species (OFAH/OMNRF 2012, MDNR 2019).

3 Desired Future Conditions

DFO intends to reconnect Reeve Slough to the Coquitlam River to create overwintering habitat for juvenile coho and juvenile summer chinook. Prior to reconnection, however, conditions within Reeve Slough must be improved. The overarching goal of our restoration plan is to improve ecological conditions within Reeve Slough through invasive species removal and native vegetation planting. These planting efforts will help Reeve Slough stay within suitable temperature ranges in the summer so that stream-type chinook can move into the area to escape high water temperatures in the mainstem and the lower temperature is expected to contribute to higher DO (Allen and Hassler 1986, Garner et al. 2017, Kalny et al. 2017). Invasive fish removal will reduce competition and increase available habitat for salmonids.

To establish more suitable conditions, we will minimize the amount of invasive fish and plants in and around Reeve Slough and increase naive plant cover (Table 4). We suggest:

- decreasing the abundance of invasive fish to reduce predation on juvenile salmonids and competition for resources between juvenile salmonids and invasive species (Bajer and Sorensen 2012), and
- decreasing the abundance of invasive plants to prevent waterway constriction and drying of the channel.

Table 4. Desired parameters in Reeve Slough to support overwintering coho and summer rearing chinook.

Parameter / Species	**Coho**	**Chinook**
Season	Winter	Summer
Optimal Temperature (°C)	12.0 to 14.0[1,2,3]	4.5 to 19.1[1,4,5]
Lower and Upper Lethal Temperature Limits (°C)	1.7 to 26.0[1,2,3]	Greater than 25.1[1,4,5]
Optimal Dissolved Oxygen (mg/l)	5.0 to 8.3[6,7]	7.75 to 13.0[4,8]
Dissolved Oxygen Lower Limit (mg/l)	3.0[6,7]	4.25[8,9]

[1]Brett 1952, [2]Stein et al. 1972, [3]Amour 1999, [4]Raleigh et al. 1986, [5]McCullough 1999, [6]Colt et al. 1979, [7]McMahon 1983,[8]Davis 1975, [9]Whitmore et al. 1960

4 Restoration Goals and Objectives

Goal 1: Reduce abundance of invasive fish and plant species in Reeve Slough prior to establishing a connection between Reeve Slough and the Coquitlam River.

Objective 1.1: Reduce the abundance of invasive fish in Reeve Slough by 90%, through intensive trapping from January to March and from October to November in 2020, 2021, 2022 and 2023 (FRGZ 2006, MDNR 2020, Sharpe 2019).

Objective 1.2: Reduce abundance of RCG, yellow iris, Himalayan blackberry and purple loosestrife by 80%, within 30 m of Reeve Slough, by spring 2022, to prevent constriction of waterways (WRCGMW 2009).

Goal 2: Improve the quality of rearing habitat for overwintering rearing juvenile coho and summer rearing chinook salmon in Reeve Slough.

Objective 2.1: Increase native riparian vegetation by 30% within 5 m of Reeve Slough to provide solar cover and aim to increase DO in Reeve Slough to between 6.0 to 9.0 mg/l and decrease summer temperature to between 16 °C and 19 °C by 2026.

5 Restoration Treatments

5.1 Invasive Species

5.1.1 Invasive Fish

We will use a combination of traps and electrofishing to reduce the abundance of invasive fish in Reeve Slough. The population size will be estimated using CPUE methods and absolute abundance will be calculated using a multi-pass depletion technique (Skalski et al. 2005). A decline in catch after each trapping period would be attributed to a reduced density of invasive fishes (Skalski et al. 2005, Hubert and Fabrizio 2007).

5.1.1.1 Trapping

Trapping will be conducted over 2 periods: the first between January and March and the second between October and November. Two sessions will occur in the first period (January to March) and 3 sessions will occur in the second (October to November). Each session will consist of a 24 hour trap set. This will allow species to be trapped before their respective breeding seasons (first period), as well as directly after emergence (second period) (FRGZ 2006, Sharpe 2019, MDNR 2020). All individuals captured will be humanely euthanized using clove oil.

Our methods entail deploying 100 Gee minnow traps per trapping session to provide optimal coverage throughout Reeve Slough. A sampling map dividing Reeve Slough into 2x2 m plots using GIS software will randomly distribute the trap locations. These traps can be used in a variety of habitats and are attached

to a float for retrieval (Portt et al. 2006). Gee minnow traps are used to target juvenile fish and small adult fish (BCMELP 1997). Traps will be soaked for 24 hours (1 session) and baited with cat food. We believe that population size should decrease after the first trap period and as a result, an increase in effort in the second trap period to 150 traps, distributed in the same manner as the first trap sessions. Having an increase in effort (traps) in the second period will increase the opportunity for trapping individual fish.

5.1.1.2 Electrofishing

Electrofishing will occur in conjunction with each period. Two electrofishing days will be allocated for the first session, and 3 days for the second. Due to the size and maximum depth of Reeve Slough, we will use a team of two and a small boat to electrofish the length of Reeve Slough. One team member will wear a backpack electrofisher and the other will collect fish using a dip net (BCMELP 1997).

