Squamish Central Estuary Brownfield Restoration Project
Final Report
16.CMS.02

Prepared by:
Squamish River Watershed Society
Box 1791
Squamish, B.C.
V08B 0B3

Prepared with the Financial Support of the Fish and Wildlife Compensation Program on behalf of its program partners BC Hydro, the Province of BC, Fisheries and Oceans Canada, First Nations, and Public Stakeholders

November 10, 2015

Executive Summary

The focus of this project was to restore a former log sort back into functional estuarine habitat through re-grading of the site to create a natural tidally influenced wetland salt marsh. Some of the key objectives of this project included: creation of over 35,000 square metres of new estuarine habitat; planting native riparian vegetation; daylighting channels and removal of redundant culverts; removal of fill and overburden and returning the site to historic grades to allow natural estuarine processes to resume; monitoring the site to gauge the carbon sequestering potential (through identifying soil composition, depth, woody debris, and plant matter); installation of educational interpretive signage; exploring eelgrass restoration in the sub-tidal shorelines; Rivers Day Festival event location; and establishing the site as a “living classroom” for university public school students. The 2015 year included the removal of soil layer and re-grading of the site and the construction of tidal channels. Included in the first year were three volunteer planting days (March 7, 22, and September 27) to establish over 2,000 native riparian plants. As well pre-construction monitoring, including soil sampling, bathymetry, aerial surveys, and site survey were completed as part of a long-term monitoring program. Aside from providing important habitat for salmonids and other fisheries and wildlife resources, the restored brownfield will now be used as an outdoor learning classroom by the local schools, university and college students with highlights of the site’s ecological driven services for students. Surveys of the site were conducted in partnership with Squamish Nation and the Seagrass Conservation Working Group to explore the potential for eelgrass restoration along the sub-tidal shoreline. A test planting for eelgrass will be explored in the coming year.

Table of Contents

Abbreviations:

BCIT – BC Institute of Technology
DFO – Fisheries and Oceans Canada
DOS – District of Squamish
LWD – Large woody debris
MFLNRO – Ministry of Forests, Lands and Natural Resource Operations
SFU – Simon Fraser University
SqNtn – Squamish Nation
SRWS – Squamish River Watershed Society
WMA – Skwelwil'em Wildlife Management Area

1.0 Introduction

The Squamish Central Estuary Brownfield Restoration Project restored a former log sort (of over 50 years) back into estuarine habitat through site re-grading to re-create a natural tidally influenced salt marsh. Some of the key objectives of this project included:

- Re-creating functional estuarine salt marsh habitat (including the planting of native sedge marsh plants including Lyngbyei sedge, and other native species (see detailed list in Section 4.4 below);
- Daylighting channels, removal of redundant culverts and berms;
- Removal of ecologically unsuitable imported fill and waste overburden materials, thereby returning the site to historic grades to reestablish natural estuarine processes;
- Recontouring a previously modified estuarine lagoon to re-establish proper functioning sub-tidal foreshore elevations;
- Establish salmon habitat for rearing, overwintering and spawning (focus on Coho and Chinook salmon but benefits for Pink, Steelhead, and Chum salmon as well as other fisheries and wildlife);
- Develop and Installing educational outreach/interpretive signage;
- Exploring eelgrass restoration opportunities in the sub-tidal shorelines; and
- Establishing the subject site as an in-situ “living classroom” for university and high school students.

Year 1 (2015/2016) works commenced in early March 2015 and included soil and water sampling in and around the site to establish base line data as well as identify any potential contamination issues (none of which were identified through the sampling program – but more on this later in the report), surveying of the site to determine the elevations required to remediate the brownfield and to determine the necessary design criteria for restoring tidal channel function. Construction began March 6th and continued until late September to fully regrade the entire site, construct a pedestrian trail along the eastern edge, and construct several tidal channels. In preparation of Year 2 works surveys of the site will be conducted in partnership with the Seagrass Conservation Working Group to explore the potential for eelgrass restoration along the sub-tidal shoreline. Test plantings of eelgrass (*Zostera marina*) will be explored as well.

2.0 Goals and Objectives

The main focus of the project was to reestablish tidally influenced habitat and channels, thereby reestablishing valuable fisheries rearing, spawning and overwintering habitat as well as providing habitat for species at risk, migratory and resident bird populations, and improve flood storage, drainage, and water quality. All of these features will now become the focus of educational experiential learning opportunities through engaging the local elementary schools in the Education Outreach Program or working directly with college and university students to monitor and study the site as it transforms back into naturalized habitat. As well, this area is open to the public and is part of a well maintained interpretive trail system. Signage and news releases will educate the public on the history of the site and the importance of the restoration project. Squamish is a growing community and access to natural spaces is becoming increasingly important and acknowledged by the larger population.

