

## Appendix V – Marsh Habitat Summary Data

Site ID	River Arm	Year of Compensation	Marsh Design	Mudflat Present	Riprap Fore-shore	Riprap Erosion	Log Debris protection	Eroded Edge	Waterfowl Grazing Evidence Observed	Area Sampled (sqm)	Area Target Habitat (sqm)	Proportion Target Habitat Established	Target Habitat							Site Wetland Indicator Status	
													Log Debris % Cover ± 95% CI	% Bare Ground ± 95% CI	Max Stem Height <i>Carex lyngbyei</i> ± 95% CI	Relative % Cover Exotic	Relative % Cover Invasive	Relative % Cover Native	Relative % Cover Threatened		Relative % Cover Unknown
01-003-B	North	1991	Embayment Protruding DS	Y	Y	N	None	N/A	Y	248.0	173.0	28	19 ± 3	4 ± 9	86 ± 47	6.0	8.0	76.0	0.0	10.0	1.4
01-008	North	2003	Embayment Protruding DS	N	Y	N	Log boom	N/A	N	2269.8	2269.8	100	1 ± 2	24 ± 12	N/A	6.0	7.0	84.0	1.0	1.0	1.3
02-001	North	1988	In-line	Y	N	N	None	N	Y	15685.1	10824.3	70	3 ± 3	9 ± 5	98 ± 7	28.0	13.0	59.0	0.0	0.0	1.4
02-002	North	1989	Embayment	N	Y	N	None	N/A	Y	596.3	596.3	94	10 ± 9	17 ± 10	97 ± 10	13.0	7.0	76.0	0.0	3.0	1.2
02-003-A	North	1992	In-line	N	Y	N	Log boom	N/A	N	5274.5	5274.5	100	0 ± 0	10 ± 7	106 ± 17	16.0	10.0	69.0	0.0	5.0	1.2
02-003-B	North	1992	In-line	Y	Y	N	Log boom	N/A	Y	3885.1	3400.3	100	1 ± 2	38 ± 15	128 ± 25.4	8.0	33.0	58.0	0.0	1.0	1.2
02-005-A	North	1993	Protruding	Y	Y	N	Log boom	N/A	N	304.6	249.0	74	0 ± 0	9 ± 8	108 ± 21	49.0	3.0	47.0	0.0	1.0	1.8
02-005-B	North	1993	Protruding	Y	Y	N	Log boom	N/A	N	337.3	63.3	74	0 ± 0	17 ± 10	93 ± 18	30.6	1.8	66.2	0.6	0.8	1.5
02-005-C	North	1993	Protruding	Y	Y	N	Log boom	N/A	N	555.6	323.1	74	0 ± 0	34 ± 8	N/A	20.1	5.0	73.9	0.3	0.7	1.0
02-005-D	North	1993	Protruding protruding DS	Y	Y	N	Log boom	N/A	N	194.0	167.6	74	0 ± 0	15 ± 17	63 ± N/A	49.8	16.7	31.5	0.3	1.8	1.8
02-005-E	North	1993	Protruding DS	N	Y	N	Log boom	N/A	N	327.2	327.2	74	0 ± 0	5 ± 6	111 ± 8	32.0	0.4	67.2	0.1	0.3	1.5
02-007-A	North	1993	Embayment	Y	Y	Y	None	N/A	Y	1380.0	997.0	67	0 ± 0	2 ± 2	96 ± 16	28.3	4.5	57.5	0.5	9.2	1.7
02-007-B	North	1993	Embayment	Y	Y	Y	None	N/A	Y	590.0	481.0	67	1 ± 2	4 ± 3	73 ± 4	11.2	9.0	69.7	0.6	9.4	1.8
02-007-C	North	1993	Embayment	Y	Y	Y	None	N/A	Y	1764.0	1202.0	67	0 ± 0	7 ± 19	78 ± 16	31.1	4.4	62.8	0.0	1.7	1.6
02-009	North	2001	In-line	Y	N	N/A	None	N	N	1084.9	392.5	28	6 ± 13	6 ± 8	96 ± N/A	6.4	7.7	80.6	0.3	5.0	1.8
02-014	North	2008	In-line	N	Y	Y	None	N/A	N	1651.4	1651.4	100	13 ± 11	25 ± 9	134 ± N/A	0.7	74.7	23.3	0.2	1.1	1.1
03-002	North	1989	Embayment	Y	N/A	N/A	None	N	N	4601.1	789.1	19	0 ± 0	13 ± 25	N/A	3.6	0.0	94.5	0.4	1.5	1.0
03-003	North	1992	In-line	Y	Y	N	Marina Lattice Fence	N/A	N	933.6	654.4	97	0 ± 0	6 ± 5	115 ± N/A	5.6	7.8	84.3	1.8	0.5	2.0
03-004	North	1994	inland	N	N/A	N/A	Marina Lattice Fence	N/A	N	5714.5	5714.5	100	0 ± 0	34 ± 8	147 ± N/A	2.2	75.0	22.3	0.0	0.4	1.0
03-006	North	1998	In-line Protruding US	N	Y	N	Log boom	N/A	Y	353.0	353.0	40	2 ± 3	3 ± 7	102 ± 5	0.6	1.5	97.5	0.0	0.4	1.6
04-001	North	1990	Embayment	N	Y	N	None	N/A	Y	3060.2	3060.2	88	0 ± 0	13 ± 12	N/A	0.0	0.0	100.0	0.0	0.0	1.2

04-005	North	2007	Protruding DS	N	Y	N	None	N/A	N	494.3	494.3	100	0 ± 0	3 ± 2	91 ± 32	0.3	3.9	95.8	0.0	0.0	1.0
05-001	North	1991	Protruding	N	Y	N	None	N/A	Y	107.1	107.1	100	1 ± 1	2 ± 2	89 ± 6	2.9	1.4	93.1	0.2	2.3	1.6
09-001-A	South	1990	Protruding	N	Y	N	None	N/A	N	3100.0	3100.0	100	3 ± 3	24 ± 14	161 ± 26	6.8	43.3	48.8	0.0	1.1	1.6
09-001-B	South	1990	Protruding	N	Y	N	None	N/A	N	1678.1	1678.1	100	2 ± 3	7 ± 5	134 ± 15	13.1	50.4	33.3	0.1	3.2	1.7
09-002-A	South	1989	Embayment	N	Y	N	None	N/A	N	649.0	649.0	54	0 ± 0	3 ± 4	102 ± 11	1.6	4.0	94.4	0.0	0.0	1.9
09-002-B	South	1989	Embayment	N	Y	N	None	N/A	N	258.2	258.2	54	0 ± 0	8 ± 9	98 ± 10	0.8	0.0	98.5	0.0	0.7	1.3
09-004	South	1990	Protruding	N	Y	N	Marina	N/A	N	899.0	899.0	100	0 ± 0	10 ± 10	151 ± 9	11.7	23.5	63.2	0.1	1.6	1.4
09-008-A	South	1991	In-line	Y	Wall	N/A	Marina	N/A	N	254.0	220.5	52	0 ± 0	4 ± 6	137 ± 37	21.7	49.5	27.9	0.0	0.9	1.9
09-008-B	South	1991	In-line	N	Wall	N/A	Marina	N/A	N	197.0	197.0	52	0 ± 0	21 ± 11	138 ± 7	27.3	24.9	41.8	1.2	4.9	1.9
09-009	South	1994	Protruding DS	N	Y	N	None	N/A	N	751.3	751.3	100	8 ± 9	14 ± 6	N/A	0.0	0.2	99.8	0.0	0.0	1.9
09-013	South	1997	Protruding	N	Y	N/A	Marina	N/A	N	2650.0	2650.0	95	0 ± 0	3 ± 2	144 ± 12	24.6	10.5	61.3	1.1	2.5	1.7
09-015	South	2000	Protruding	N	Y	N/A	None	N/A	N	1565.9	1565.9	100	1 ± 1	9 ± 5	144 ± 13	1.4	4.5	88.3	5.7	0.1	1.2
10-002-A	South	1988	inland	N	N	N/A	Other	N/A	N	15300.0	15300.0	100	1 ± 2	31 ± 12	130 ± N/A	7.7	41.5	48.7	0.1	2.0	1.2
10-002-B	South	1988	in-line	N	N	N/A	Other	N/A	N	3611.0	2248.0	100	21 ± 17	2 ± 4	134 ± 29	15.9	12.6	68.5	1.1	1.9	1.4
10-003	South	1990	In-line	N	N	N/A	None	N	Y	496.0	398.4	100	54 ± 28	17 ± 9	90 ± 60	11.8	13.5	69.9	0.0	4.8	1.4
10-004	South	1995	In-line	N	Y	N/A	Other	N/A	N	1498.7	1498.7	98	0 ± 0	13 ± 8	105 ± N/A	14.3	17.3	66.8	0.4	1.2	1.4
11-002	South	1990	Protruding DS	N	Y	N	Log boom	N/A	N	1574.8	1574.8	100	4 ± 6	12 ± 9	115 ± 16	17.1	8.2	71.1	0.9	2.8	1.5
11-010	North	1995	In-line	Y	N	N/A	None	N	Y	134.0	99.0	74	0 ± 0	24 ± 12	58 ± 2	12.2	4.5	79.2	0.1	4.1	1.5
11-012-A	South	2001	Land Tip	N	Y	N	None	N/A	N	3886.5	3886.5	100	1 ± 2	17 ± 10	124 ± 14	17.7	30.9	50.0	0.1	1.3	1.8
11-012-B	South	2001	Protruding US	Y	Y	N	None	N/A	N	701.4	612.7	100	0 ± 0	11 ± 5	N/A	13.4	19.3	63.6	1.6	2.1	1.5
11-013	South	2004	Embayment	Y	Y	N	Marina	N/A	N	1279.6	1043.5	99	0 ± 0	45 ± 18	N/A	2.9	4.0	90.9	0.0	2.1	1.1
12-001	South	1983	Protruding	N	Y	N	Marina	N/A	N	673.5	673.5	100	1 ± 1	11 ± 8	N/A	29.6	43.0	24.7	0.2	2.5	1.8
12-004	South	1992	inland	Y	N/A	N/A	Log boom	N/A	N	7474.4	5228.4	61	0 ± 0	15 ± 7	N/A	29.8	14.0	55.5	0.3	0.4	1.6
12-007	South	2006	Protruding	Y	Y	N	Log boom	N/A	Y	913.1	649.0	100	0 ± 0	68 ± 15	N/A	19.6	3.0	77.5	0.0	0.0	1.9
13-001	North	1988	Protruding DS	N	Y	N	None	N/A	N	208.0	179.8	94	15 ± N/A	2 ± 2	99 ± 32	2.3	14.7	81.8	0.0	1.2	1.8
13-005	Upper	1997	Embayment	N	Y	N	Log boom	N/A	Y	1570.7	1570.7	100	0 ± 0	14 ± 8	155 ± 18	10.6	13.1	68.2	2.6	5.5	1.3

13-010	Upper	1998	Protruding	N	Y	N	Other	N/A	N	196.6	196.6	100	3 ± 4	53 ± 13	N/A	55.3	4.3	39.4	0.0	1.0	2.4
13-012-A	Upper	2001	Embayment	N	Y	N	None Lattice Fence	N/A	Y	738.8	738.8	100	6 ± 5	37 ± 11	49 ± 11	37.4	10.6	45.8	0.1	6.1	1.6
13-012-B	Upper	2001	inland	N	Y	N		N/A	Y	1764.7	1764.7	100	0 ± 0	25 ± 12	N/A	32.2	28.4	34.4	1.2	3.7	2.0
14-004	Upper	1992	Protruding	Y	Y	N	Log boom	N/A	N	1097.8	981.0	98	3 ± 5	52 ± 14	N/A	0.0	81.9	18.1	0.0	0.0	1.9
15-001-B	Upper	1993	In-line	Y	N	N/A	None	Y	N	2486.0	1836.0	100	15 ± 13	10 ± 6	N/A	4.4	41.5	53.9	0.0	0.3	1.7
15-003-A	Upper	2010	In-line	Y	N	N/A	None	N	Y	620.2	427.8	88	32 ± 18	3 ± 3	N/A	55.2	35.6	9.3	0.0	0.0	2.4
15-003-B	Upper	2010	Embayment	Y	N	N/A	None	N	N	3831.3	3632.4	100	5 ± 13	30 ± 13	N/A	27.6	25.4	45.4	1.2	0.3	1.8
REF-02-001	North	REF	In-line	Y	N	N/A	Log boom	Y	Y	1876.8	1089.6	N/A	0 ± 0	19 ± 6	116 ± 16	10.7	1.4	83.4	0.7	3.8	1.2
REF-03-001	North	REF	In-line	N	N	N/A	Log boom	Y	Y	4690.0	4690.0	N/A	3 ± 3	11 ± 7	111 ± 13	2.7	6.5	90.6	0.0	0.2	1.3
REF-05-001	North	REF	In-line	Y	N	N/A	None	N	N	5149.1	4384.8	N/A	1 ± 2	30 ± 6	165 ± N/A	2.3	7.0	89.3	0.0	1.4	1.1
REF-09-001	South	REF	In-line	Y	N	N/A	None	Y	N	21870.0	19778.0	N/A	1 ± 2	8 ± 4	149 ± 33	7.7	14.0	77.3	0.0	0.9	1.2
REF-10-001	South	REF	In-line	Y	N	N/A	None	Y	Y	4963.5	4408.9	N/A	1 ± 1	10 ± 15	147 ± 9	10.0	8.5	78.6	1.2	1.7	1.2
REF-11-001	South	REF	Land Tip	Y	N	N/A	None	N	Y	4187.8	3190.4	N/A	6 ± 6	15 ± 7	95 ± 9	12.8	23.3	61.1	0.4	2.4	1.5
REF-12-001	South	REF	In-line	Y	N	N/A	None	N	Y	10864.0	1496.0	N/A	0 ± 0	3 ± 2	118 ± 12	20.1	15.3	56.5	0.4	7.7	1.4