5.1.2 Invasive Plant Removal

In the City of Coquitlam, RCG, Himalayan blackberry, and other invasive plant species are considered detrimental to local vegetation communities as both species spread aggressively and outcompete native vegetation. The result of this spread is a reduction in plant diversity (Paige and Lilley 2008). To achieve Objective 1.1, we recommend removing RCG, Himalayan blackberry, yellow iris, and purple loosestrife. This is expected to improve the overall health of riparian habitat, to provide increased predation and shading cover, and to prevent constriction of waterways (WRCGMW 2009).

5.1.2.1 Reed Canary Grass

RCG was dominant in 75% of near-shore transects and 100% of mid-shore transects during our vegetation survey. We recommend controlling RCG within 30 m of the channel edge by brushcutting, making all efforts to avoid harming native vegetation. The RCG cuttings will be removed and a shade cloth will be installed to prevent light from reaching the grass, thus reducing regrowth (Tu 2004). Holes will be cut in the cloth around large native vegetation such as trees and shrubs to allow them to survive and retain their structure. RCG treatment will begin by September 2020 and additional treatments of brush cutting and herbicide spot-spraying will be applied, if needed, every July until 2022 (Tu 2004).

5.1.2.2 Himalayan Blackberry

Himalayan blackberry was abundant in 10% of mid-shore and 10% of far-shore transects and was also present with low abundance in 20% of near-shore transects. Himalayan blackberry is near the shore of Reeve Slough, and thus using herbicide is not appropriate. Root crowns will be dug up, and all large root fragments will be removed from the site (Soll 2004). Removal will occur before seeds are produced in the late summer, beginning by August 2020, with treatments continuing until 2022.

5.1.2.3 Yellow Iris

Yellow iris was abundant in 50% of near-shore and 25% of mid-shore transects in our vegetation assessment. In mid-summer, we will use hand pulling and digging to remove rhizomes and prevent seed dispersal. Seed pods will also be cut off before rhizome removal, as they disperse aquatically in the spring and fall (Invasive Species Council of B.C. 2017). Crews will be careful to reduce fragmentation while hand pulling to reduce risk of spreading (Invasive Species Council of B.C. 2017). We will perform removal annually until 2022.

5.1.2.4 Purple Loosestrife

Purple loosestrife was abundant in 10% of near-shore and 10% of mid-shore transects, in small isolated patches. We will remove plants by digging out the entire root system to prevent regrowth (Scott and Robbins 2006). Plants will be removed mid-summer before seed production. We will perform removal annually until 2022.

5.1.3 Native Vegetation Planting

After the first year of our invasive plant treatment plan we recommend planting native species to achieve Objective 2.1. We will mulch and plant native tree and woody shrub species around Reeve Slough. Planting will stabilize bank material and increase solar cover over the water (Meehan et. al 1977). Native riparian plant coverage will promote overall species diversity and influence the abundance of invertebrates on which juvenile salmon prey on (Pusey and Arthington 2003). Riparian vegetation can help to lower water temperature by reducing net solar energy (Meehan et. al 1977, Garner et. al 2017).

We will conduct fall planting and mulching immediately after invasive removal. This will reduce the bare soil exposed to erosion and help prevent regrowth of invasive plants (Grace 2002). We will plant shrub

species that reflect the existing native community, which includes hardhack (*Spiraea douglasii*), willow sp. (*Salix*), red-osier dogwood (*Cornus sericea*), and salmonberry (*Rubus spectabilis*). Each of these species will be planted with 1 m spacing and within 1 to 5 m of the channel edge, depending on soil moisture levels. Tree species such as black cottonwood (*Populus trichocarpa*) and paper birch (*Betula papyrifera*) will be planted with 4 m spacing and within 5 to 10 m from the channel edge. As the native plants mature, they will shade out Himalayan blackberry and RCG, assisting with long-term management of the invasive species (Soll 2004). Planting should be completed by October 2020 and repeated in subsequent years if necessary.

6 Monitoring Plan

6.1 Monitoring Overview

Our monitoring plan will follow invasive fish species abundance, invasive vegetation cover, and water quality measurements. We will be monitoring the site to track results of the restoration treatments from fall 2021 through to fall of 2025 (Table 5).

Table 5. Monitoring schedule overview for invasive plants and fish for Reeve Slough and the surrounding area.

Survey	Frequency	Baseline Data Collection	Post-restoration Monitoring
Invasive Fish	Twice a year	January to March and October to November 2020 and 2021	January to March and October to November 2021 to 2025
Riparian Vegetation	Once a year	June 2020	June 2021 to 2025
Water Quality	Monthly	October 2019 to June 2020	July 2020 to July 2025

6.2 Invasive Species Monitoring

6.2.1 Invasive Fish Monitoring

Our invasive fish monitoring will use the same methods outlined in Restoration Treatment Section 5.1.1. We will compare the mean CPUE after each trap period to monitor changes in invasive species populations. CPUE can be used as an index of density, and it will be assumed that decreased CPUE is

from a decreased density of invasive species (Quist et al. 2009). The data collected in the first year of trapping will form the baseline density and monitoring will continue for 5 years.