3.0 Study Area

The site is located within the Squamish River Estuary, on the east bank of the Squamish River in the district of Squamish, British Columbia, The subject site is located in the area known as the Central Estuary. Maps covering the site are Natural Resources Canada National Topographic System 92G/11 and GeoData British Columbia Terrain Resource Information Management 92G.065 and 92G.075 near UTM coordinates of 55604250m N by 487600m E (1927 North American Datum, UTM Zone 10U).

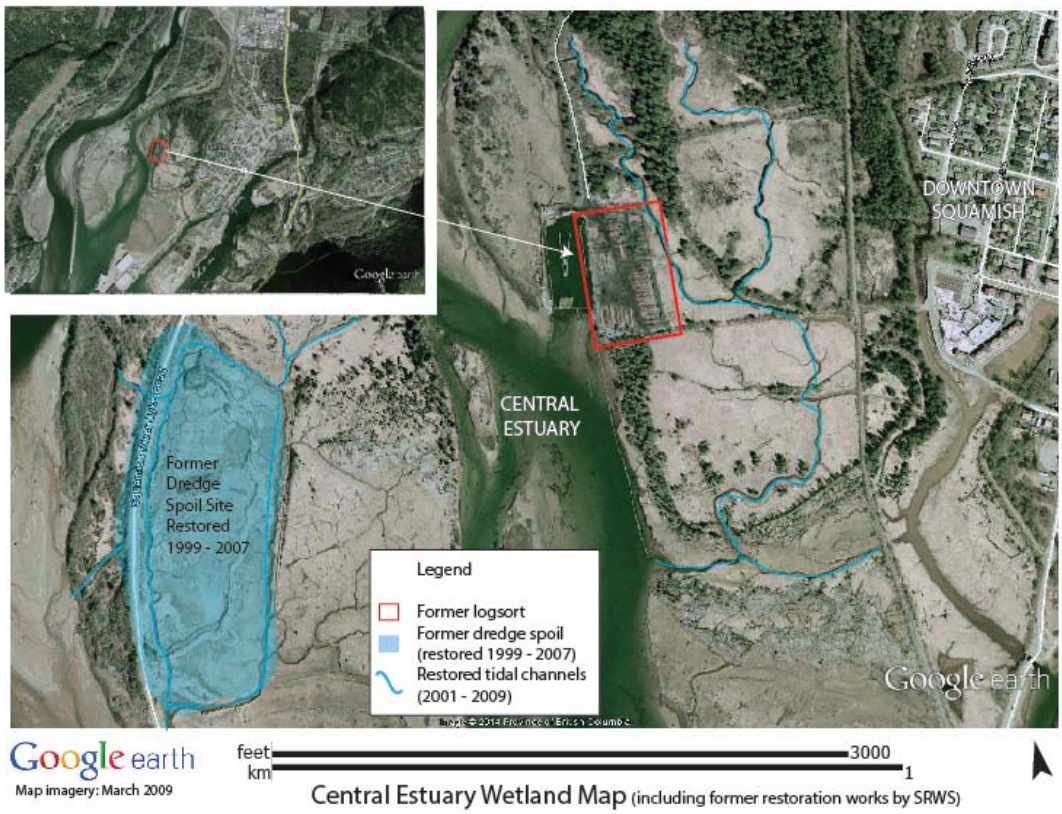
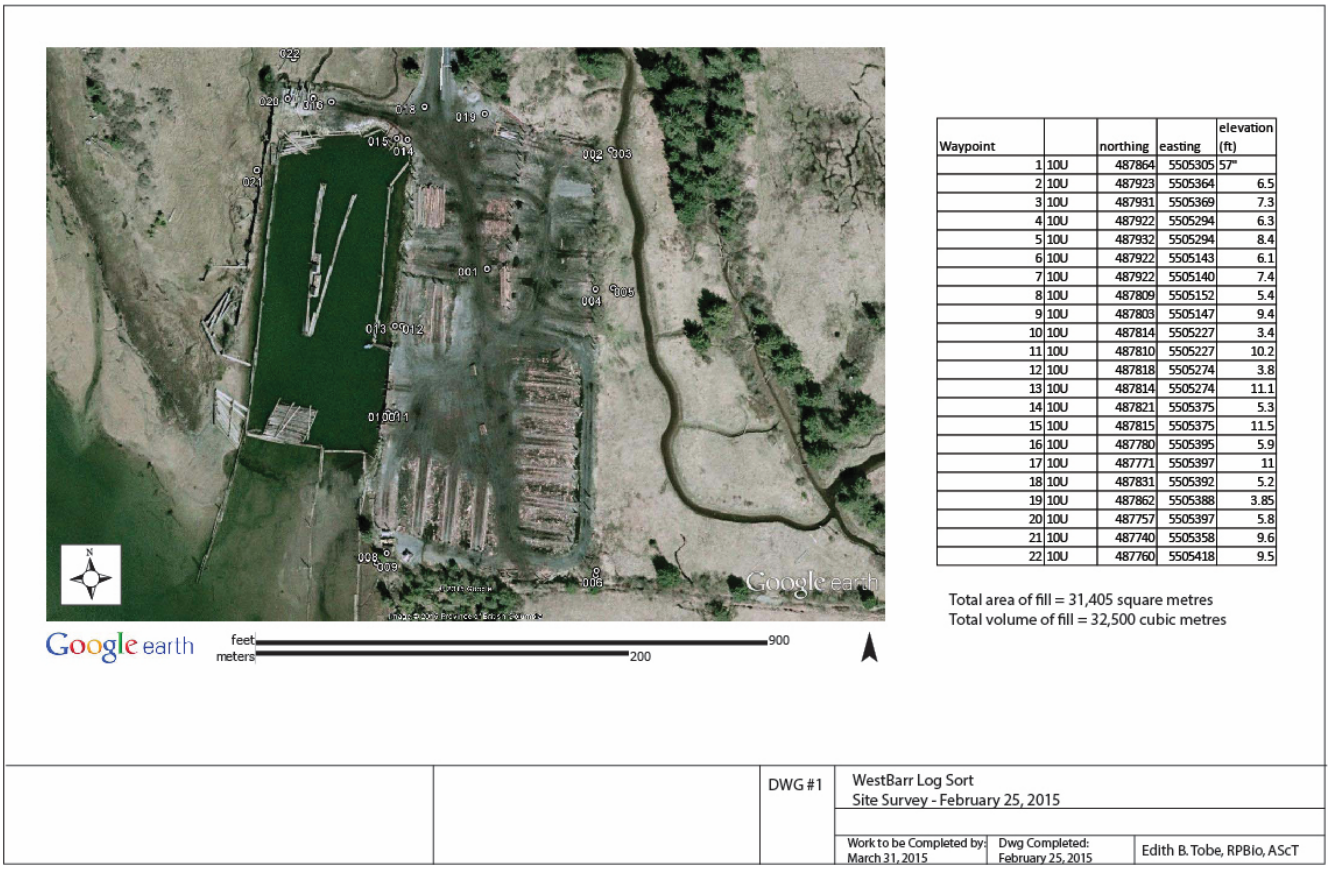