## Appendix VI – Riparian Habitat Summary Data

Site ID	Year of Compensation	Area sampled (sqm)	Legacy FREMP area goal	Unit of Measure	Confidence in Unit of Measure	Manicured	Adjacent Land Use	Riprap Pots	Overstory: stems/ha	Overstory: % Native	Overstory: % Exotic	Understory: Total % cover	Understory: Relative % cover Native	Understory: Relative % cover Exotic	Understory: Relative % cover Invasive
01-008	2002	1044.7	996	sqm	H	N	Light industrial	N	153	100	0	100	91	1	8
02-006	1997	200.0	138	sqm	H	N	Park	N	100	100	0	100	67	0	40
02-007-A	1993	35.0	175/3	UNK	N/A	N	residential	Y	2001	86	14	77	92	4	4
04-001	1990	617.9	105	m	M	N	Gold course	N	146	66	34	100	97	1	2
04-005	2007	36.0	3600	UNK	N/A	N	residential	Y	0	N/A	N/A	100	100	0	0
05-003	2000	350.1	274	sqm	L	N	urban	N	57	100	0	100	44	0	59
05-004	1999	963.2	624	sqm	L	N	urban	N	0	N/A	N/A	100	36	0	65
09-013	1997	368.0	325	sqm	L	N	under development	Y	870	100	0	39	88	0	12
09-015	2000	897.6	170	m	M	N	agricultural	N	245	100	0	72	98	0	2
10-002-B	1979	637.0	0	UNK	N/A	N	light industrial	N	235	100	0	61	98	0	2
10-004	1997	141.5	30	m	M	N	Light industrial	N	3251	93	7	18	46	0	46
10-006	1997	728.0	420	sqm	M	N	condo	N	0	0	0	83	8	2	90
11-007	1991	3270.0	270	m	H	N	light industrial	N	662	84	6	96	13	1	87
11-013	2004	382.4	200	sqm	M	Y	residential	N	157	67	33	63	90	9	1
13-005	1997	1570.7	7136	sqm	L	Y	residential	N	178	25	75	78	70	28	2
13-010	1998	452.2	210	sqm	H	N	railway	N	22	99	1	99	86	0	14
13-012-B	2001	5741.9	5260	sqm	H	N	park	N	235	100	0	100	33	17	50
15-003-A	2010	1300.0	1293	sqm	H	N	urban	N	1733	100	0	10	84	0	16
15-003-B	2010	8115.8	8019	sqm	H	N	industrial/rural	N	16840	100	0	20	93	0	6

## Appendix VII – Marsh Compensation Site Descriptions

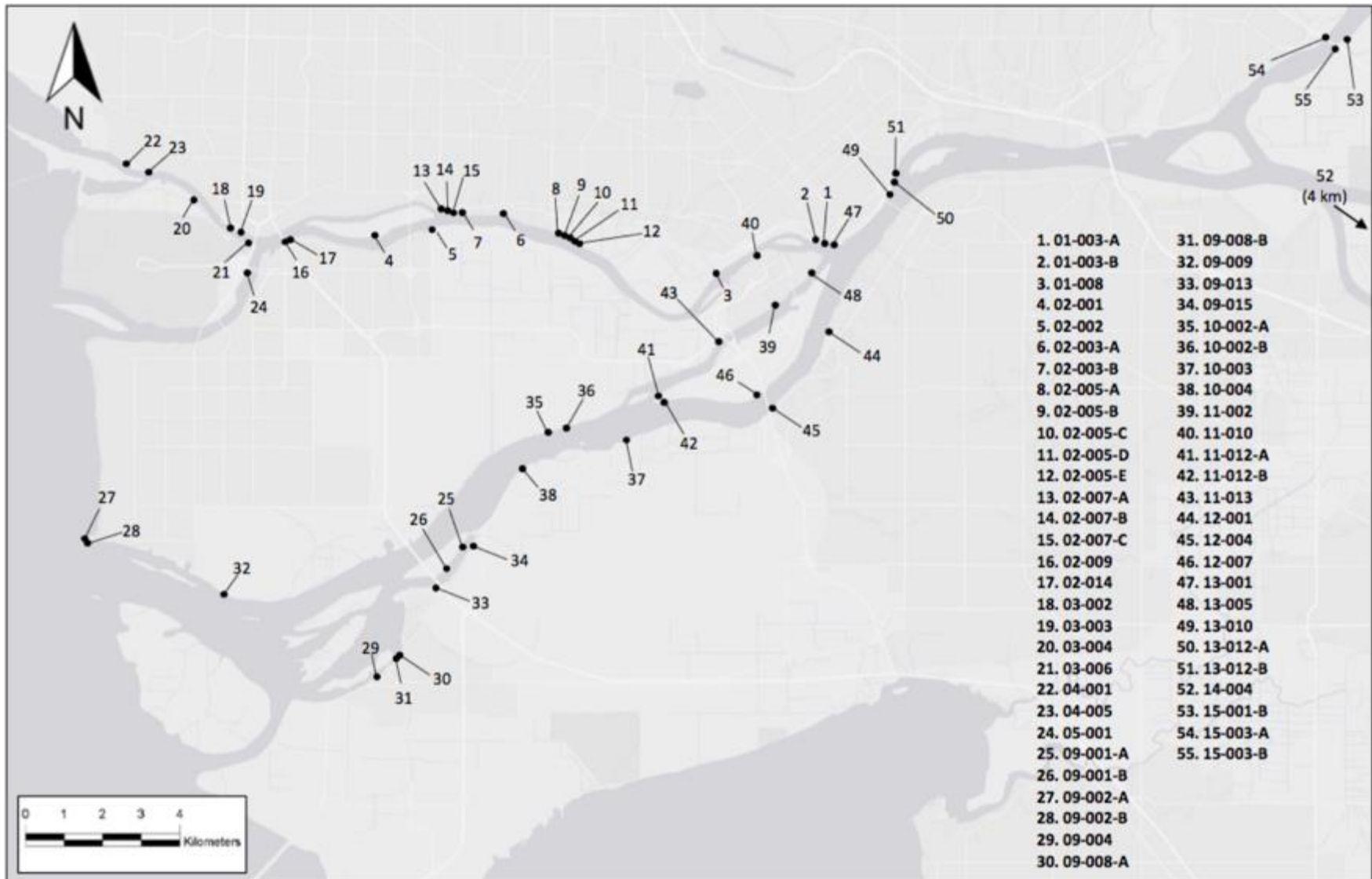


Figure 1. Locations of FREMP compensation marshes surveyed July-October 2015. Large scale map features (e.g. precise locations, site boundaries, vegetation communities) can be viewed on the FREMP-BIEAP Atlas online, under the 2015 Field Data map layer: [http://www.cmNBC.ca/atlas\\_gallery/fremp-bieap-habitat-atlas](http://www.cmNBC.ca/atlas_gallery/fremp-bieap-habitat-atlas).

Site# 01-003-A  
CPR# 8812-0105

---

*Background*

501 sqm of unvegetated intertidal mudflat were lost as a result of foreshore filling in 1991. Notes from 1996 state that compensation marsh benches were constructed, however no vegetation had been planted. Natural colonization was noted, but existing plant growth was described as ‘sparse.’ Marsh and riparian plantings were recommended, however no remedial action was undertaken, as there was no legally binding agreement between the proponent and DFO. Habitat compensation goal = 627 sqm of marsh habitat.

*Description*

The site consists of an embayed unvegetated mudflat, which gradually slopes from backshore to intertidal. Marsh backshore is armoured by a riprap slope, and there is no evidence of armouring along the foreshore. The mudflat is only visible at low tide. Pilings are present along the foreshore of the site (see photos). The riprap slope above the site is vegetated by a mixture of native, ornamental exotic, and invasive species, including invasive *Buddleja davidii*, *Tanacetum vulgare*, and *Rubus armeniacus*. The site was described in 1996 as unplanted marsh habitat, and vegetation has yet to colonize decades later, likely due to a combination of erosion and low site elevation.

*Morphological Features*

Marsh habitat consists of an unvegetated mud/sand flat. Site appears to be eroded, as substrate is sandy with little to no fine particles. Erosion is likely from boat wake and high flow events.

*Impacts & Stressors*

None (no created habitat exists).

*Wildlife Sightings/Evidence*

None (no created habitat exists).

*Adjacent Land Use*

Residential development with BC Parkway trail at top of dike (N), Fraser River North Arm (S) and train trestle (E).

*Threatened Plant Species (Provincial/Federal)*

None (no vegetation present).

*Invasive Species*

None (no vegetation present).

*Community Descriptions*

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	100.0	100.0	100.0	None	n/a	n/a	Unvegetated mud/sandflat

*Dominant Species*

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
None	---	---	---	---	---	---	n/a	---

*Compensation Success*

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established (% of area goal)</b>	100.0*	27.6%	Poor	This site fails to fulfill the area requirements of the habitat compensation goals. The paired site (01-003-B) contains 173 sqm of functioning marsh accounting for the 28% successful establishment of target habitat for the entire site ID. This site (01-003-A) fails to contain any functioning habitat.
<b>2. Proportion/Relative % Cover Native Species</b>	72.2	0.0	Poor	No functioning marsh habitat, with no marsh vegetation present.

*Recommendations*

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
No vegetation	5	Create new habitat	Currently this embayment has potential for approximately 100 sqm of marsh habitat. However, this current bench would have to be (1) raised, as its current elevation is too low to sustain marsh vegetation and (2) armoured, as wave and current erosion appears problematic locally.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
None			





## Site# 01-003-B

### CPR# 8812-0105

---

#### Background

501 sqm of unvegetated intertidal mudflat were lost as a result of foreshore filling in 1991. Notes from 1996 state that compensation marsh benches were constructed, however no vegetation had been planted. Natural colonization was noted, but existing plant growth was described as 'sparse.' Marsh and riparian plantings were recommended, however no remedial action was undertaken, as there was no legally binding agreement between the proponent and DFO. Habitat compensation goal = 627 sqm of marsh habitat.

#### Description

Site is a 248 sqm embayed marsh with an armoured riprap foreshore. The backshore of the site is bordered by both concrete wall and riprap dike, both supporting the BC Parkway trail above. Public access is deterred due to a metal fence surrounding the site. Log booms have been installed along the marsh foreshore, but are angled inwardly (perhaps broken), likely offering little protection to the site.

Currently 70% of the site is dominated by mid-to high marsh vegetation (target habitat), dominated by *Juncus balticus*, *Carex lyngbyei*, *Potentilla anserina* and *Lycopus* sp.. Low marsh habitat (Community 2) represents 14% of site area, and occurs along the foreshore where soil loss and erosion is most prevalent. Community 2 is dominated by *Juncus articulatus*, *Hypericum scouleri*, *Crassula aquatica* and *Lilaeopsis occidentalis*. The remainder of the site is covered by log debris, which has accumulated along the site backshore.

Marsh productivity is being impacted by log debris and erosion. Log debris currently accounts for 16% of site area, and will continue to reduce vegetative cover due to smothering and grounding unless addressed. Erosion is occurring along the riprap edge of the marsh, as well as within the unvegetated intertidal portion of the marsh, where a coarser substrate is now exposed due to soil loss. The log boom, which is currently funneling wave energy into the center of the marsh due to improper angling, is likely the primary cause of this soil loss. A lack of planting (and subsequent lack of soil binding by roots) has likely also contributed to erosion of habitat.

#### Morphological Features

Site is a flat marsh bench with exception to lower, eroded areas. Some erosion is occurring along the foreshore edge of the marsh, as well as within the unvegetated intertidal portion in the center of the marsh, where a coarser substrate is now exposed due to soil loss.

#### Impacts & Stressors

Log debris is a significant stressor to the backshore of the site, accounting for 16% of the site area. The embayment shape, and lack of functional log boom protection increase site susceptibility to further deposition. *Carex lyngbyei* appears to be reduced in height by waterfowl grazing.

#### Wildlife Sightings/Evidence

Evidence of waterfowl graze in areas with more palatable species (e.g. *Carex* spp.).

#### Adjacent Land Use

Residential development with BC Parkway trail at top of dike (N), Fraser River North Arm (S) and train trestle (E).

#### Threatened Plant Species (Provincial/Federal)

None.

### Invasive Species

Three invasive species were sampled in target habitat: *Lythrum salicaria*, *Phalaris arundinacea* and *Iris pseudacorus*, totaling a mean % cover of 9.1 +/- 11.3.