6.2.2 Invasive Plant Monitoring

We will conduct a pre-restoration vegetation survey in June 2020 and then each June for the following 5 years. The first year of monitoring will serve as a pre-restoration baseline against which the following years of data will be compared. Monitoring of riparian vegetation will take place in a 30 m zone from the bank of Reeve Slough as this represents the area influenced by the aquatic ecosystem (Ackerman 2001). Our survey will estimate the percent cover of native and invasive plant species including RCG, Himalayan blackberry, yellow iris, and purple loosestrife. For these four species we will monitor progress towards an 80% reduction in area from the baseline. The surveys will be performed mid-summer when plants have easily identifiable flowers and foliage (2021 to 2025).

We will establish 30 sampling sites, each of which will be a 2.82 m radius (25 m^2) plot. The sampling design will consist of 10 plots at each of the following distances from the water: in the near-shore (0 m), mid-shore (15 m from shoreline), and in the far-shore (30 m from shoreline). The first plot along these distances will start at a randomly selected number between 1 and 200 m; from the first point the plots will be 200 m apart. This will ensure that there is a combination of systematic and simple random sampling to provide optimal coverage and unbiased results. To ensure consistent and accurate sample locations each year, locations for each plot will be recorded with a Geo 6000 Trimble GPS unit using a UTM map projection.

The center of each 2.82 m radius plot will be marked with a stake and the radius measured with an Eslon tape. Species present will be identified, and each species' area cover estimated on a scale from trace to 100% of the plot.

We will use a one-way ANOVA test to compare the baseline data with each year's monitoring results. The analysis will be done after the 5 years of monitoring and the results will determine whether the changes in invasive plant species cover are significant and that treatments have been effective.

6.2.3 Water Quality Monitoring

Our water quality monitoring will use methods outlined in the Current Conditions Section 2.3.4 with a focus on DO and temperature measurements. In October 2019, we obtained UTMs for each sampling

station using a Geo 6000 Trimble GPS unit, which will allow our monitoring to occur in the same location at each sampling session. We will use a handheld YSI Professional Plus multiparameter meter that has been calibrated according to manufacturer specifications before each sampling session. Samples will be taken from the point furthest south first then continue to the further point north, or upstream. Measurements will be taken at both the surface of the water and at a 1 m depth in order to include surface and benthic conditions.

We will conduct post-restoration monitoring for 5 years following implementation of the restoration plan (2021 to 2025); this will consist of monthly sampling to monitor long-term trends in DO and temperature in Reeve Slough and reference sites. Sampling monthly will allow us to capture the effect of seasonal temperature, river flow and vegetation cover on DO and temperature. We will compare the first year of monitoring to the following years for both DO and temperature within Reeve Slough, Coquitlam River, and Reeve Creek using a one-way ANOVA.

7 Maintenance Plan

Long-term maintenance may be required on the Reeve Slough site to ensure the restoration goals and objectives are achieved. Our maintenance plan focuses on vegetation management, including invasive plant removal and native plant survival, and invasive fish management, including invasive fish trapping. The level of effort will be determined throughout the monitoring phase of the project.

7.1 Invasive Fish Maintenance

Objective 1.1 Section 4 is to reduce invasive fish abundance by 90%; if this reduction has not been achieved, the maintenance plan will be implemented. Removal methods outlined in Section 5.1.1 will be followed for all maintenance activities. The monitoring plan will be continued for 5 years to follow invasive fish population trends. Periodic trapping will be carried out following the monitoring period to understand post-restoration trends. Subsequent removals will be implemented if the restoration target has not been met. No additional response post-treatment will be required if the restoration target is met.

If the restoration treatment has shown minimal declines in the fish populations, reduced by 50% to 89%, we will continue to use the outlined methods in Section 5.1.1 until the target is reached. This will aim to

remove species before and after spawning events and maintain a low presence of invasive fish species in Reeve Slough.

A less than 50% reduction in invasive fish populations will determine that an increase in the effort that is outlined in our Restoration Treatment (Section 5.1.1). Four sessions will occur in the first trap period (January to March) and 6 sessions will occur in the second trap period (October to November). This may require increased participation from project stakeholders and student groups, as outlined in Sections 8.1 and 8.2. Some training may be needed for setting and retrieving traps, and for fish identification.

7.2 Vegetation Maintenance

Objective 1.2 Section 4 is to reduce invasive plant cover by 80%; if this reduction has not been achieved maintenance will be required. Removal methods and planting prescriptions outlined in Restoration Treatment Section 5.1.2 will be followed for all maintenance activities. The monitoring plan will be continued for 5 years to ensure the long-term success of the native vegetation. We will consider our restoration a success 80% or higher reduction in invasive plant cover.

Should our restoration target not be met, and plant cover has been reduced by 40% to 79%, maintenance measures will be taken. We will continue to remove invasive plants as needed. Opportunistic plantings or staking will occur in areas that are found to have invasive species as their dominant vegetation. This will require minimal involvement, and could be carried out by student groups as outlined in Section 8.2

When monitoring is complete and a reduction of less than 40% has been found, complete reimplementation of the restoration treatments will be done. Following mechanical and manual removal, an increased planting density will be used to promote native species growth. Larger, more established plants will be planted to outcompete invasive vegetation in the understory. This will require increased participation from project stakeholders and student groups, as outlined in Sections 8.1 and 8.2.

8 Public Outreach Plan

Our outreach plan focuses on KFN stewardship of the land and, providing BCIT students sampling experience, and educating the public on limiting the spread of invasive plant and aquarium fish species.