Figure 1. Site location

4.0 Methods

The project proceeded in several stages starting in March 2015. The first stage was to secure all the permits and approvals to undertake the restoration of the site. The Ministry of Forests, Lands, and Natural Resource Operations issued an authorization on March 3rd as part of the Wildlife Act Section 4(4) (refer to Appendix B). The District of Squamish provided verbal confirmation that no site alteration permit was required as the site was fully within the provincial Skwelwil'em Wildlife Management Area (WMA). Squamish Nation also provided approval for the works to proceed, emphasizing their support of the project in recognition of the benefits to Site 'A' within the WMA. Fisheries and Oceans Canada staff were directly involved with every stage of the project and provided the detailed engineering and design drawings for the project.

The Squamish River Watershed Society initially surveyed the site (Figure 2) establishing the total terrestrial and aquatic area and the approximate total volume of material that would need to be removed at around 17,000 cubic metres. Through detailed bathymetry of the log-dump pond the total volume by which the pond could be infilled was established at around 32,000 cubic metres (Figure 3).



Waypoint		northing	easting	elevation (ft)
1	10U	487864	5505305	57'
2	10U	487923	5505364	6.5
3	10U	487931	5505369	7.3
4	10U	487922	5505294	6.3
5	10U	487932	5505294	8.4
6	10U	487922	5505143	6.1
7	10U	487922	5505140	7.4
8	10U	487809	5505152	5.4
9	10U	487803	5505147	9.4
10	10U	487814	5505227	3.4
11	10U	487810	5505227	10.2
12	10U	487818	5505274	3.8
13	10U	487814	5505274	11.1
14	10U	487821	5505375	5.3
15	10U	487815	5505375	11.5
16	10U	487780	5505395	5.9
17	10U	487771	5505397	11
18	10U	487831	5505392	5.2
19	10U	487862	5505388	3.85
20	10U	487757	5505397	5.8
21	10U	487740	5505358	9.6
22	10U	487760	5505418	9.5

Total area of fill = 31,405 square metres
Total volume of fill = 32,500 cubic metres

		DWG #1	WestBarr Log Sort Site Survey - February 25, 2015		
			Work to be Completed by: March 31, 2015	Dwg Completed: February 25, 2015	Edith B. Tobe, RPBio, ASCT

Figure 2. Site survey

An aerial drone was deployed to take an aerial survey of the site for comparison purposes. A follow-up aerial survey is planned for November 2015. The aerial survey can be viewed at: https://youtu.be/X1a0ZYUp1PY.