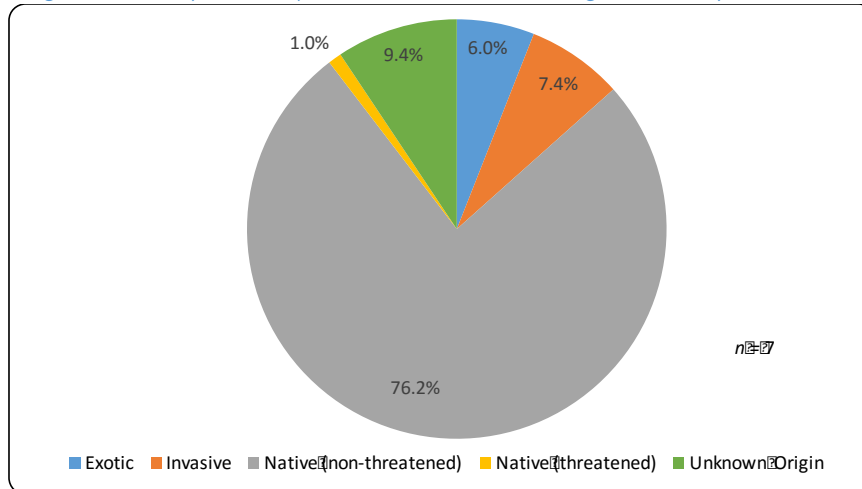
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	173.0	69.8	4.3 +/- 9.3	1.3 +/- 3.4	1.43	7	Marsh habitat (target habitat)
2	36.0	14.5	72.7 +/- 14.2	None	1.21	3	Vegetated mudflat along foreshore
3	39.0	15.7	None	100	n/a	n/a	Log debris accumulation zone. No vegetative cover.

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	Baltic rush	<i>Juncus balticus</i>	N	2	42.6	31.8	7	30.3
1	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	20.7	20.7	7	22.1
1	common silverweed	<i>Potentilla anserina</i>	N	1	11.7	5.4	7	14.6
1	horehound	<i>Lycopus</i> sp.	U	1	11.9	4.9	7	12.6
2	jointed rush	<i>Juncus articulatus</i>	N	1	4.3	3.5	3	22.9
2	western St. John's-wort	<i>Hypericum scouleri</i> ssp. <i>scouleri</i>	N	2	3.7	3.5	3	19.4
2	pigmyweed	<i>Crassula aquatica</i>	N	1	3.5	3.7	3	18.5
2	western lilaeopsis	<i>Lilaeopsis occidentalis</i>	N	1	3.7	3.6	3	12.9

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established (% of area goal)</b>	100*	27.6%	Poor	Only 28% (173 sqm) of the initial goal is functioning as viable marsh habitat. This can easily be increased to 34% (212 sqm) by removing the buildup of log debris and planting to native species. The paired site (01-003-A) currently contains no functioning marsh habitat, but an embayed marsh could be created to increase total compensation area. To achieve the habitat compensation goal of 627sqm, a total of 454 sqm of marsh will have to be restored or created.
<b>2. Proportion/Relative % Cover Native Species</b>	72.8	76.0	Good	Invasive species only represent 8% of vegetative cover. Native species represent a higher proportion of vegetative cover than average of neighbouring reference sites REF-11-001 and REF-02-001.

### Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Log Debris	5	Remove log debris and plant with native vegetation. Consider replacing log boom structure to mitigate log debris.	Approximately 16% of the site is covered in log debris with the majority of it building up along the backshore. The embayment shape of the site allows log debris to build up and get stuck at the back of the site. A structure to mitigate future buildup of log debris would be advisable.
Invasive Species	3	Control <i>Iris pseudacorus</i> .	<i>Iris pseudacorus</i> occurs in small clumps and could be easily controlled.
Low Target Habitat Success	5	Increase area of marsh habitat through mitigation.	Only 28% (173sqm) of the initial goal is functioning as viable marsh habitat. This can easily be increased to 34% (212 sqm) by removing the buildup of log debris and planting to native species. Planting of the vegetated mudflat is an option, however, the vegetated mudflat may indicate other stressors preventing growth (such as waterfowl grazing, elevation - too low, wave action, hydrological processes); therefore, planting this zone may have a higher chance of failure.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
None			



Site# 01-008  
CPR# 0112F080

---

### Background

Intertidal mudflat habitat (4083 sqm) and subtidal riverbed (3124 sqm) was disturbed due to sediment and groundwater remediation works. Compensation habitat created in 2002 and planted in 2003. Habitat compensation goal = 996 sqm riparian, 2161 sqm intertidal marsh, 562 sqm intertidal mudflat, and 199 sqm subtidal riverbed habitat created.

### Description

Site consists of a 2270 sqm intertidal marsh bench, armoured by a riprap berm foreshore. Backshore is bordered by riprap dike, with riparian compensation plantings above (see riparian file). Site drainage appears to be inhibited by the foreshore riprap berm, which is slightly elevated above the marsh behind it. As a result, the marsh is generally saturated with pools of standing water present at all times. A log boom was present in front of marsh.

The entire site consists of marsh vegetation (target habitat), dominated by *Typha latifolia* and *Juncus supiniformis*. Invasive species, although present, only account for 8% of marsh vegetation. Habitat is functioning well, but management of invasive *Typha angustifolia* is recommended to ensure long-term success of site.

### Morphological Features

Foreshore riprap berm is slightly higher than marsh, likely reducing drainage. As a result, standing water is distributed throughout site. No channels or significant depressions were observed.

### Impacts & Stressors

A low to moderate amount of log debris.

### Wildlife Sightings/Evidence

None.

### Adjacent Land Use

Light industrial (NW), Fraser River North Arm (SE).

### Threatened Plant Species (Provincial/Federal)

Two threatened species were sampled in target habitat: *Juncus oxymers* (blue-listed) and *Eleocharis parvula* (blue-listed), totaling a mean % cover of 0.8 +/- 1.0.

### Invasive Species

Three invasive species were sampled in target habitat: *Lythrum salicaria*, *Typha angustifolia* and *Phalaris arundinacea*, totaling a mean % cover of 5.1 +/- 4.9. *Typha angustifolia* is confined to a single patch, where it is the dominant species.

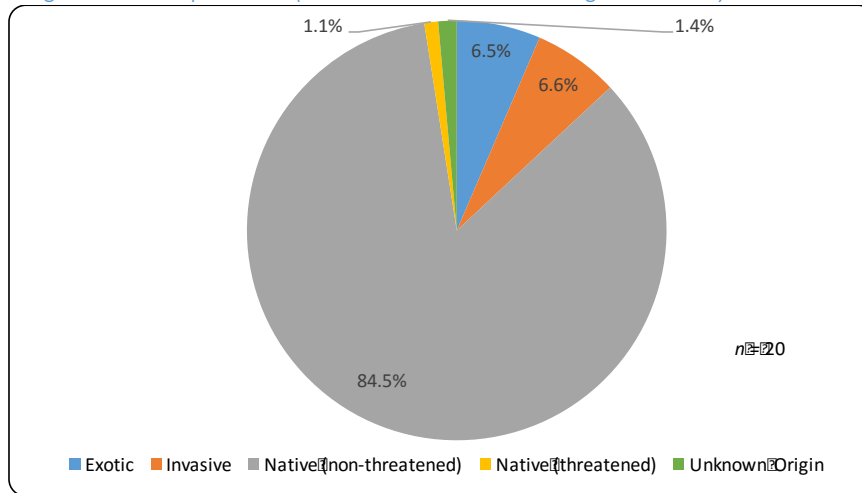
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	2269.8	100.0	24.2 +/- 11.6	1.0 +/- 1.96	1.28	20	Marsh habitat (target habitat)

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	common cattail	<i>Typha latifolia</i>	N	1	10.1	7.0	20	22.0
1	spreading rush	<i>Juncus supiniformis</i>	N	1	5.2	3.7	20	13.1

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established (% of area goal)</b>	100.0*	105.1%	Good	The site successfully fulfills the requirements of area compensation and is functioning well. The area of functioning target habitat (2270 sqm) exceeds the compensation goal of 2161 sqm.
<b>2. Proportion/Relative % Cover Native Species</b>	72.8	85.5	Good	The majority of the vegetation at this site is native (86%), exceeding the combined average native species dominance of nearby reference habitats REF-11-001 and REF-02-001. The total vegetation cover is only 75%; however lower total vegetation cover is natural in cattail-dominated habitats

### Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	5	Eradicate <i>Typha angustifolia</i> while manageable.	<i>Typha angustifolia</i> occurs as a small, single patch, but is dominant where it occurs (no other species are present where lesser cattail occurs). At this stage it would be easy to control this patch to prevent spread.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Log debris	2	Monitor	Monitor log debris to ensure it does not increase and impact vegetation growth.





## Site# 02-001

### CPR# N/A

---

#### Background

Creation of intertidal marsh and mudflat from dredged material in 1988. Shear and log boom installed as erosion protection. Marsh was planted with vegetation salvaged from a tidal marsh on Lulu Island that was slated for development. Vegetation was extracted in the form of large sods, which were cut into 16,000 10 x 10 x 10 cm plugs, typically transplanted at 1.0 m intervals. Plug species included *Carex lyngbyei*, *Scirpus validus*, and *Typha latifolia*. After three growing season, monitoring indicated that wake erosion had caused the habitat to recede 18 m, and a significant sand berm had formed. By 1991, half of transplanted area did not sustain transplants, which may have been the result of plug burial by shifting sands, anaerobic soil conditions, and/or geese graze. Habitat compensation goal = 15400 sqm marsh and 27000 sqm mudflat habitat.

#### Description

The site is a complex marsh 15685 sqm in size (approximately 60 m X 295 m), which narrows to the west. The backshore is bordered by a riprap dike, with a strip of riparian vegetation above. A channel draining a storm water culvert delineates the east boundary of the site. There is no riprap armouring at the foreshore of the site. Despite installation of a log boom for erosion protect at the time of construction, no log boom was present at the time of this survey. A sand bar extends nearly the length of the site along the foreshore edge of the marsh. A vegetated mudflat extends into the marsh and wraps around the sand bar at the east and west ends.

69% of the site is comprised of typical mid to high marsh vegetation (Community 1), dominated by *Carex lyngbyei*, *Agrostis capillaris*, *Equisetum fluviatile*, and *Schoenoplectus tabernaemontani*. A vegetated mudflat (Community 2) accounts for 19% of the site, and is most dominated by the aquatic *Callitriche stagnalis*. A vegetated sand bar (Community 3) occupies the remaining 12% of site, and is sparsely vegetated by *Lythrum salicaria*, *Carex lyngbyei*, and *Juncus balticus*.

Smothering of habitat by river sand aggradation, as well as foreshore erosion are likely the greatest threats to compensation success. Log debris build up is moderate at this site, but is not significantly limiting vegetation growth. A significant amount of Canada Geese were observed on the vegetated mudflat at low tide and *Carex lyngbyei* throughout the site displayed evidence of graze.

#### Morphological Features

A vegetated sand bar (Community 3) extends nearly the length of the site along the foreshore boundary, and has been present for several decades. It slopes moderately steeply from foreshore to top of sand bank and steeply drops off at approximately 1 m high to the mid-high marsh (Community 1). A vegetated mudflat (Community 2) extends and wraps into the site around the sand bar at the east and west ends. Marsh contains many small drainage channels and depressions.

#### Impacts & Stressors

Many Canada Geese observed using site. Graze impacts observed on *Carex lyngbyei* and *Juncus* spp.. Log debris build up near back of site, including a full dock float.

#### Wildlife Sightings/Evidence

Killdeer on vegetated mudflat (Community 2). Raccoon prints observed. Old posts being used by cavity nesting birds (inactive at time is survey), likely by swallows. Small fish in pooled areas of marsh.

#### Adjacent Land Use

Industrial land use (N,E) and Fraser River North Arm with anchored barges (South).

### Threatened Plant Species (Provincial/Federal)

Two threatened species were sampled: *Juncus oxymeris* (blue-listed) and *Eleocharis parvula* (blue-listed), totaling a mean % cover of 0.22 +/- 0.29. *Lilaea scilloides* (blue-listed) and *Bidens amplissima* (blue-listed, SARA-listed) were observed incidentally.

### Invasive Species

Four invasive species were sampled in target habitat: *Cirsium arvense*, *Lythrum salicaria*, *Phalaris arundinacea* and *Iris pseudacorus*, totaling a mean % cover of 11.8 +/- 10.2. *Lythrum salicaria* is primarily responsible for the 12% mean cover.