The project site is on KFN Indian Reserve #2 is currently closed off to public access and it is important to discuss what levels of outside involvement, like the participation of student groups, the KFN desires.

8.1 Indigenous Stewardship

The future land use of Reeve Slough, within Indian Reserve #2, will be developed and directed by the KFN, in collaboration with DFO and NFSAS. All discussions regarding treatments and site access will involve the KFN. Future feasibility studies related to the reconnection of Reeve Slough to the Coquitlam River, should be in close communication with DFO to avoid worsening the flooding of the KFN cemetery adjacent to Reeve Slough.

8.2 Student Stewardship and Research

We suggest involving post-secondary students from BCIT in restoration treatments and monitoring. Students can have the opportunity to gain sampling experience in our vegetation and water quality surveys and contribute that valuable data to DFO and KFN. We recommend that BCIT instructors from the School of Construction and the Environment (Master's and Bachelor's in Ecological Restoration, Forest and Natural Areas Management, and Fish, Wildlife and Recreation) establish applied research projects and class field components in Reeve Slough, possibly in collaboration with DFO. These programs all have a year-long capstone project component in which students conduct research and/or write restoration plans. These projects are ongoing from September through April each year, and have varying focusses like wildlife, fisheries, and forestry. Through placement and guidance from DFO and KFN sponsors, we believe that both students and project leaders can benefit from the resulting field work. Students can assist in fall planting and mulching, year-round water quality testing, and invasive plant removal and vegetation monitoring in the spring. They may also choose to do additional research on the site depending on their program focus. This would be treated as an educational experience, which would reduce the cost of labour for basic treatment and monitoring.

8.3 Public Education

Reeve Slough is currently fenced off with accompanying signage. For this reason, members of the public will not be involved in restoration treatments or monitoring. However, because of the presence of invasive plant and aquarium fish species, we believe it is important to inform the public about invasive species dumping and the negative impact on ecosystems. We will reach out to the City of Coquitlam

Parks, Recreation and Cultural Services, who may be able to install signage to remind citizens about the and the detrimental effects of dumping yard waste (which often carries invasive plants) and non-native aquarium species on ecosystem health (Moyle 1976).

9 Project Budget

Treatment Personnel	**Description**	**Units**	**Unit Rate ($)**	**Quantity**	**Tax ($)**	**Line item total ($)**	**Line item total rounded ($)**
Fish trapping crew	Technicians (2)	person hours	20.00[1]	160	n/a	3,200	3,200
Electrofishing crew	Technicians (2)	person hours	20.00[2]	25	n/a	500	500
Vegetation Crew (invasive removal and native planting)	Technicians (4)	person hours	20.00[3]	120	n/a	2,400	2,400
Total	-	-	-	-	-	6,100	**6,100**

[1,2,3] Average hourly wage for Environmental Technicians in Canada from www.payscale.com.

Treatment Equipment	**Description**	**Units**	**Unit Rate ($)**	**Quantity**	**Tax ($)**	**Line item total ($)**	**Line item total rounded ($)**
Inflatable boat	For electrofishing	Boat	179.98[4]	1	n/a	179.80	180
Electrofishing dip net*	For electrofishing	Net	183.00[5]	1	n/a	183	180
Electrofishing (backpack)*	For electrofishing	per/day	300.00[6]	10	n/a	3,000	3,000
Gee minnow traps*	For fish trapping treatment	Trap	19.99[7]	100	n/a	1,999	2,000
Clove oil	Euthanization method for invasive fish	118 mL bottle	30.00[8]	2	n/a	60	60
Trap bait (canned cat food)	Bait to be set in Gee minnow traps, 0.5 cans per trap	156 g can (96 pack and 4 cans)	58.74 + 2.60[9]	5	n/a	763.62	765
Dip nets*	For processing fish from traps	unit	1.29[10]	6	n/a	7.74	8
Buckets*	For processing fish from traps	unit	36.50[11]	4	n/a	146	150
Fish measuring board*	For processing fish from traps	unit	19.99[12]	2	n/a	39.98	40
Total	-	-	-	-	-	6,398.63	**6,400**

*is for in-kind donations

[4] Aqua Marine Motor Sports inflatable boat on www.walmart.ca.

[5] Electrofishing pole and mesh dip net from Smith-Root on www.smith-root.com.

[6] Electrofishing backpack rental estimate from Hoskin Scientific.

[7] Gees Feets G-40 Minnow Trap on www.amazon.ca.

[8,9,10,11,12] Product estimates from www.amazon.ca.

Baseline Data and Monitoring Personnel	**Description**	**Units**	**Unit Rate ($)**	**Quantity**	**Tax ($)**	**Line item total ($)**	**Line item total rounded ($)**
Vegetation monitoring	Technicians (4)	person hours	20.00[13]	72	n/a	1,440.00	1,440
Water Quality	Technician	person hours	20.00[14]	172	n/a	3,450.00	3,450
Total	-	-	-	-	-	5,290.00	**5,290**

[13,14] Average hourly wage for Environmental Technicians in Canada from www.payscale.com.

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Appendices

Appendix A: Fish sampling data 22 March 2019.

Fish sampling data from 22 March 2019 from Reeve Slough and Reeve Creek provided by DFO. Gee minnow traps were used to sample and were set for 24-hour soak time.