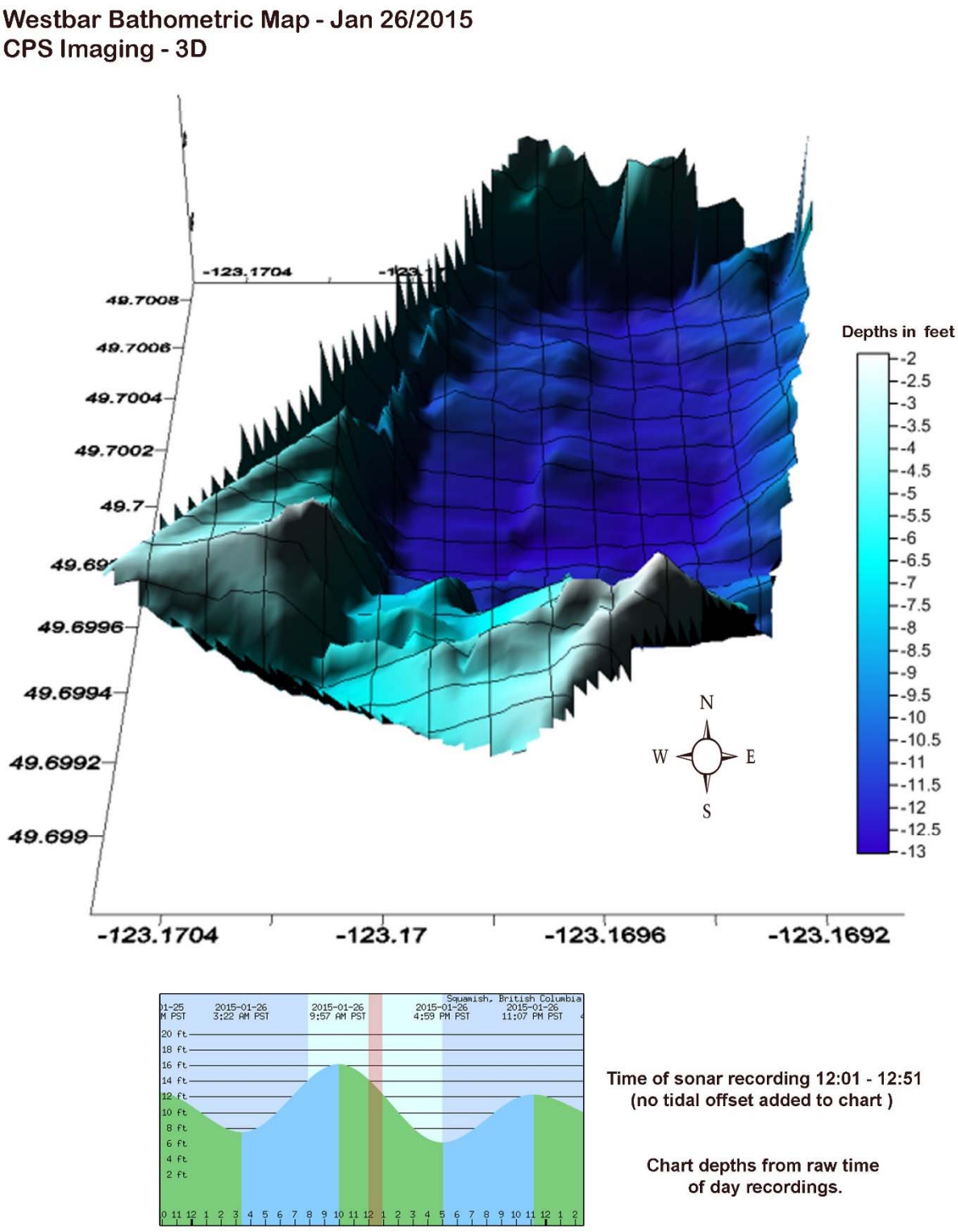


Figure 3. Bathymetry of pond illustrating total pond depth.

In early March, in partnership with Simon Fraser University, soil and sediment sampling were undertaken to establish a baseline of the site (samples being taken on-site and off-site) and to determine if there were any deleterious substances within the subject site and identify any concerns regarding the nature of any contaminates (Photos 1 & 2). Sampling was again undertaken in June once the majority of the overburden of material had been removed. Although the sediment sampling revealed no areas of concern a small pocket of hydrocarbons were detected almost as soon as excavation of the site commenced – not surprisingly under the location of the former fuel tank. With the discovery of the contaminated soils all work in that area ceased immediately and the Provincial government was notified and immediately attended the site. The result was a detailed sampling of the contaminated areas to determine the depth and area affected. All contaminated materials were removed from the site and disposed to a suitable location (materials that exceeded Provincial hydrocarbon limits were transported – two truck-loads – to a suitable location in Burnaby; the remainder of the material, approximately 20 truck-loads, were disposed of at the Squamish land-fill site).