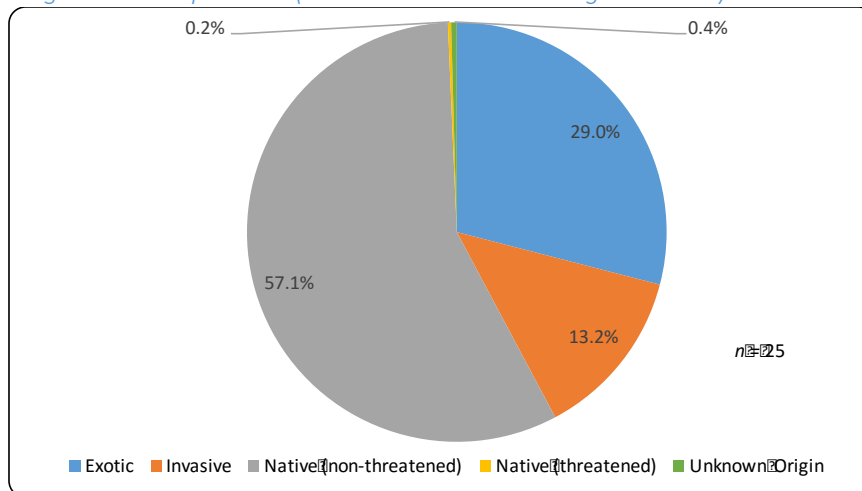
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	10824.3	69.0	8.6 +/- 5.1	2.8 +/- 2.7	1.45	25	Mid to high marsh (target habitat)
2	2976.3	19.0	88 +/- 7.4	None	1.00	11	Vegetated mud flat
3	1884.4	12.0	79 +/- 12.0	None	1.20	10	Partially vegetated sand bar

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	27.6	8.4	25	39.7
1	colonial bentgrass	<i>Agrostis capillaris</i>	E	3	19.4	9.0	25	21.0
1	swamp horsetail	<i>Equisetum fluviatile</i>	N	1	10.5	5.6	25	12.6
1	soft-stemmed bulrush	<i>Schoenoplectus tabernaemontani</i>	N	1	9.5	4.8	25	12.5
2	pond water-starwort	<i>Callitriche stagnalis</i>	E	1	8.0	7.0	11	83.0
3	purple loosestrife	<i>Lythrum salicaria</i>	I	1	6.0	4.0	10	48.0
3	Baltic rush	<i>Juncus balticus</i>	N	2	8.0	11.0	10	21.0
3	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	3.0	2.0	10	15.0

### Origin Class Proportions (Based on % Cover in Target Habitat)





### Compensation Assessment

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Target Habitat Established (% of area goal)</b>	100.0	70.3	Fair	Only 10,824 sqm (70% of initial goal) is functioning as mid to high marsh habitat. The other habitats, Community 2 (vegetated mudflat) and Community 3 (sandbar) comprise the remainder. These other habitats provide complexity to the site, but were not the target habitats of the compensation project and appear more susceptible to invasive and exotic species.
<b>2. Proportion/Relative % Cover Native Species</b>	86.7	58.9	Fair	87% target based off average of references sites REF-05-001 and REF-02-001. Relative % cover of native species was only 59%; however, 3 out of 4 species with relative dominance over 10% were native. This indicates that there is a lower diversity of native species and a greater diversity of non-native species.

### Recommendations

<b>Mitigation</b>			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	3	Remove <i>Iris pseudacorus</i>	Yellow iris is present in infrequent, small clumps that are still manageable. Mitigate now or monitor to ensure it does not spread.
<b>Monitoring</b>			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Mudflat and Sandflat	3	Monitor mudflat and sandflat erosion/aggradation	Monitor mudflat and sandflat for expansion. If these habitats expand significantly mitigation efforts may be advisable.



Site# 02-002  
CPR# 8803-0019

---

*Background*

Compensation for habitat lost by foreshore construction for a dredged basin. Marsh created by filling on mudflat in 1989. Site was planted with 2000 *Carex lyngbyei* and golf-cup cutter plugs from upstream marshes along Lulu Island. Plugs were planted at 0.5 m intervals centre-to-centre. Site was also planted with 105 x 30 sqcm sods of *Scirpus validus* from a downstream marsh along Lulu Island and planted at 0.75 m intervals along the eastern edge of the site. Both species were placed at elevations equivalent to where they occur in natural marshes in region. No vegetation monitoring was documented, though both species appeared to comprise > 90% of their planted areas in 1993 observations.

*Description*

Site is a 596 sqm embayed marsh with an armoured riprap foreshore. Backshore bordered by riprap dike. No log boom was present at time of survey. 100% of the site is comprised of marsh habitat (target habitat), dominated by *Carex lyngbyei*, *Typha latifolia*, *Scirpus microcarpus*, and exotic *Myosotis scorpioides*. Species are locally abundant due to morphological heterogeneity, with *T. latifolia* dominating areas of poor drainage along backshore, *Carex* spp. dominating the foreshore, and *S. microcarpus* occupying elevated areas at the toe of the riprap dike.

*Morphological Features*

Poorly-drained area of standing water along eastern backshore, dominated by *Typha latifolia*. Site is gradually sloped from backshore to foreshore. A dendritic drainage channel borders the eastern boundary, draining east half of site.

*Impacts & Stressors*

Some evidence of waterfowl graze. A moderate amount of log debris present.

*Wildlife Sightings/Evidence*

Canada Geese.

*Adjacent Land Use*

Log sorting facilities (W) River Road and other industry (S), Fraser River North Arm (N).

*Threatened Plant Species (Provincial/Federal)*

Two threatened species were sampled in target habitat: *Juncus oxymeris* (blue-listed) and *Eleocharis parvula* (blue-listed), totaling a mean % cover of 0.8 +/- 0.4.

*Invasive Species*

Four invasive species were sampled in target habitat: *Cirsium arvense*, *Lythrum salicaria*, *Phalaris arundinacea* and *Iris pseudacorus*, totaling a mean% cover of 5.3 +/- 3.4.

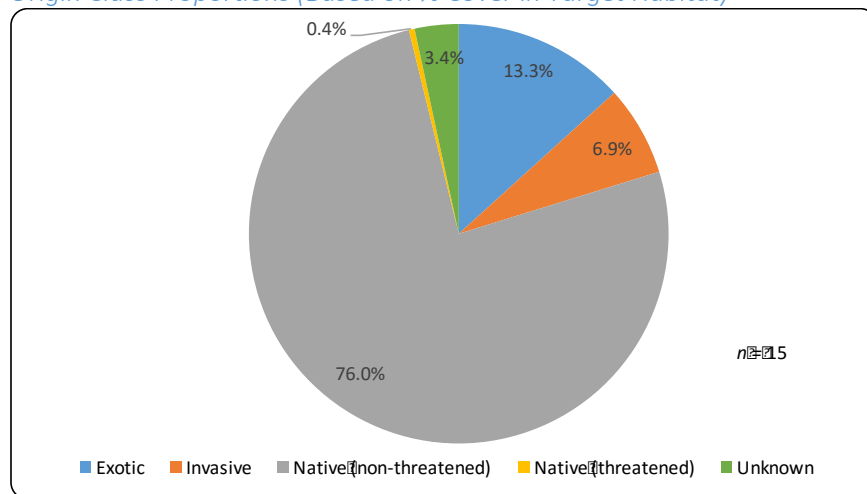
*Community Descriptions*

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	596.3	100.0	16.9 +/- 9.7	10.3 +/- 8.8	1.25	15	Marsh habitat (target habitat)

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	13.2	9.4	15	22.6
1	common cattail	<i>Typha latifolia</i>	N	1	8.9	6.0	15	13.6
1	small-flowered bulrush	<i>Scirpus microcarpus</i>	N	1	9.3	6.4	15	12.3
1	European forget-me-not	<i>Myosotis scorpioides</i>	E	2	5.5	2.4	15	11.6

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established (% of area goal)</b>	100.0	93.9%	Good	94% of target habitat area has been achieved. In reality, site likely achieved 100%, however true site boundaries were difficult to discern in field.
<b>2. Proportion/Relative % Cover Native Species</b>	86.7	76.4	Good	Relative % cover of native species is higher than average of nearby reference sites REF-05-001 and REF-02-001. Vegetation is well-established, with high vegetation cover.

### Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive species	2	Control <i>Iris pseudacorus</i>	Yellow iris is present in small clumps and is still easily removed. Control to avoid further expansion.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Log debris	3	Monitor	Monitor buildup of log debris. Currently accounts for approximately 10% cover. If log debris increases then consider removal.





## Site# 02-003-A

### CPR# 9206-0064

---

#### Background

Compensation was required after existing bank was graded for riprap placement, cutting, and filling as well as pier construction in 1992. In total, 2000 sqm of subtidal mudflats and 8268 sqm of unvegetated and intertidal mudflats were lost. In compensation, marsh habitat was created at two separate compensation sites under the 02-003 Site ID. Marsh habitat was created by building an elevated bench and protecting it with a riprap border. Dominant plant species at time of disturbance included *Carex lyngbyei*, *Polygonum* sp., *Trifolium* spp. and *Callitriche verna*. This site is one of two compensation sites under the 02-003 site ID. The other site, labelled 02-003-B (located ~ 1 km due east) has a separate report under that name. Habitat compensation goal = 7755 sqm marsh habitat.

Sites were planted with 14160 *C. lyngbyei* golf-cup cutter plugs extracted from nearby tidal marshes, and planted at 0.75 m centre-to-centre intervals. Monitoring indicated that after 3 growing seasons marsh vegetation cover was approaching 100%, dominated by *C. lyngbyei*, *Eleocharis palustris*, and *Typha latifolia*.

#### Description

The site is a long and narrow marsh bench (approximately 12 x 800 m) that parallels the Fraser River and is in line with the surrounding shoreline. The north and eastern site boundaries are bordered by a 3 - 5 m strip of riparian vegetation containing mature *Populus balsamifera* and shrubs. The riparian strip is paralleled to the north by a public walking trail and a rail line. Beyond the narrow rail line are residential neighbourhoods. The west boundary overlaps with a more recent compensation site (02-004) and is a continuation of marsh habitat. The southern/foreshore boundary of the site is armoured with riprap along the Fraser River, preventing erosion of the site.

The entire site is covered by mid-to-high marsh vegetation dominated by *Carex lyngbyei* and *Equisetum fluviatile*. Small homogenous clumps of *Juncus* spp. and *Typha latifolia* are distributed throughout the site. A few small pockets of relatively unvegetated exposed mud exist along the foreshore boundary near the riprap. The riparian vegetation along the backshore contains invasive *Polygonum cuspidatum* and *Rubus armeniacus*. Site contains little log debris. Marsh is protected from excessive log debris and wave action due to large log boom along southern boundary of site approx. 10-15 m off shore, which also creates calmed water useful for waterfowl.

#### Morphological Features

Site is a relatively flat marsh bench with areas of standing water and small drainage channels running to the river. A couple of culverts, likely channeling storm water from the nearby residential area, drain into site backshore.

#### Impacts & Stressors

Various informal access points to site exist along walking path, suggesting that the public will on occasion access the site. Minor trampling may be occurring.

#### Wildlife Sightings/Evidence

Song Sparrows in marsh vegetation. Wildlife trail observed leading from public walking path to an area of flattened vegetation to the river edge. Potentially Coyotes accessing the site.

#### Adjacent Land Use

Beyond the 3-5 m riparian strip along the northern border of the site there is a public walking trail. Paralleling the walking trail and separated by a 2-3 m riparian strip to the north is a railway line. Paralleling the rail line is a road with residential homes to the north.

### Threatened Plant Species (Provincial/Federal)

One threatened species was sampled in target habitat: *Juncus oxymeris* (blue-listed), totaling a mean % cover of 0.1 +/- 0.1. Several *Platanthera dilatata* (rare in region) were observed along backshore.

### Invasive Species

Three invasive species were sampled in target habitat: *Lythrum salicaria* (most abundant with a mean % cover of 8.1 +/- 4.5), *Phalaris arundinacea*, and *Iris pseudacorus*, totaling a mean % cover of 9.3 +/- 4.3.

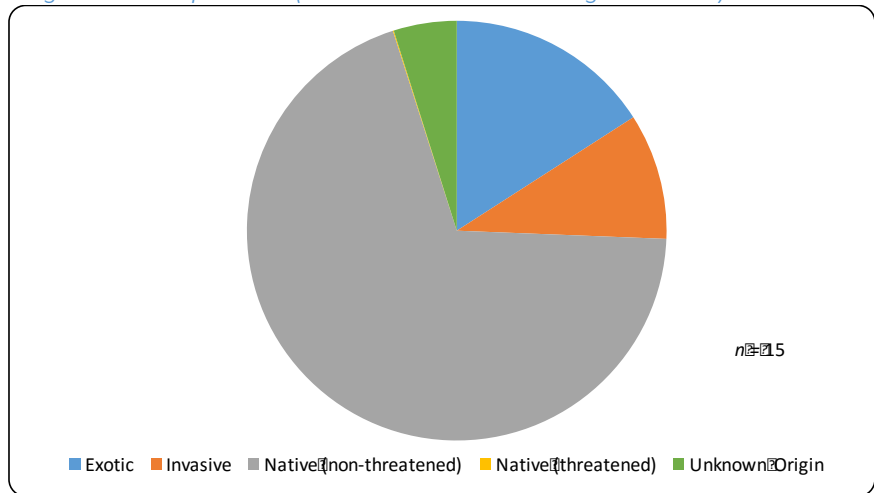
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI(95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	5274.5	100.0	9.9 +/- 7.2	None	1.20	15	Marsh habitat (target habitat)

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	36.1	14.6	15	52.4
1	swamp horsetail	<i>Equisetum fluviatile</i>	N	1	10.5	4.9	15	15.3

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established(% of area goal)</b>	100.0*	112.0%	Good	The combination of 02-003-A and 02-003-B exceeds project goal of 7755 sqm. Excess 12% may be due to mapping inaccuracy or marsh expansion over time.
<b>2. Proportion/Relative % Cover Native Species</b>	86.7	69.5	Fair	Relative % cover of native species is 20% less than the average of nearby reference sites REF-05-001 and REF-02-001. This site is relatively healthy, hosting an established community of <i>Carex lyngbyei</i> (52% relative dominance) and has high total vegetation cover.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	3	Control invasive species	There are some small patches of <i>Iris pseudacorus</i> which would be easy to control at this stage to prevent spread. <i>Lythrum salicaria</i> has a mean % cover of 8%. Consider biological, mechanical or chemical control methods.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
None.			