Code	Species Name
CO	Coho
TSB	Threespine stickleback
PMB	Pumpkinseed
BCB	Black crappie
BNH	Brown bullhead
LSU	Largescale sucker
OWU	Chinese weather loach
CAS	Prickly sculpin

Trap #	Location	Species	Count	Invasive (I) or native (N)
1	RC	CO	1	N
1	RC	TSB	7	N
2	RS	PMB	2	I
2	RS	BCB	1	I
3	RS	PMB	1	I
4	RS	BNH	1	I
5	RS	PMB	1	I
6	RC	CO	3	N
6	RC	TSB	1	N
7	RC	TSB	12	N
8	RC	CO	1	N
8	RC	TSB	42	N
9	RC	TSB	30	N
10	RC	CO	2	N
11	RC	N/A	0	
12	RC	CO	1	N
12	RC	PMB	1	I
12	RC	LSU	1	N
13	RC	TSB	8	N
13	RC	CAS	1	N
13	RC	LSU	1	N
14	RS	N/A	0	
15	RS	PMB	30	I
15	RS	OWU	6	I
16	RS	PMB	7	I

17	RS	PMB	3	I
18	RS	PMB	1	I
19	RS	N/A	0	
20	RS	N/A	0	
21	RS	N/A	0	
22	RS	PMB	1	I
22	RS	OWU	1	I
23	RS	OWU	1	I
24	RS	N/A	0	
25	RS	N/A	0	

Appendix B: Fish trap location maps.

Reeve Slough Fish Trap Locations

Author: Anna Bondartchouk
Date: 2020-01-25

Coordinate System: UTM NAD 1983 Zone 10N
Location: Coquitlam, BC, Canada

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Appendix C: Fish sampling data 19 October 2019.

Fish sampling data collected by project team.

Trap #	Location	Species	Count	Invasive (I) or native (N)
1	RC	LSU	2	N
1	RC	TSB	1	N
2	RC	TSB	1	N
2	RC	American bullfrog tadpole	3	I
3	RC	LSU	2	N
4	RC	LSU	5	N
4	RC	TSB	63	N
5	RC	TSB	10	N
5	RC	LSU	4	N
5	RC	CAS	1	N
6	RC	TSB	1	N
6	RC	LSU	7	N
6	RC	CAS	1	N
7	RS	BNH	3	I
8	RS	BNH	4	I
8	RS	OWU	2	I
9	RS	OWU	2	I
9	RS	American bullfrog tadpole	1	I
10	RS	BNH	3	I
10	RS	Crayfish	1	N
11	RS	BNH	8	I
12	RS	BNH	1	I
13	RS	BNH	3	I
13	RS	OWU	1	I
14	RS	BNH	1	I
14	RS	OWU	1	I
14	RS	PMB	2	I
15	RS	OWU	1	I
16	RS	BNH	1	I
17	RS	OWU	4	I
18	RS	BCB	1	I
19	RS	PMB	2	I
19	RS	BNH	3	I
19	RS	OWU	1	I

Appendix D: Water quality sampling locations from 18 October 2019.

Reeve Slough Water Quality Sampling Locations

Author: Anna Bondartchouk
Date: 2020-01-25

Coordinate System: UTM NAD 1983 Zone 10N
Location: Coquitlam, BC, Canada

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Appendix E: Water quality data collected from Reeve Slough and Reeve Creek

The handheld multiparameter meter we used to measure water quality malfunctioned (would not stabilize) while sampling the mainstem Coquitlam River, so DO %, DO mg/L and conductivity were not recorded on 18 October 2019.

18 October 2019

Location	Station #	DO (%)	DO (mg/L)	Conductivity (S/cm)	pH	Temp (℃)
Reeve Creek	Wq01	49.1	5.36	156.6	6.38	11.9
Reeve Creek area ditch	Wq02	21	2.19	300.0	6.1	12.7
Coquitlam River	Wq03	-	-	-	6.57	9.3
Reeve Slough	Wq04	42.6	4.85	248.8	6.43	9.5
Reeve Slough by industrial pipe	Wq05	69.8	7.88	323.9	7.76	9.9
Reeve Slough	Wq06 (surface)	50.7	5.69	311.6	6.63	10.1
Reeve Slough	Wq06 (1 m deep)	47.3	5.33	315.0	6.65	10.1
Reeve Slough	Wq07 (surface)	45.9	5.14	257.8	6.97	10.3
Reeve Slough	Wq07 (1 m deep)	45.8	5.13	257.3	6.92	10.3