Photo 1 & 2: March 2015. Soil sampling (adjacent to brownfield on natural estuary)

4.1 Central Estuary Side Channel Tidal Connector:

Works commenced in early March with an initial side channel constructed to connect to the existing tidal channels to the south-east of the brownfield site. A small excavator was used to construct the connector tidal channel to reduce impacts to the estuary. The material removed from the channel was side cast in a thin (<0.5m) layer adjacent to the channel which was followed up with dense riparian planting (Photos 3, 4, & 5).

Photo 3 & 4: March 2015 with initial side tidal channel connector

Photo 5: September 2015 showing fully regrown site

Two large excavators (200 and 300 series) were used to clear the vast amount of soil in the main site and two rock trucks were also used to transport the material to initially stockpile at the edge of the log-dump pond and later the excavators were used to push the soil into the pond (Photos 6 & 7).

Any large woody debris uncovered was placed to the site of the site for later use as either complexing or as part of the road deactivation.

The soil was removed to the same elevation as the adjacent natural estuary gradients with some features including ridges, knolls, and small hills to provide variations in the topography to attract different vegetation types and different species of wildlife.


Photos 6 & 7: March 2015. Site excavation – right photo including central tidal channel construction

4.2 Brownfield Tidal Channels:

One large tidal channel was excavated diagonally from the north-east corner (connecting to the Central Estuary tidal channel constructed in 2005) in a meander towards the south-west corner of the site discharging into the lower section of the former log-dump pond. A second ephemeral tidal channel was constructed adjacent to the eastern edge of the site and then following a south-western direction towards the lower section of the former log-dump pond and the smaller side tidal channel for a total of three main new tidal channel connections (refer to photo below and Figure 4).

Photo 8: (courtesy of Colin Bates) taken in June 2015

4.3 Trail Construction:

A narrow walking trail was constructed (i.e. original fill material was not removed) along the eastern and north section of the site to allow access for pedestrian traffic. The walking trail was planted up with native riparian vegetation, in particular with *Salix sitchensis* (Sitka willow), *Myrica gale* (Sweet Gale) and *Spirea* (Purple Spirea or hard hack) to encourage rapid root growth (Photos 9 & 10). During late summer high tide, high flood events in September the surge of water over-topped the trail in some sections providing a good indicator as to the anticipated high water marks expected during the winter king tides. Some crush gravel was placed along the walking trail to establish a narrow 1.0 m wide cordon to smooth the trail out for bicycles and strollers. The walking trail connects the South Loop Trail with the North Loop and Swan Slough Trails.

Photo 9: March 2015. Volunteer planting support

Photo 10: March 2015. Volunteers assisting with planting walking trail

4.4 Wood Waste:

As the soil was being stripped a layer of wood waste was discovered across the entire site approximately 1.0 m below the surface. This material was stripped away and stockpiled (as can be seen in the centre of Photo 11). The total volume of wood waste material was approximately 15,000 cubic metres. Several meetings with staff from the Ministry of Forests, Lands, and Natural Operations (MFLNRO), Fisheries and Oceans Canada (DFO), Squamish Nation, and the District of Squamish were held to discuss how best to manage and ultimately remove the wood waste material from the site. The SRWS worked closely with the District of Squamish (DOS) to determine a suitable location where the wood waste could be removed and the DOS ultimately agreed to allow the wood waste in DL69, which is zoned wood waste disposal (located by the Squamish Airport in Brackendale). The SRWS was able to secure additional outside funding to removal all the wood waste as this cost had not been budgeted for in the existing funding.

Photo 11. July 2015. Wood waste being stockpiled at north end of site (circled in yellow).

4.5 Tree & Shrub Planting Scheme:

Native shrubs were purchased from a native nursery supplier (Peels Nursery).

400 Sweet Gale (*Myrica gale)*
200 Nootka Rose (*Rosa nutkana)*
250 Salmonberry *(Rubus spectabilis)*
250 Thimbleberry (*Rubis parviflorus)*
200 Sitka Willow (*Salix sitchensis)*
500 Purple Spirea/Hardhack (*Spirea douglasii)*
175 Red Cedar (*Thuja plicata)*
25 Sitka Spruce (*Pinus sitchensis)*
1,200 Lyngbyei sedge plugs (*Carex lyngbyei)*

5.0 Results and Outcomes

Using scientifically sound engineering design the Squamish River Watershed Society and Fisheries and Oceans staff developed drawings and construction plans detailing the total area to be restored, the depth to which undesirable materials must be removed, re-contouring of the adjacent lagoon, proposed site grading (including the location and depth of tidal channel excavations), the planting plan, as well as the monitoring plan.