## Site# 02-003-B

### CPR# 9206-0064

---

#### Background

Compensation was required after existing bank was graded for riprap placement, cutting, and filling as well as pier construction in 1992. In total, 2000 sqm of subtidal mudflats and 8268 sqm of unvegetated and intertidal mudflats were lost. In compensation, marsh habitat was created at two separate compensation sites under the 02-003 Site ID. Marsh habitat was created by building an elevated bench and protecting it with a rip-rap border. Dominant plant species at time of disturbance included *Carex lyngbyei*, *Polygonum* sp., *Trifolium* spp. and *Callitriche verna*. This site is one of two compensation sites under the 02-003 site ID. The other site, labelled 02-003-A (located ~ 1 km due west) has a separate report under that name. Habitat compensation goal = 7755 sqm marsh habitat.

Sites were planted with 14160 *C. lyngbyei* golf-cup cutter plugs extracted from nearby tidal marshes, and planted at 0.75 m centre-to-centre intervals. Monitoring indicated that after 3 growing seasons marsh vegetation cover was approaching 100%, dominated by *C. lyngbyei*, *Eleocharis palustris*, and *Typha latifolia*.

#### Description

The site is a large, elevated marsh bench armoured by riprap on all sides. The foreshore of the site is in line with the surrounding shoreline, the east boundary parallels a public pier, and the backshore boundary is delineated by an elevated, wooden boardwalk above a riprap dike. There is a log boom immediately off-shore to mitigate wave action.

Habitat is heterogeneous, with several pools of standing water, drainage channels, and elevated mounds that promote a healthy species diversity. Pools of standing water are occupied by emergent aquatic species (e.g. *Sagittaria latifolia*, *Alisma* spp.). There are two distinct vegetative communities within the site. Community 1 (88% of site) contains typical mid to high marsh vegetation dominated by *Lythrum salicaria*, *Carex lyngbyei*, and *Equisetum fluviatile*. Community 2 (12% of site) is a vegetated mudflat located along the foreshore, dominated by low-marsh species such as *Crassula aquatica*, and *Limosella aquatica* among others.

Site is most impacted by invasive species (particularly *L. salicaria*) which in total account for 33% of vegetative cover. Waterfowl graze is impacting marsh vegetation, particularly along the foreshore edge. Wood debris is present but in low abundance.

#### Morphological Features

Two small drainage channels are present. Channels drain areas of standing water in the northern portion of the marsh. A large culvert outflows under pier to the NE, flowing alongside eastern riprap border. Site is relatively flat, gradually sloping from backshore to foreshore edge.

#### Impacts & Stressors

Invasive species represent 33% of marsh vegetation in target habitat. Significant evidence of waterfowl grazing.

#### Wildlife Sightings/Evidence

Significant evidence of waterfowl grazing. Canada Geese spotted nearby. Song Sparrow and Common Yellowthroat observed in marsh vegetation. Raccoon was observed under pier to east, and prints were visible in mud on-site. Mallards were observed in the marsh vegetation at high-tide. At low tide, Great Blue Heron (blue-listed, SARA-listed) and Mallard were sighted using calm waters created by log booms just south of site.

### Adjacent Land Use

Housing development with greenway boardwalk (N), exposed mudflat with log booms (S), and elevated walkways/piers (W and E).

### Threatened Plant Species (Provincial/Federal)

No threatened species were sampled in target habitat. One threatened species was sampled in Community 2: *Eleocharis parvula* (blue-listed) with a mean % cover of 2.9 +/- 3.5.

### Invasive Species

Three invasive species were sampled in target habitat: *Typha angustifolia*, *Lythrum salicaria*, and *Phalaris arundinacea*, totaling a mean % cover of 22.5 +/- 13.1.

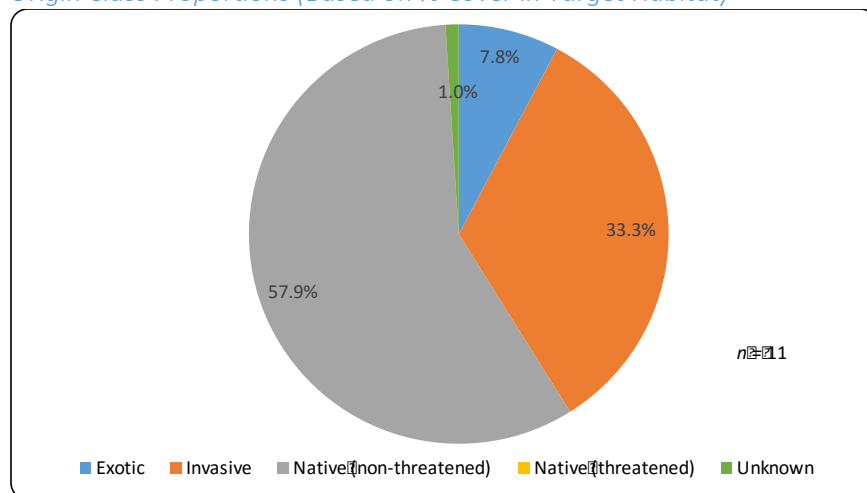
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	3400.3	87.5	38.4 +/- 15.2	0.9 +/- 1.8	1.19	11	Marsh habitat (target habitat)
2	484.8	12.5	78.7 +/- 13.2	0 +/- 0	1.07	5	Mostly exposed mud, with stunted herb community (1 cm tall). Vegetation dominated by species associated with mud flats and low marsh habitats.

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	purple loosestrife	<i>Lythrum salicaria</i>	I	1	13.1	9.9	11	29.8
1	swamp horsetail	<i>Equisetum fluviatile</i>	N	1	9.8	6.9	11	27.7
1	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	10.8	11.3	11	12.3
2	pigmyweed	<i>Crassula aquatica</i>	N	1	4.8	1.1	5	21.3
2	water mudwort	<i>Limosella aquatica</i>	N	1	3.7	2.5	5	16.4
2	small spike-rush	<i>Eleocharis parvula</i>	T	1	2.9	3.5	5	12.9
2	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	3.3	5.7	5	11.7
2	common cattail	<i>Typha latifolia</i>	N	1	4.0	3.2	5	10.6

### Origin Class Proportions (Based on % Cover in Target Habitat)



Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
1. Proportion of Target Habitat Established(% of area goal)	100.0*	112.0%	Good	The combination of 02-003-A and 02-003-B exceeds project goal of 7755 sqm. Excess 12% may be due to mapping inaccuracy or marsh expansion over time.
2. Proportion/Relative % Cover Native Species	86.7	57.9	Fair	Of the vegetation present, only 58% of cover is native species. Relative % cover of native species was greater in nearby reference sites REF-05-001 and REF-02-001, with an average of 86.7% between them. The vegetation cover is moderate at 61% mean % cover not vegetated across the site. This is primarily due to areas of standing water and a couple of drainage channels.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	5	Control invasive species. Replace with native species.	The relative amount of invasive species at this site is quite high at 33%. <i>Lythrum salicaria</i> is quite widespread throughout the site (average % cover = 13%) and is the most dominant species with relative dominance of 30%. There is also a large patch of <i>Typha angustifolia</i> (average % cover = 6%). Control methods should be implemented on these species. Followed by planting of native species to prevent recolonization of invasives.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
None			



Site# 02-005-A  
CPR# 9307-0098

---

### Background

The Site ID was described as containing six marsh benches in one monitoring report. We only identified five benches. Habitat constructed in 1993 and planted in 1995. The entire project was planted with 11460 *Carex lyngbyei* golf-cup cutter plugs extracted from natural marshes in the North and middle arms, and Sturgeon Bank. Transplants were planted at 0.5 centre-to-centre interval. Monitoring indicated a near-100% survivorship of transplants, with a coverage <25%. Habitat compensation goal = 1524 sqm marsh habitat.

### Description

02-005-A is the first in a series of 5 marsh benches. The site is a small protruding bench (305 sqm). Soil deposition has almost completely covered the riprap foreshore, creating a smooth transition from marsh to mudflat. There are 2 vegetative communities at this site. Community 1 (82% of area) is most representative of typical marsh vegetation; however, *Carex* and *Juncus* spp. are patchy and the Community is instead dominated by exotic *Myosotis scorpioides*, and *Agrostis capillaris*, followed by subdominant native *Carex lyngbyei* and *Myriophyllum ussuriense*. Community 2 (18% of area) is primarily exposed mud (approx. 79% unvegetated) with a stunted herb community ( $\geq 1$  cm tall) dominated by aquatic *Callitriche stagnalis*.

### Morphological Features

Flat site with no significant drainage channels or depressions. Significant evidence of sediment deposition along foreshore.

### Impacts & Stressors

Exotic species *Myosotis scorpioides* and *Agrostis capillaris* are acting aggressively at this site, and may be displacing native species (>15% cover in >10% of plots (Oregon Department of State Lands, 2009)<sup>1</sup>.

<sup>1</sup> Oregon Department of State Lands. (2009). Routine Monitoring Guidance for Vegetation. Retrieved from [http://www.oregon.gov/dsl/PERMITS/docs/dsl\\_routine\\_monitoring\\_guidance.pdf](http://www.oregon.gov/dsl/PERMITS/docs/dsl_routine_monitoring_guidance.pdf)

### Wildlife Sightings/Evidence

None.

### Adjacent Land Use

Public walking trail above site (N), separated by mature riparian vegetation. Beyond the walking trail are light industrial facilities.

### Threatened Plant Species (Provincial/Federal)

Two threatened species were sampled: *Eleocharis parvula* and *Juncus oxymersis*, totaling a mean % cover of 0.3 +/- 0.3 in target habitat.

### Invasive Species

Two invasive species were sampled: *Lythrum salicaria* and *Phalaris arundinacea*, totaling a mean % cover of 3.3 +/- 1.8 in target habitat.

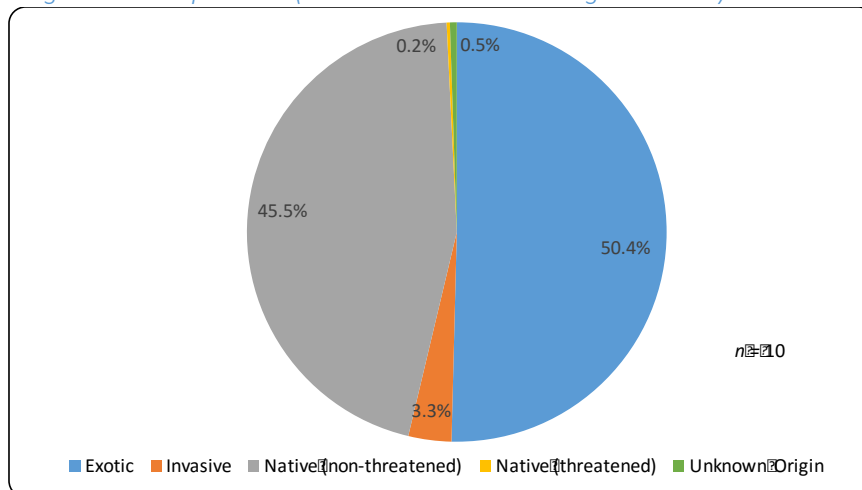
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	249.0	81.7	9.3 +/- 7.8	None	1.84	10	Marsh habitat (target habitat)
2	55.6	18.3	78.8 +/- 6.5	None	1.07	5	Mostly exposed mud, with stunted herb Community (1 cm tall). Vegetation dominated by species associated with mud flats and low marsh habitats.

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	European forget-me-not	<i>Myosotis scorpioides</i>	E	2	30.8	17.3	10	40.6
1	colonial bentgrass	<i>Agrostis capillaris</i>	E	3	14.1	8.8	10	20.7
1	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	20.7	16.8	10	15.2
1	Ussurian water-milfoil	<i>Myriophyllum ussuriense</i>	N	1	8.1	7.7	10	10.7
2	pond water-starwort	<i>Callitriche stagnalis</i>	E	1	16.8	6.6	5	83.7

### Origin Class Proportions (Based on % Cover in Target Habitat)



Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
1. Proportion of Target Habitat Established(% of area goal)	100.0*	74.0%	Fair	The successful establishment of target habitat for sites O2-005-A to E is 74%; however, including the mudflat habitat, the total area built exceeds the target marsh gain of 1524 sqm.
2. Proportion/Relative % Cover Native Species	86.7	45.7	Poor	The total vegetation cover in the target habitat at this site is high (91%), but is dominated by exotic species acting aggressively. Relative % cover native species is far below average of nearby reference sites REF-05-001 and REF-02-001.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Exotic Species	5	Control and replant with native species	<i>Myosotis scorpioides</i> and <i>Agrostis capillaris</i> are acting aggressively and may be displacing native species or limiting their colonization. Exotic species account for 31% of the vegetation present in the target habitat dominated by <i>M. scorpioides</i> (13% relative dominance) and <i>A. capillaris</i> (20%). This site would benefit from control actions and replanting of native species to prevent further expansion of these exotic species.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
None			



Site# 02-005-B  
CPR# 9307-0098

---

### Background

The Site ID was described as containing six marsh benches in one monitoring report. We only identified five benches. Habitat constructed in 1993 and planted in 1995. The entire project was planted with 11460 *Carex lyngbyei* golf-cup cutter plugs extracted from natural marshes in the North and middle arms, and Sturgeon Bank. Transplants were planted at 0.5 centre-to-centre interval. Monitoring indicated a near-100% survivorship of transplants, with a coverage <25%. Habitat compensation goal = 1524 sqm marsh habitat.