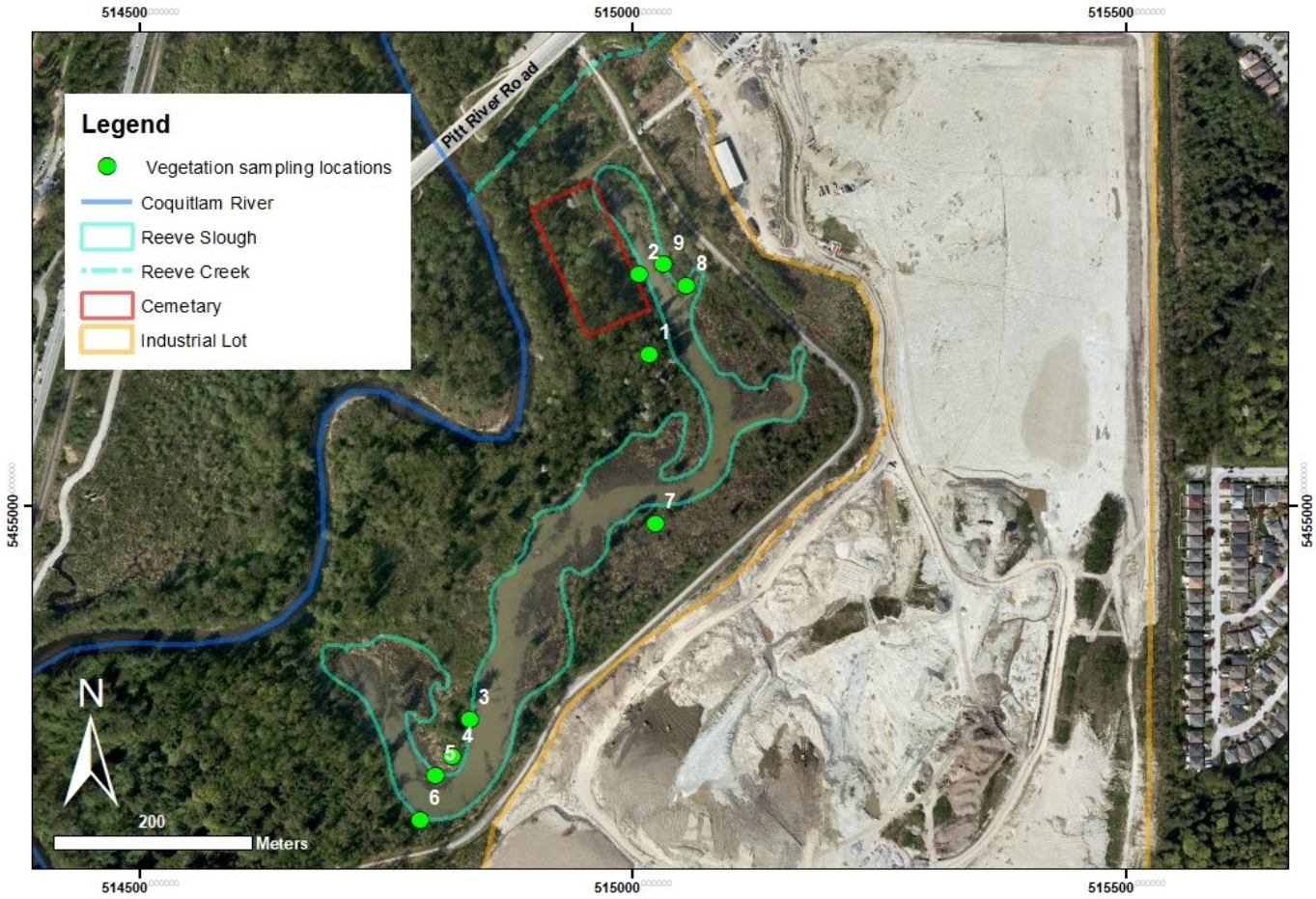
Water quality data collected by the project team on 29 January 2020 in Reeve Slough, Reeve Creek and the Coquitlam River.

Location	Station #	DO (%)	DO (mg/L)	Conductivity (S/cm)	pH	Temp (℃)
Reeve Creek	Wq01	58.3	6.6	281.2	6.4	9.7
Reeve Creek area ditch	Wq02	68.5	7.8	285.7	6.3	9.9
Coquitlam River	Wq03	103.5	13.2	24.3	6.1	5.2
Reeve Slough	Wq04	71.7	7.9	138.8	6.6	6.3
Reeve Slough by industrial pipe	Wq05	91.8	7.3	123.3	9.6	6.9
Reeve Slough	Wq06	46.6	5.7	96.9	8.8	6.5
Reeve Slough	Wq07	51.1	6.3	152.2	8.2	6.4

Water quality data collected by the project team on 9 March 2020 in Reeve Slough, Reeve Creek and the Coquitlam River.

Location	Station #	DO (%)	DO (mg/L)	Conductivity (S/cm)	pH	Temp (℃)
Reeve Creek	Wq01	80	9.4	389.4	6.9	8.6
Reeve Creek area ditch	Wq02	42.5	4.8	337.2	6.7	9.2
Coquitlam River	Wq03	109.6	14.2	37.3	7.0	4.6
Reeve Slough	Wq04	66.5	8.1	203.8	6.9	7.3
Reeve Slough by industrial pipe	Wq05	44	5.5	431.3	7.3	6.1
Reeve Slough	Wq06	44.5	5.7	121.1	6.8	4.8
Reeve Slough	Wq07	71	8.5	161.7	6.8	7.3

Appendix F: Vegetation sampling locations from in and around Reeve Slough, 19 October 2019.



Reeve Slough Vegetation Sampling Locations

Author: Anna Bondartchouk
Date: 2020-01-25

Coordinate System: UTM NAD 1983 Zone 10N
Location: Coquitlam, BC, Canada

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Appendix G: List of plant species located in and around Reeve Slough collected 19 October 2019.