Terrestrial and aquatic sediments were collected at key locations on and off-site (as control) and sent to a soil testing lab to be analyzed for hydrocarbons, metals, wood preservatives, and other potential contaminants that are common to log sorts. Intertidal sediments and site groundwater were evaluated for the same suite of potential contaminants. Soil composition and sediment conventional parameters (e.g. total organic carbon and grain size) were also analysed. Sampling of environmental media was intended to identify any contaminant "hotspots" but the results turned up negative for any significant materials. A summary of the soils testing is being compiled by SFU and Quest University students and will be completed in 2016.

In the spring over 1,400 native trees and shrubs were planted on the site (primarily around the trail) and an additional 600 plants were placed in late September. As well, over 1,000 sedge plugs were translocated from the healthy adjacent estuary and planted approximately 1 meter centers through a test area in the centre of the restoration site. Shrub clumps and sedge meadows provide important wildlife values as well as providing valuable carbon sequestering potential. The SRWS has extensive experience with the successful restoration of these species at other sites within the same estuary and was able to establish a strong base of plant species that should help to "jump start" the natural plant recruitment on the site. Quite unexpectedly, within a few months of removing the overburden of material, there was widespread emergence of native vegetation including cattails, Sitka willow shrubs, and common rush throughout the southern section of the site.

As part of the SRWS ongoing educational programming, students were invited (Quest University, SFU, and BCIT) to participate in experiential learning opportunities to gain first-hand experience on restoration, estuary function, and base-line studies.

Through SCUBA and underwater video the site was surveyed by a trained crew (with over 10 years of experience on eelgrass restoration and techniques) to determine the potential to establish eelgrass test plots along the sub-tidal shoreline. Hopefully in the late winter months test plots will be established in the deepest section of the channel in the former log-dump pond to determine if eelgrass will live in this environment.

Two kiosks were installed at either end of the trail (with benches so the public can enjoy the wildlife) and will contain information on the project and acknowledgement of the funding support and project partners.