### Description

02-005-B is the second in a series of 5 marsh benches (West to East). The site is a small protruding bench (337 sqm), protected by a large log boom along the immediate foreshore. Soil deposition has almost completely covered the riprap foreshore, creating a smooth transition from marsh to mudflat. There are 2 vegetative communities at this site. Community 1 (19% of site) is most representative of typical marsh vegetation, and is dominated by native *Carex lyngbyei*, and aggressive exotics, such as *Agrostis capillaris* and *Myosotis scorpioides*. Community 2 (81% of site) is primarily exposed mud (~ 75% bare ground) with a stunted herb community (1 cm tall) dominated by low marsh hydrophytes (e.g. *Callitriche stagnalis*).

### Morphological Features

Flat site with no significant drainage channels or depressions. Significant evidence of sediment deposition along foreshore.

### Impacts & Stressors

Exotic species *Myosotis scorpioides* and *Agrostis capillaris* are acting aggressively at this site and may be displacing native species (>15% cover in >10% of plots (Oregon Department of State Lands, 2009)<sup>1</sup>.

<sup>1</sup> Oregon Department of State Lands. (2009). Routine Monitoring Guidance for Vegetation. Retrieved from [http://www.oregon.gov/dsl/PERMITS/docs/dsl\\_routine\\_monitoring\\_guidance.pdf](http://www.oregon.gov/dsl/PERMITS/docs/dsl_routine_monitoring_guidance.pdf)

### Wildlife Sightings/Evidence

None.

### Adjacent Land Use

Public riverside walking trail above site (N), separated by mature riparian vegetation. Beyond the walking trail are light industrial facilities.

### Threatened Plant Species (Provincial/Federal)

Two threatened species were sampled: *Eleocharis parvula* and *Juncus oxymeris*, totaling a mean % cover of 0.6 +/- 0.4 in target habitat.

### Invasive Species

Two invasive species were sampled: *Lythrum salicaria* and *Phalaris arundinacea*, totaling a mean % cover of 1.6 +/- 1.2 in target habitat.

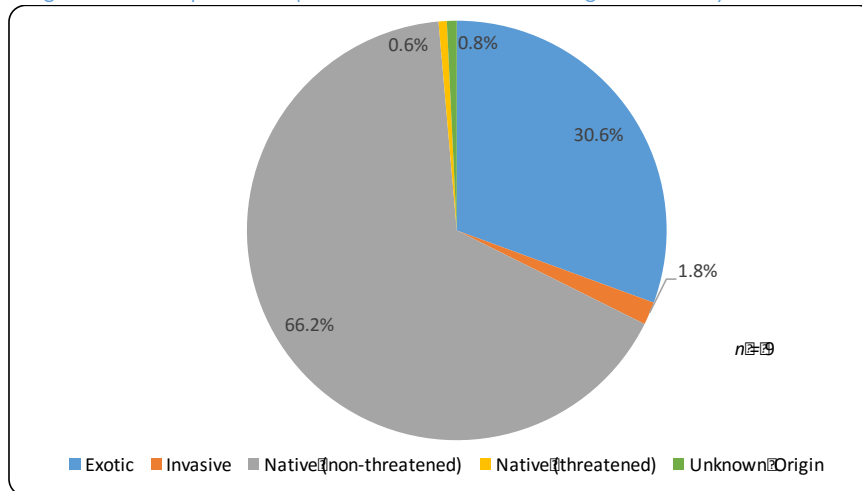
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI(95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	63.3	18.8	17.3 +/- 9.8	0 +/- 0	1.53	9	Marsh habitat (target habitat)
2	274.0	81.2	75.0 +/- 14.0	0 +/- 0	1.04	6	Mostly exposed mud, with stunted herb Community (1 cm tall). Vegetation dominated by species associated with mud flats and low marsh habitats.

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	47.3	21.0	9	62.0
1	colonial bentgrass	<i>Agrostis capillaris</i>	E	3	15.2	10.4	9	19.9
1	European forget-me-not	<i>Myosotis scorpioides</i>	E	2	11.1	15.0	9	12.7
2	pond water-starwort	<i>Callitriche stagnalis</i>	E	1	21.5	11.9	6	93.0

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
1. Proportion of Target Habitat Established(% of area goal)	100.0*	74.0%	Fair	The successful establishment of target habitat for sites O2-005-A to E is 74%; however, including the mudflat habitat, the total area built exceeds the target marsh gain of 1524 sqm.
2. Proportion/Relative % Cover Native Species	86.7	66.9	Fair	The total vegetation cover in the target habitat at this site is high (83%), but is dominated by exotic species acting aggressively. Relative % cover native species is far below average of nearby reference sites REF-05-001 and REF-02-001.

### Recommendations



Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Exotic Species	3	Control exotic species and replant with native species	At this site exotic <i>Myosotis scorpioides</i> and <i>Agrostis capillaris</i> are acting aggressively and may be displacing native species or limiting their colonization. Exotic species account for 31% of the vegetation present in the target habitat dominated by <i>M. scorpioides</i> (13% relative dominance) and <i>A. capillaris</i> (20%). This site would benefit from control actions and replanting of native species to prevent further expansion of these exotic species.
Bare Ground	4	Increase vegetation cover	The majority of this site is dominated by Community 2, a sparsely vegetated mudflat. The presence of a mudflat may indicate other stressors and may suggest that it cannot support a high density of vegetation without addressing them (such as waterfowl grazing, elevation too low, wave action, hydrological processes). Determining the cause of the mudflat is advisable prior to any planting actions.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
None			



## Site# 02-005-C

### CPR# 9307-0098

---

#### Background

The Site ID was described as containing six marsh benches in one monitoring report. We only identified five benches. Habitat constructed in 1993 and planted in 1995. The entire project was planted with 11460 *Carex lyngbyei* golf-cup cutter plugs extracted from natural marshes in the North and middle arms, and Sturgeon Bank. Transplants were planted at 0.5 centre-to-centre interval. Monitoring indicated a near-100% survivorship of transplants, with a coverage <25%. Habitat compensation goal = 1524 sqm marsh habitat.

#### Description

02-005-C is the third in a series of 5 benches (West to East). The site is a small protruding bench (556 sqm) armoured by a large log boom along the immediate foreshore. Soil deposition has almost completely covered the riprap foreshore, creating a smooth transition from marsh to mudflat. There are 2 vegetative communities at this site. Community 1 (58% of area) is most representative of marsh vegetation, and is dominated by *Sparganium angustifolium* and *Callitriche stagnalis*. Both of these species are indicators of slow moving standing water, perhaps suggesting that the foreshore log boom may be impacting vegetation by calming flows. Community 2 (42% of area) is primarily exposed mud (apx. 68% bare ground) with a stunted herb community dominated by *Callitriche stagnalis* and other low-marsh hydrophytes.

#### Morphological Features

Flat site with no significant drainage channels or depressions. Significant evidence of sediment deposition along foreshore.

#### Impacts & Stressors

Site is dominated by *Sparganium angustifolium* and *Callitriche stagnalis*, indicating slow moving or standing water. This suggests that the log boom may be impacting vegetation by reducing river flows.

#### Wildlife Sightings/Evidence

None.

#### Adjacent Land Use

Public riverside walking trail above site, separated by mature riparian vegetation. Beyond the walking trail are light industrial facilities.

#### Threatened Plant Species (Provincial/Federal)

One threatened species was sampled in target habitat: *Eleocharis parvula* (blue-listed), totaling a mean % cover of 0.2 +/- 0.3 in target habitat.

#### Invasive Species

Two invasive species were sampled in target habitat: *Lythrum salicaria* and *Phalaris arundinacea*, totaling a mean % cover of 3.4 +/- 6.6.

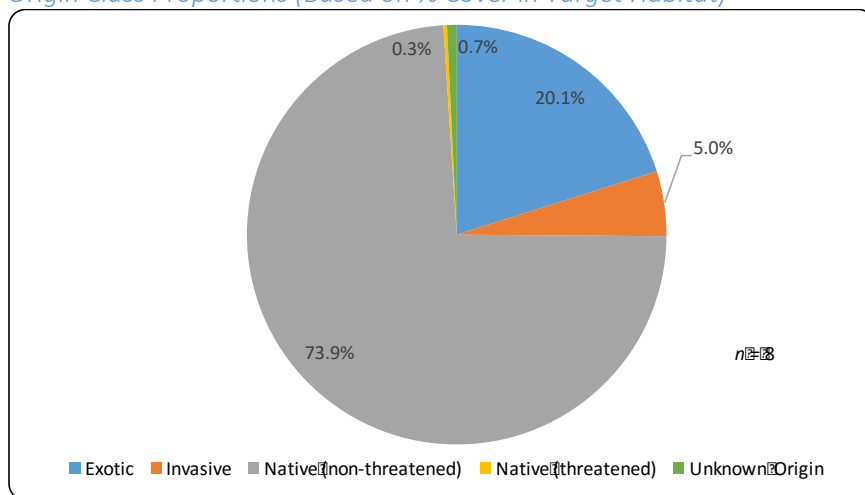
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris CI (95%)	Wetland Indicator Status	n	Description
1	323.1	58.2	34.1 +/- 8.4	None	1.04	8	Marsh habitat (target habitat)
2	232.5	41.8	67.8 +/- 18.8	None	1.01	5	Mostly exposed mud, with stunted herb Community (1 cm tall). Vegetation dominated by species associated with mud flats and low marsh habitats.

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	narrow-leaved bur-reed	<i>Sparganium angustifolium</i>	N	1	37.1	16.3	8	69.2
1	pond water-starwort	<i>Callitriche stagnalis</i>	E	1	10.1	10.1	8	18.9
2	pond water-starwort	<i>Callitriche stagnalis</i>	E	1	27.0	21.0	5	93.0

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established(% of area goal)</b>	100.0*	74.0%	Fair	The successful establishment of target habitat for sites 02-005-A to E is 74%; however, including the mudflat habitat, the total area built exceeds the target marsh gain of 1524 sqm.
<b>2. Proportion/Relative % Cover Native Species</b>	86.7	74.1	Good	Relative % cover of native species is slightly less than nearby reference sites REF-05-001 and REF-02-001, but still within acceptable limits. Site success is reduced by the abundance of bare ground, with 34% mean cover in Community 1 (58% of site) and 68% in Community 2 (42% of site).

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Slow moving water	4	Improve water flow	Site is dominated by <i>Sparganium angustifolium</i> and <i>Callitriche stagnalis</i> , indicating slow moving or standing water. This suggests that the log boom may be impacting vegetation by reducing river velocity. Consider ways to improve water flow to this site.
Bare Ground	3	Increase vegetation cover	Community 2 accounts for 42% of this site. It is a sparsely vegetated mudflat with bare ground accounting for approximately 68% of this community. The presence of a mudflat may indicate other stressors and may suggest that it cannot support a high density of vegetation without first addressing them (such as waterfowl grazing, elevation too low, wave action, hydrological processes). Determining the cause of the mudflat is advisable prior to any planting actions.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
None			



Site# 02-005-D  
CPR# 9307-0098

---

### Background

The Site ID was described as containing six marsh benches in one monitoring report. We only identified five benches. Habitat constructed in 1993 and planted in 1995. The entire project was planted with 11,460 *Carex lyngbyei* golf-cup cutter plugs extracted from natural marshes in the North and middle arms, and Sturgeon Bank. Transplants were planted at 0.5 centre-to-centre interval. Monitoring indicated a near-100% survivorship of transplants, with a coverage <25%. Habitat compensation goal = 1524 sqm marsh habitat.

### Description

02-005-D is the fourth in a series of 5 benches (West to East). The site is a small protruding bench (194 sqm) protected by a large log boom along the immediate foreshore. Soil deposition has almost completely covered the riprap, creating a smooth transition from marsh to mudflat. There are vegetative 2 communities at this site. Community 1 (86% of area) is most representative of marsh vegetation; however, it is heavily dominated by exotic *Myosotis scorpioides* (62% relative dominance) followed by native *Sparganium angustifolium* (14% relative dominance), a species that often indicates slow-moving water. The dominance of *S. angustifolium* may suggest that the foreshore log boom may be impacting vegetative community by reducing river velocities. Community 2 (14% of area) is primarily exposed mud, with stunted herb community dominated by *Callitriche stagnalis*, and other low-marsh hydrophytes.

### Morphological Features

Flat site with no significant drainage channels or depressions. Significant evidence of sediment deposition along foreshore.