Common Name	Scientific Name	Species status: native (N), invasive (I) or exotic (E)
Beaked hazelnut	Corylus cornuta	N
Bitter cherry	Prunus emarginata	N
Black cottonwood	Populus trichocarpa	N
False lily-of-the-valley	Maianthemum dilatatum	N
Fringecup	Tellima grandiflora	N
Hairy cat's-ear	Hypochaeris radicata	N
Hardhack	Spiraea douglasii	N
Himalayan blackberry	Rubus armeniacus	E
Hooker's fairybells	Prosartes hookeri	N
Indian-plum	Oemleria cerasiformis	N
Lady's-thumb	Persicaria maculosa	N
Lady fern	Athyrium filix-femina	N
Giant horsetail	Equisetum telmateia	N
Licorice fern	Polypodium glycyrrhiza	N
Nootka rose	Rosa nutkana	N
Pacific crab apple	Malus fusca	N
Pacific ninebark	Physocarpus capitatus	N
Paper birch	Betula papyrifera	N
Policeman's helmet	Impatiens glandulifera	E

Purple loosestrife	Lythrum salicaria	E
Red alder	Alnus rubra	N
Red-osier dogwood	Cornus sericea	N
Reed canarygrass	Phalaris arundinacea	E
Salmonberry	Rubus spectabilis	N
Small-flowered bulrush	Scirpus microcarpus	N
Thimbleberry	Rubus parviflorus	N
Unknown fern		
Unknown grass		
Vine maple	Acer circinatum	N
Wall lettuce	Mycelis muralis	N
Water-pepper	Persicaria hydropiperoides	N
Water-plantain	Alisma sp.	N
Water smartweed	Persicaria amphibia	N
Water shield	Brasenia schreberi	N
Willow sp	Salix	N
Willowherb	Epilobium sp.	N
Yellow iris	Iris pseudacorus	E

Appendix H: Dominant or abundant plant species in each transect.

Species	Nearshore	Midshore	Farshore
Black twinberry	25%		
Common cattail		25%	
Common rush	25%		
Fringecup			50%
Giant horsetail		25%	
Hardhack	50%	50%	
Himalayan blackberry		25%	50%
Lady's-thumb	75%		
Lady fern	25%		
Pacific ninebark		25%	
Policeman’s helmet		25%	
Purple loosestrife	25%	25%	
Red-osier dogwood	75%	50%	
Reed canary grass	75%	100%	
Salmonberry	50%	25%	
Thimbleberry			50%
Water smartweed	25%		
Water shield	25%		
Yellow iris	50%	25%	

Appendix I: Data collected from vegetation transects conducted on 19 October 2019.

Due to a back channel running through Plot 10, a new direction for the transect was randomly chosen and is labelled as Plot 11.

Plot	Distance from Slough	Dominant	Abundant	Low
1	Farshore	Salmonberry	Salmonberry	English holly, Lady fern, Indian plum, bitter cherry, beaked hazelnut, snowberry, non-native oak, paper birch, cottonwood
2	Nearshore	Reed canary grass	Salmonberry, red-osier dogwood	Pepper cress, fringe cup, lady fern, other fern, red elderberry, hardhack, black twinberry, European bittersweet, Nootka rose, black gooseberry, lady's thumb
3	Nearshore	Reed canary grass	Common rush, lady's thumb, lady fern, red-osier dogwood, water smartweed, watershield, yellow flag iris	Alisma, bracken fern, cherry laurel, common dandelion, European bittersweet, hairy cat's ear, hardhack, Himalayan blackberry, Indian plum, salmonberry, snowberry, unknown grass, wall lettuce
4	Midshore	Reed canary grass	Himalayan blackberry, large horsetail, pacific ninebark, policeman's helmet, salmonberry	Black twinberry, bracken fern, European bittersweet, false lily-of-the-valley, lady fern, licorice fern, Nootka rose, pepper cress, red alder, snowberry
5	Midshore	Reed canary grass	Cattail, purple loosestrife, yellow flag iris	Alisma sp., common bullrush, epilobium sp., hardhack, lady's thumb, red-osier dogwood, small-flowered bullrush
6	Nearshore	Reed canary grass	Hardhack, lady's thumb, purple loosestrife, red-osier dogwood, yellow flag iris	Black twinberry, Himalayan blackberry, lady fern, pacific ninebark, salmonberry, water smartweed

7	Midshore	Reed canary grass	Hardhack, red-osier dogwood	Black twinberry, European bittersweet, lady fern, pacific crabapple, willow sp.
8	Midshore	Reed canary grass	Hardhack, red-osier dogwood	Black twinberry, pacific crabapple, policeman's helmet
9	Nearshore	Hardhack	Black twinberry, lady's thumb	Pacific ninebark, reed canary grass
10	Not completed			
11	Farshore	Salmonberry	Himalayan blackberry, fringe cup, thimbleberry	Beaked hazelnut, black gooseberry, English holly, Hooker's fairybell, Indian plum, lady fern, large horsetail, Nootka rose, red elderberry, snowberry, vine maple

Appendix J: Safety Plan

Student Applied Research Project **Safety Plan**	
Date & Version (e.g. 1, 2, etc) (*this plan may be revised*):	Date: 20th October 2019 Version: 1