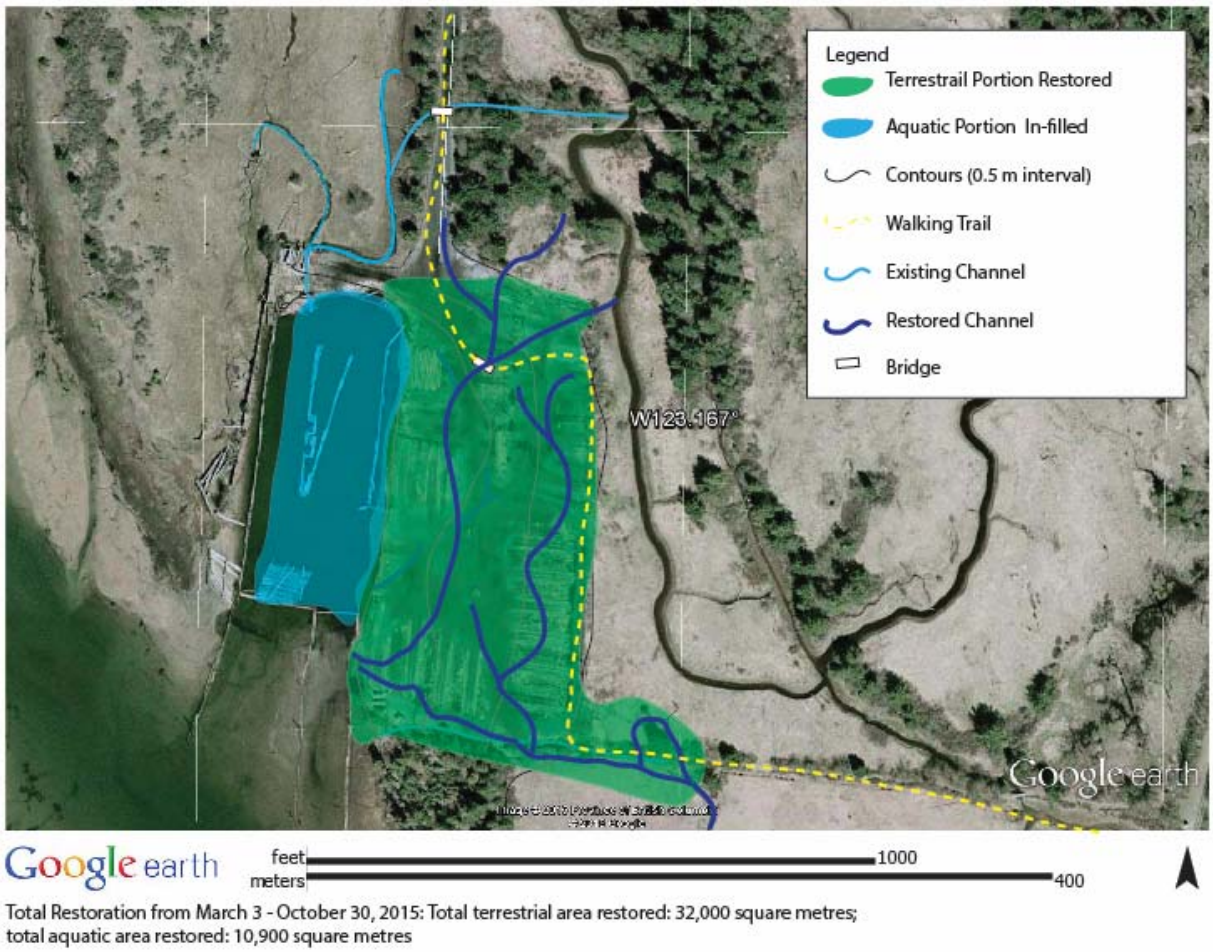


Figure 4. Overview map of actual area restored

6.0 Discussion

The intention of the project was to restore 3.5 hectares of former brownfield lands back into functional estuarine habitat. The result far exceed the original expectations by dramatically increasing the tidal inflow through the multiple new tidal connections that were established creating well over 35,000 square metres of new habitat for salmonids and other fisheries and wildlife habitat during the diurnal tidal cycles. Over 50 large woody debris (LWD) structures were placed throughout the site but the number of LWD has substantially increased with each tidal inundation as the site has naturally recruited new woody debris as high-high tide events. It was anticipated that within 12 – 18 months new vegetation would start to become established on the newly restored site (apart from the species that were hand planted). What was completely a surprise was the volume of cattails, rushes, willow seedlings, and lyngbyei sedge that all cultivated at the southern end of the site within two months of the area being cleared! Extensive effort has been undertaken to study the site to establish base line data prior to the restoration works, during the restoration of the site, and will continue well after all works have been completed. These studies, including soil analysis and chemical composition, water quality measurements, photo-point monitoring, and visual surveys. The

intention is to provide a detailed overview of how the soils, water, and plants transform the lands into functional estuary, as will be contrasted against the estuarine lands adjacent to the site that remained in a natural state. This project site has already become a central component to University and College programs and student projects (SFU, BCIT, and Quest U) and will only continue to provide an ongoing experiential learning environment for years to come.

6.1 Measures of Success:

- Removal of over 25,000 cubic metres of material from the log-sort and infilling of over 10,000 cubic metres into the log-dump pond to create over 35,000 cubic metres of tidally influenced estuary.
- Construction of 200 m connector trail for public access at eastern edge.
- Construction of four new tidal channels exceeding a total linear length of 500m or around 1,500 square metres of habitat.
- Placement of over 50 LWD structures around the site
- Construction of two kiosk/signs (one at each entrance to the trail)
- Total number of partners: 5 (MFLNRO, DFO, SqNtn, DOS, local conservation groups)
- Over 500 volunteers assisting with the project (especially with the riparian plantings).
- Planting of over 2,000 native riparian trees and shrubs and 1,200 sedge plugs.
- Pre and post monitoring of the site to establish baseline data on the soils, water, and plant communities on the site.

6.2 Changes in Project Scope and Outcomes:

No project proceeds without unexpected circumstances. Early on in the project, within days of starting up, the excavator operator uncovered an area contaminated with hydrocarbons (situated directly under the former fuel tank in the south-western corner of the property). The Provincial government was immediately contacted and a contaminated soils expert (Piteau Associates) was brought in to determine the extent of the hydrocarbons and provide recommendations on the removal of the materials. In total over 20 trucks loads of material were hauled off-site (of which only two truck-loads were considered hazardous materials and required shipping to a certified location in Burnaby for treatment). Within one week of first being identified the site was certified clean and work in that area was able to continue.

The second unexpected issue that immediately became apparent was a layer throughout the site of wood waste material (approximately 1.0 metre in depth and approximately 1.0 metres below the surface). This wood waste (also known as hog fuel), although no contamination was found in the tested materials, was nonetheless not deemed to be suitable for infilling the former log-dump pond and arrangements had to be made to find a suitable location off-site to remove the materials. As well as additional funding needed to be secured to cover the costs of the trucking the material away. Several meetings were held between April and June with MFLNRO, DFO, Squamish Nation and DOS staff to discuss options for the disposal of this material. By early August all wood waste (over 15,000 cubic metres) was removed to a location on District of Squamish Lands (Lot DL69) located adjacent to the Squamish Airport and zoned for the storage of wood waste.