### Impacts & Stressors

Site has a significant amount of *Sparganium angustifolium* suggesting that the log boom may be creating too much of a water calming effect. Exotic *Myosotis scorpioides* is acting aggressively at this site and may be displacing or preventing the colonization of native species (>15% cover in >10% of plots (Oregon Department of State Lands, 2009)<sup>1</sup>.

<sup>1</sup> Oregon Department of State Lands. (2009). Routine Monitoring Guidance for Vegetation. Retrieved from [http://www.oregon.gov/dsl/PERMITS/docs/dsl\\_routine\\_monitoring\\_guidance.pdf](http://www.oregon.gov/dsl/PERMITS/docs/dsl_routine_monitoring_guidance.pdf)

### Wildlife Sightings/Evidence

None.

### Adjacent Land Use

Public riverside walking trail above site, separated by mature riparian vegetation. Beyond the walking trail are light industrial facilities.

### Threatened Plant Species (Provincial/Federal)

One threatened species was sampled in target habitat: *Lilaea scilloides* (blue-listed), totaling a mean % cover of 0.3 +/- 0.3. *Eleocharis parvula* was also sampled in Community 2, totaling a mean % cover of 0.2 +/- 0.3.

### Invasive Species

Two invasive species were sampled in target habitat: *Lythrum salicaria* and *Phalaris arundinacea*, totaling a mean % cover of 14.9 +/- 27.5.

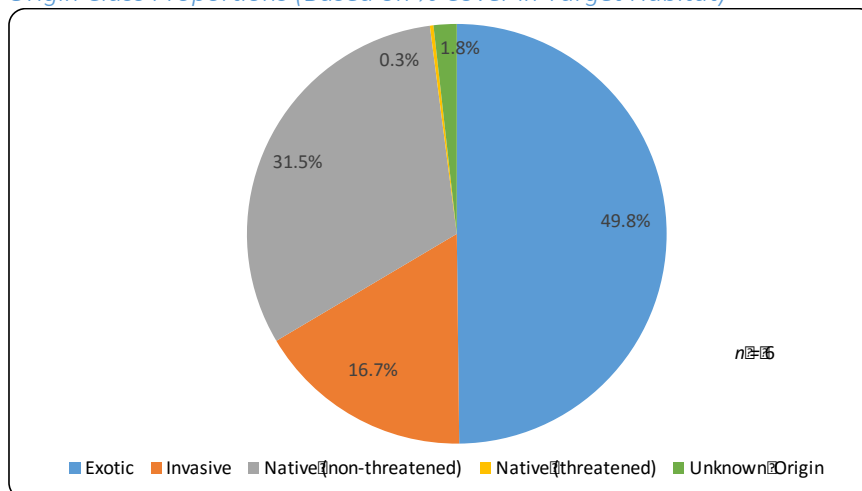
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI(95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	167.6	86.4	15.4 +/- 17.4	None	1.79	6	Marsh habitat (target habitat)
2	26.4	13.6	45.0 +/- 39.2	None	1.02	3	Mostly exposed mud, with stunted herb Community (1 cm tall). Vegetation dominated by species associated with mud flats and low marsh habitats.

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	European forget-me-not	<i>Myosotis scorpioides</i>	E	2	37.0	31.2	6	61.6
1	narrow-leaved bur-reed	<i>Sparganium angustifolium</i>	N	1	20.8	26.6	6	13.9
2	pond water-starwort	<i>Callitriche stagnalis</i>	E	1	55.7	36.6	3	96.1

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established(% of area goal)</b>	100.0*	74.0%	Fair	The successful establishment of target habitat for sites 02-005-A to E is 74%; however, including the mudflat habitat, the total area built exceeds the target marsh gain of 1524 sqm.
<b>2. Proportion/Relative % Cover Native Species</b>	86.7	31.8	Poor	The total vegetation cover in the target habitat at this site is high (85%), but is dominated by exotic species acting aggressively. Relative % cover of native species is significantly lower than average of nearby reference sites REF-05-001 and REF-02-001.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Exotic species	5	Control exotics and replace with native species	At this site exotic <i>Myosotis scorpioides</i> and <i>Agrostis capillaris</i> are acting aggressively and may be displacing native species or limiting their colonization. Exotic species account for 50% of the vegetation present in the target habitat dominated by <i>M. scorpioides</i> (62% relative dominance). This site would benefit from control actions and replanting of native species to prevent further expansion of these exotic species.
Slow moving water	3	Improve water flow	Site has a significant amount of <i>Sparganium angustifolium</i> , indicating slow moving or standing water. Log boom is likely the primary driver of these conditions. Consider ways to improve water flow to this site to increase vegetative cover.
Bare ground	2	Increase vegetation cover	Community 2 accounts for 14% of this site. It is a sparsely vegetated mudflat with bare ground accounting for approximately 45% of this community. The presence of a mudflat may indicate other stressors and may suggest that it cannot support a high density of vegetation without first addressing them (such as waterfowl grazing, elevation too low, wave action, hydrology). Determining the cause of the mudflat is advisable prior to any planting actions.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
None			





Site# 02-005-E  
CPR# 9307-0098

---

### Background

The Site ID was described as containing six marsh benches in one monitoring report. We only identified five benches. Habitat constructed in 1993 and planted in 1995. The entire project was planted with 11460 *Carex lyngbyei* golf-cup cutter plugs extracted from natural marshes in the North and middle arms, and Sturgeon Bank. Transplants were planted at 0.5 centre-to-centre interval. Monitoring indicated a near-100% survivorship of transplants, with a coverage <25%. Habitat compensation goal = 1524 sqm marsh habitat.

### Description

02-005-E is the fifth in a series of 5 benches (West to East). The site is a small protruding bench (327 sqm) protected by a large log boom along the immediate foreshore. Soil deposition has almost completely covered the riprap, creating a smooth transition from marsh to mudflat. There is only 1 vegetative community at this site. Community 1 represents typical marsh vegetation, and is dominated by native *Carex lyngbyei*, and exotics *Myosotis scorpioides* and *Agrostis capillaris*.

### Morphological Features

Flat site with no significant drainage channels or depressions. Significant evidence of sediment deposition along foreshore.

### Impacts & Stressors

Exotics *Myosotis scorpioides* and *Agrostis capillaris* are acting aggressively at this site and may be displacing or preventing the colonization of native species (>15% cover in >10% of plots (Oregon Department of State Lands, 2009)<sup>1</sup>.

<sup>1</sup> Oregon Department of State Lands. (2009). Routine Monitoring Guidance for Vegetation. Retrieved from [http://www.oregon.gov/dsl/PERMITS/docs/dsl\\_routine\\_monitoring\\_guidance.pdf](http://www.oregon.gov/dsl/PERMITS/docs/dsl_routine_monitoring_guidance.pdf)

### Wildlife Sightings/Evidence

None.

### Adjacent Land Use

Public riverside walking trail above site, separated by mature riparian vegetation. Beyond the walking trail are light industrial facilities.

### Threatened Plant Species (Provincial/Federal)

Two threatened plant species were sampled in target habitat: *Eleocharis parvula* (blue-listed) and *Juncus oxymers* (blue-listed), with a total mean % cover of 0.1 +/- 0.2.

### Invasive Species

Two invasive species were sampled in target habitat: *Lythrum salicaria*, and *Iris pseudacorus*, totaling a mean % cover of 0.4 +/- 0.4.



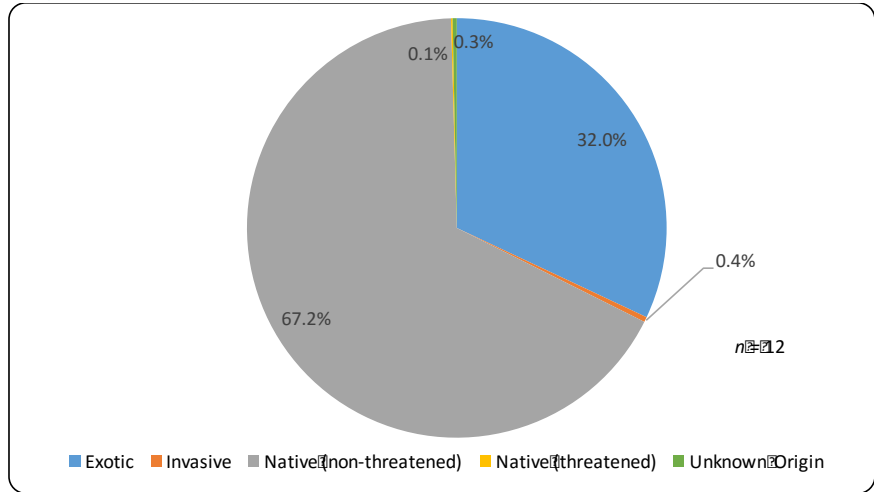
Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI(95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	327.2	100	4.6 +/- 6.5	None	1.54	12	Marsh habitat (target habitat)

Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	48.2	20.5	12	50.8
1	European forget-me-not	<i>Myosotis scorpioides</i>	E	2	19.3	8.8	12	24.5
1	colonial bentgrass	<i>Agrostis capillaris</i>	E	3	12.3	5.3	12	14.2

Origin Class Proportions (Based on % Cover in Target Habitat)



Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established(% of area goal)</b>	100.0*	74.0%	Fair	The successful establishment of target habitat for sites 02-005-A to E is 74%; however, including the mudflat habitat, the total area built exceeds the target marsh gain of 1524 sqm.
<b>2. Proportion/Relative % Cover Native Species</b>	86.7	67.3	Fair	The total vegetation cover in the target habitat at this site is high (95%), but exotic species acting aggressively are the next most dominant and may warrant mitigation to prevent 02-005-E from becoming as dominated by exotics as 02-005-A,B & D. Relative % cover of native species is significantly lower than average of nearby reference sites REF-05-001 and REF-02-001.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Exotic Species	4	Control and replant with native species	At this site exotic <i>Myosotis scorpioides</i> and <i>Agrostis capillaris</i> are acting aggressively and may be displacing native species or limiting their colonization. Exotic species account for 32% of the vegetation present in the target habitat dominated by <i>M. scorpioides</i> (24%). This site would benefit from control actions and replanting of native species to prevent 02-005-E from becoming as dominated by exotics as 02-005-A,B & D.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments



Site# 02-007-A  
CPR# 8901-003

---

### Background

1085 sqm of intertidal mudflat, 1720 sqm of marsh, and 175 sqm of riparian habitat were impacted as a result of shoreline works. Compensation habitats (3) were created and planted in 1993. Marsh habitats were planted with 14272 *Carex lyngbyei* golf-cup cutter plugs, acquired from nearby natural tidal marshes, and planted at 0.5 m centre-to-centre intervals. Monitoring revealed that after three growing seasons coverage by marsh vegetation had approached 100%, dominated by *C. lyngbyei*, *Eleocharis palustris* and *Juncus articulatus*. Total habitat compensation goal of three compensation habitats (02-007-A,B,C) = 3984 sqm marsh and 175 sqm riparian habitat.

### Description

Marsh is created in an embayment with its foreshore edge in line with the surrounding shoreline. Backshore boundaries of marsh are bordered by a riprap slope with a ~1.5 m strip of riparian vegetation above. Front of marsh is armoured by a riprap slope, which descends into the low intertidal. An outflow pipe feeds into the Fraser River approximately 5 m upstream from site. No log boom protection is in place, despite frequent tug activity in neighbouring North Arm. A vegetated mudflat (Community 2) presently accounts for approximately 28% of the site and occurs along the marsh foreshore.

Community 1 (target habitat) was dominated by *Agrostis stolonifera* and *Carex lyngbyei* with 27% and 23% relative dominance respectively, followed by *Schoenoplectus tabernaemontani* and *Equisetum fluviatile*, each with 10% relative dominance. Community 2 (vegetated mudflat) vegetation was severely stunted, and was dominated by low-marsh species such as threatened *Eleocharis parvula* and aquatic *Crassula aquatica*. Significant evidence of waterfowl grazing was observed in both communities. Some log debris was present, especially along the backshore near toe of riprap dike.

### Morphological Features

Flat marsh with occasional pool of standing water. No significant drainage channels. Backed by riprap slope.

### Impacts & Stressors

Significant evidence of waterfowl grazing. Some log debris, especially along back near riprap. Exotic *Agrostis stolonifera* is acting aggressively at this site (>15% cover in >10% of plots (Oregon Department of State Lands, 2009)<sup>1</sup>.

<sup>1</sup>Oregon Department of State Lands. (2009). Routine Monitoring Guidance for Vegetation. Retrieved from [http://www.oregon.gov/dsl/PERMITS/docs/dsl\\_routine\\_monitoring\\_guidance.pdf](http://www.oregon.gov/dsl/PERMITS/docs/dsl_routine_monitoring_guidance.pdf)

### Wildlife Sightings/Evidence

5 Canada Geese were observed using habitat.

### Adjacent Land Use

Residential condos and town houses (N). Paved BC Parkway multi-use trail at top of backshore dike.

### Threatened Plant Species (Provincial/Federal)

Two threatened species were sampled in target habitat: *Eleocharis parvula* (blue-listed) and *Juncus oxymeris* (blue listed), with a mean % cover of 0.6 +/- 1.1. *Eleocharis palustris* also occurred in Community 2, with a mean % cover of 10.6 +/- 2.4.

### Invasive Species

Two invasive species were sampled in target habitat: *Lythrum salicaria* and *Phalaris arundinacea*, with a mean % cover of 5.5 +/- 5.0.