Part 1 - Emergency Contact Information

Project Title:	Restoration Plan for Reeve Slough, Coquitlam, British Columbia
Brief Project Description:	Reeve Slough is a floodplain of the Coquitlam River but it is infrequently connected to the mainstem. The DFO is interested in restoring this site as it presents an opportunity to create off-channel habitat for juvenile salmonid species. We will be doing field work including, fish trapping, water quality, vegetation and soil sampling.
Primary Project Advisor:	Name: Kim Ives and Lisa Henault Phone number: 604-412-7526 and 604-992-9757 Email: Kives@bcit.ca and Lhenault@bcit.ca

Student Contact Information

	Person 1:	Person 2:	Person 3:	Person 4:
Student Names:	Anna Bondartchouk	Jessie Chestnut	Sonia Waiz	
Cell Phone Number:	604-600-4732	250-937-0072	604-317-1178	

Emergency Contact Name: (must be external from BCIT)	Roman Bondartchouk 604-505-1523	Cole Haider 250-735-2540	Cynthia Waiz 604-538-8163	
Relationship to student:	Father	Significant other	Mother	
Cell Phone Number of Emergency Contact:	604-505-1523	250-735-2540	604-317-5629	
Existing Medical Conditions (among the team):	Applicable? No medical conditions			
Project Location 1 (name of general geographic area & address):	Name: Reeve Slough, Coquitlam BC Address of access: Traboulay PoCo Trail, Port Coquitlam, BC V3C 1R9			
UTM coordinates of location 1:	Coordinates: Easting 514972.84 Northing 5455443.94 UTM zone 10U			
Project Location 2 (name of general geographic area):	Applicable? No Name: _____ Address (if applicable): _____ _____			

	_____
UTM coordinates of location 2:	Applicable? Yes ☐ / No ☐ Coordinates:_____ _____
Name & contact info of project sponsor/client and agency: Sponsoring agency: DFO	Primary contact with agency: Email Contact information: Murray Manson. Murray.manson@dfo-mpo.gc.ca Are you required to complete a permit with this agency? No
Caretaker on site?	No

Part 2 - Check-In/Out Procedure

- Make arrangements with your project advisor to check-in/out each field day.
- Let your advisor know 48 hrs ahead of any field day so they can expect a text/phone call from you in the morning. This person would report a failure to call-in at the end of each field day.
- You may be required to report-in several times a day depending on the nature of the project (i.e. location, distance from hospital).

Anticipated Field Dates: (Give specific dates or if unknown, expected timeframe, days of the week, number of field days, etc.)	Expected 10 days out in the field. Starting in the morning and going until the afternoon. Field days will be on Monday and Friday predominantly.

Cell phone service available?	Yes. Cellphone will be the primary method of communication.
BCIT Project Advisor / Main Contact for Check-In/Out	Name: Lisa Henault Cell phone number: 604-992-9757
Provide a map of the project site(s):	
Frequency of Check-Ins	We will be checking in by text every two hours when on site. We will send a message when we leave the site to let Lisa know we are safe and have left the field.

Part 3 - First Aid & Emergency Response

For Emergency purposes: CALL 911

Emergency Transport: If an emergency requires stabilization and emergency transportation to a hospital it is recommended that you request an ambulance. You will need to ensure the ambulance is met at the access point to your site. Stay on the phone with the 911 operator.

Injury Transport: Only transport an injured individual if the person is stable, ambulatory and able to move themselves. If there is a head injury, do not move the patient. Keep stable in c-spine.	
Nearest Hospital to Project Location 1:	Name: Eagle Ridge Hospital Address: 475 Guildford Way, Port Moody, BC V3H 3W9 Driving distance (km): 7 km
Nearest Hospital to Project Location 2:	Name:_____ Address:_____ Driving distance (km):_____
Team Members with First Aid Training:	Name: Sonia Waiz Level: 50 hour wilderness first aid Name: Jessie Chestnut Level: OFA level 1 Name: _____ Level: _____ Name: _____ Level: _____
First Aid Kit (personal or other):	Team will be required to carry a basic first aid (personal). Where are the first kits located? In a backpack carried with us during the field day

Part 4 - Hazard Assessment & Mitigation Measures

Instructions for the following section:

- List all potential hazards (e.g. slips trips falls, danger trees, wildlife, driving to/from site, hypothermia, etc). Consider the nature of your project.
- Briefly describe each hazard as they pertain to your project
- List measures to reduce risk or exposure to those hazards. Include necessary PPE for risk and exposure reduction, as well as other appropriate strategies.
- Keep realistic and practicable.

Hazards	**Description of tasks where this hazard is pertinent**	**Risk and Exposure Mitigation Measures**

Slips trips and falls	Field work that involves bushwhacking such as water sampling and fish trapping	Wearing proper footwear and being slow and careful
Danger trees	Being close to danger trees for longer periods of time	Keeping an eye out for possible danger trees and not doing field work on windy days
Canoeing: possible hypothermia and drowning	When we use a canoe for taking water quality samples and for fish trapping	Wearing PFD whenever we are in the boat. Having a blanket and another change of clothes close by on shore
Wildlife encounters	Possible encounters with bears and beavers while on site	Keep an eye out for wildlife and stay in a group of at least two
Construction site	We will be checking in with the construction site next door at the start of each field day	Wear safety vest whenever on site and follow instructions of the site