One of the unexpected benefits of the project was the ability to work closely with staff from the Provincial government and Squamish Nation to discuss deactivating the access road (which runs through the Skwelwil'em Wildlife Management Area and Squamish Nation Site 'A'). There was strong support for this extension (beyond the scope of the FWCP project funding) and the opportunity to expand the project and extend the pedestrian access trail to the north was well received.

6.3 Added Benefits:

The focus of the project was to expand on fisheries habitat through the construction of new tidal channels that would connect with the previously constructed tidal channels adjacent to the site. The existing natural channels to the north of the site had been all but isolated since the log sort was constructed (and bermed at the north end). Once the berm at the north end was removed the entire Central Estuary now becomes inundated with tidal waters at high tides and even provides enough flow through the channels to allow recreational kayaking access (although this is not something the site was specifically designed for but an unexpected and positive benefit). The other benefit of the site became immediately apparent to the Squamish bird watching community. Right from the start long-eared owls (not native to the area) were spotted around the site. As the work proceeded numerous bird species were seen colonizing the area, including Redstarts, Northern harrier, Osprey, various owls, and Great Blue Heron. With the salmon run in August (pink salmon) and now the Chum salmon run in October/November a large number of Bald Eagles are being observed in the area. Through the construction period, river otters frequented the log-dump area undoubtedly enjoying salmon. Adult pink salmon were seen throughout the tidal channels in August and September and now in November Chum and the occasional Coho salmon can be observed in the channels at the higher tides.

Another benefit of the study will be the importance this work will play in the development of a Squamish Blue Carbon protocol that was being studied concurrent to all the works and will help to establish Provincial guidelines and protocols for future potential carbon sequestering programs.

7.0 Recommendations

The work associated with the FWCP funding was completed in mid-October with the site being fully restored, soil sediments sampled and monitored, riparian vegetation planted throughout the site and alongside the newly established trail, construction of two information kiosks, and the restoration of 3.5 hectares of habitat. The next steps include ongoing riparian planting, installation of additional signage, and on-going monitoring. Once all the approvals and details are in place the access road will also be deactivated, old culverts removed, bridge crossings installed and the trail network extended. A final post-construction survey will be undertaken in the early spring.

The site has already become an important area to the local community who have been regularly visiting the area to watch the progression of works. The site will be managed by MFLNRO as part of the WMA and the intention is that in future years there will be minimal maintenance required.

8.0 Acknowledgement
We would like to thank BC Hydro and the Fish and Wildlife Compensation Program for all of their help and assistance in funding and supporting this project.

We would also like to thank:

- Sylvia Letay & Scott Shaw McLaren, Ministry of Forests, Lands and Natural Resource Operations;
- Dave Nanson Al Jonsson, and Sam Gidora, Fisheries and Oceans Canada
- Randall Lewis, Squamish Nation
- Caroline Ashekian and Rod Macleod, District of Squamish
- John Hunter & Company & Whistler Excavations Limited
- And all the volunteer support

9.0 References

- Goodman, D., and P.R. Vroom. 1972. "Investigations into fish utilization of the inner estuary of the Squamish River." *Technical Report 1972-12*, Environment Canada, Fisheries Service, Vancouver, BC.
- Levy, D.A. and C.D. Levings. 1978. "A description of the fish community of the Squamish River Estuary, British Columbia: relative abundance, seasonal changes, and feeding habits of salmonids." Department of Fisheries and the Environment, Fisheries and Marine Service Resource Services Branch. *Fisheries and Marine Service Manuscript Report No. 1475*
- Gebauer and Associates. 2006. “Impacts of Channel Restoration on Birds within the Squamish Estuary.
- Raincoast Applied Ecology. 2004. “Effects of Fish Habitat Restoration Activities on Plant Communities in the Squamish River Estuary.”

10.0 Confirmation of FWCP Recognition
Throughout the project there were numerous media releases and spots on the local television station all acknowledging the funding support from the FWCP program for the success of the project. Signage at the two kiosks also provides recognition (logos) of FWCP.

11.0 Photos

Photo 12. March 2, 2015 – prior to construction. Facing east from berm at north end of log-dump pond

Photo 13. March 5, 2015 – Construction just starting. Facing east from berm north of log-dump pond

Photo 14. March 7, 2015 – Constructing new tidal channel – facing west

Photo 15. April 11, 2015 – Facing east. Constructing large tidal channel at south end

Photo 16. April 14, 2015 – facing east towards construction (note in-filling of log-dump pond)

Photo 17. April 22, 2015 - Volunteers helping with planting new trail

Photo 18. April 22, 2015 – Completed tidal channel at south end of site (lower section)

Photo 19. May 22, 2015 – top end of completed southern tidal channel – note riparian vegetation planted by volunteer support

Photo 20. August 26, 2015 – facing south from north-east end of trail

Photo 21. September 27, 2015 Rivers Day volunteer planting

Photo 22. October 3, 2015 – facing south from north end of site