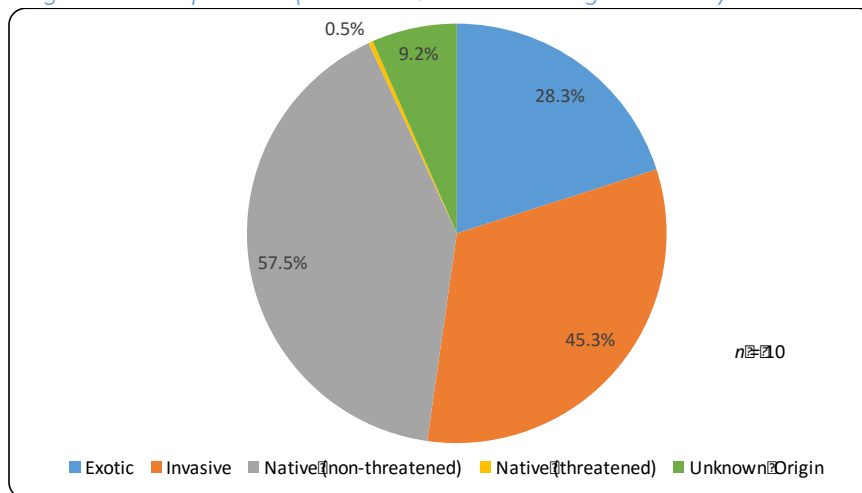
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI(95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	997.0	72.2	2.5 +/- 1.5	n/a	1.65	10	Marsh habitat (target habitat)
2	383.0	27.8	69.5 +/- 14.0	n/a	1.00	5	Vegetated Mudflat

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	creeping bentgrass	<i>Agrostis stolonifera</i>	E	3	24.5	8.0	10	27.3
1	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	26.4	15.5	10	23.5
1	soft-stemmed bulrush	<i>Schoenoplectus tabernaemontani</i>	N	1	13.0	12.0	10	10.1
2	small spike-rush	<i>Eleocharis parvula</i>	N	1	10.6	2.4	5	38.3
2	pigmyweed	<i>Crassula aquatica</i>	E	1	6.6	7.6	5	23.8
2	pond water-starwort	<i>Callitriche stagnalis</i>	E	1	4.8	7.5	5	17.3

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established(% of area goal)</b>	100.0*	67.0%	Fair	The successful establishment of target habitat for sites 02-007-A to C is 67%; however, including the mudflat habitat, the total area built meets the target marsh gain of 3984 sqm. The presence of the mudflat at this location may be due to a number of stressors or a combination of stressors such as waterfowl grazing, trampling, wave action, erosion, hydrological processes, and/or site elevation.
<b>2. Proportion/Relative % Cover Native Species</b>	86.7	58.0	Fair	The total vegetation cover in the target habitat at this site is high (98%), however the relative % cover of native species is below the average of neighbouring reference sites REF-05-001 and REF-02-001.

### Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Exotic species	3	Control and replant with native species.	Exotic <i>Agrostis stolonifera</i> is acting aggressively at this site. Exotic species account for 28% of the vegetation present in the target habitat dominated by creeping bentgrass (27% relative dominance). This site would benefit from exotic control activities and replanting of native species in order to increase dominance of native species, and improve site resiliency.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Log debris	2	Monitor increase/decrease over time	Monitor log debris by measuring log debris accumulation zone or via photo monitoring. Consider removal if log debris builds up and begins to significantly impact vegetation cover.
Mudflat expansion	4	Monitor recession/expansion of foreshore vegetated mudflat	Monitor mudflat for expansion via area mapping/photo monitoring. If expansion is occurring, consider determining cause and mitigating expansion. The presence of the mudflat at this location may be due to a number of stressors or a combination of stressors such as waterfowl grazing, trampling, wave action, erosion, hydrological processes, and/or elevation.





## 02-007-B

### CPR# 8901-003

---

#### Background

1085 sqm of intertidal mudflat, 1720 sqm of marsh, and 175 sqm of riparian habitat were impacted as a result of shoreline works. Compensation habitats (3) were created and planted in 1993. Marsh habitats were planted with 14272 *Carex lyngbyei* golf-cup cutter plugs, acquired from nearby natural tidal marshes, and planted at 0.5 m centre-to-centre intervals. Monitoring revealed that after three growing seasons coverage by marsh vegetation had approached 100%, dominated by *C. lyngbyei*, *Eleocharis palustris* and *Juncus articulatus*. Total habitat compensation goal of three compensation habitats (02-007-A,B,C) = 3984 sqm marsh and 175 sqm riparian habitat.

#### Description

Marsh is created in an embayment with its foreshore edge in line with the surrounding shoreline. Backshore boundaries of marsh are bordered by a riprap slope with a ~1.5 m strip of riparian vegetation above. Front of marsh armoured by a riprap slope, which descends into the low intertidal. An outflow pipe feeds into the Fraser River approximately 5 m upstream from site. No log boom protection is in place, despite frequent tug activity in neighbouring North Arm. A vegetated mudflat (Community 2) presently accounts for approximately 18% of the site.

Community 1 (target marsh habitat) was dominated by native *Juncus balticus*, followed by subdominant *Lycopus* sp. and exotic *Agrostis stolonifera*. Community 2 (vegetated mudflat) vegetation was severely stunted, and was dominated by low-marsh species such as native *Juncus articulatus* and threatened *Eleocharis parvula*. Significant evidence of waterfowl grazing was observed in both communities. Some log debris was observed, especially along backshore near toe of riprap slope.

#### Morphological Features

Flat marsh with a significant area of pooled water in the middle. Hummocking by *Juncus balticus* has led to creation of minor channels, potentially increasing access for fish. No significant drainage channels were observed. Backed by riprap slope.

#### Impacts & Stressors

Significant evidence of waterfowl grazing. Some log debris, especially along backshore near to of riprap slope.

#### Wildlife Sightings/Evidence

Small fish observed in ponded area.

#### Adjacent Land Use

Residential condos and town houses (N). Paved BC Parkway multi-use trail at top of backshore dike.

#### Threatened Plant Species (Provincial/Federal)

One threatened species was sampled in target habitat: *Juncus oxymers* (blue listed), with a mean % cover of 0.7 +/- 1.4. *Eleocharis palustris* (blue-listed) occurred in Community 2, with a mean % cover of 1.0 +/- 1.0.

#### Invasive Species

Three invasive species were sampled in target habitat: *Lythrum salicaria*, *Iris pseudacorus*, and *Phalaris arundinacea*, with a mean % cover of 10.0 +/- 9.6.



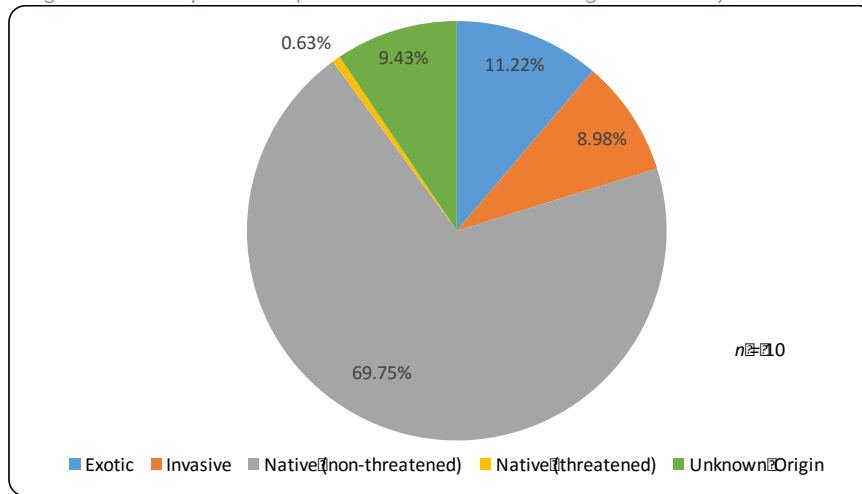
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	481.0	81.5	4.4 +/- 3.3	1.0 +/- 2.0	1.77	10	Marsh habitat (target habitat)
2	109.0	18.5	72.2 +/- 9.4	none	1.19	5	Vegetated Mudflat

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	Baltic rush	<i>Juncus balticus</i>	N	2	50.0	32.6	10	47.2
1	horehound	<i>Lycopus sp.</i>	U	1	10.3	10.9	10	13.6
1	creeping bentgrass	<i>Agrostis stolonifera</i>	E	3	11.8	11.3	10	13.4
2	jointed rush	<i>Juncus articulatus</i>	N	1	4.7	1.7	3	27.8
2	small spike-rush	<i>Eleocharis parvula</i>	T	1	3.0	1.1	3	17.9
2	water mudwort	<i>Limosella aquatica</i>	N	1	2.0	1.1	3	11.9
2	pond water-starwort	<i>Callitriche stagnalis</i>	E	1	1.8	1.4	3	10.9
2	pigmyweed	<i>Crassula aquatica</i>	N	1	1.8	2.1	3	10.9

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established(% of area goal)</b>	100.0*	67.0	Fair	The successful establishment of target habitat for sites 02-007-A to C is 67%; however, including the mudflat habitat, the total area built meets the target marsh gain of 3984 sqm. The presence of the mudflat at this location may be due to a number of stressors or a combination of stressors such as waterfowl grazing, trampling, wave action, erosion, hydrological processes, and/or elevation.
<b>2. Proportion/Relative % Cover Native Species</b>	86.7	70.4	Fair	The total vegetation cover in the target habitat at this site is high (95%), however the relative % cover of native species is below the average of neighbouring reference sites REF-05-001 and REF-02-001.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	3	Control <i>Iris pseudacorus</i>	<i>Iris pseudacorus</i> is present in small clumps and therefore would be easy to control at this stage to prevent spread.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Log Debris	2	Monitor increase/decrease over time	Monitor log debris by measuring log debris accumulation zone or via photo monitoring. Consider removal if log debris builds up and begins to significantly impact vegetation cover.
Mudflat Expansion	4	Monitor recession/expansion of foreshore vegetated mudflat	Monitor mudflat for expansion via area mapping/photo monitoring. If expansion is occurring, consider determining cause and mitigating expansion. The presence of the mudflat at this location may be due to a number of stressors or a combination of stressors such as waterfowl grazing, trampling, wave action, erosion, hydrology, and/or site elevation.



## 02-007-C

### CPR# 8901-003

---

#### Background

1085 sqm of intertidal mudflat, 1720 sqm of marsh, and 175 sqm of riparian habitat were impacted as a result of shoreline works. Compensation habitats (3) were created and planted in 1993. Marsh habitats were planted with 14,272 *Carex lyngbyei* golf-cup cutter plugs, acquired from nearby natural tidal marshes, and planted at 0.5 m centre-to-centre intervals. Monitoring revealed that after three growing seasons coverage by marsh vegetation had approached 100%, dominated by *C. lyngbyei*, *Eleocharis palustris* and *Juncus articulatus*. Total habitat compensation goal of three compensation habitats (02-007-A,B,C) = 3984 sqm marsh and 175 sqm riparian habitat.

#### Description

Site is a semi-circular embayed marsh bench. Backshore is bordered by a steep riprap slope covered in *Rubus armeniacus*, *Populus balsamifera*, *Betula papyrifera*, *Salix* spp., *Symphoricarpos albus*, *Cornus stolonifera*, and *Rosa* sp..

At the top of the slope is a paved public walking trail and a condo development. The site is bordered by an emergency boat launch and riprap to the east, and a concrete wall to the west. Some log debris is distributed throughout the site, primarily accumulating along the backshore. No log boom protection is present along the foreshore. Riprap appears to be in poor condition compared to nearby compensation sites, as riprap grade appears smaller and foreshore substrate at top of riprap appears eroded. May be contributing to erosion and/presence of community 2 (vegetated mudflat)

The site contains 2 communities. Community 1 is dominated by *Carex lyngbyei* and *Agrostis stolonifera* with 57% and 30% relative dominance respectively. There is also a patch of *Juncus balticus* that is isolated from the rest of community 1, closer to the river's edge. Community 2 composes the first 5-10 m from the river edge and is separated from Community 1 by a narrow transition zone of stunted marsh species. It is dominated by species typically associated with mudflat/low marsh environments.

#### Morphological Features

Community 1 occurs along backshore 2/3 of site, and is relatively flat. Community 2 occurs along foreshore, and is several centimeters lower either due to either soil loss or aggrading of backshore community.

#### Impacts & Stressors

Canada Geese were observed in Community 2 both grazing and roosting. Tops of most sedges and horsetail throughout site appear to be grazed. Grazing potentially from geese and/or other waterfowl floating in at high tide and grazing the emergent stalks. *Lythrum salicaria* is undamaged, and is not considered a favourable grazing species.

Public access created by the emergency boat launch make it easy for people to access the site. Garbage was present in site, and one individual was sighted attempting to dump yard waste in marsh. Dog tracks were also visible in mudflat. Foreshore erosion, either due to grazing or wave actions, appears to be impacting the foreshore. More small rocks were exposed in riprap material than seen at other sites and substrate was coarser and more undulating along the marsh foreshore. Exotic *Agrostis stolonifera* is acting aggressively at this site and may be excluding native species (>15% cover in >10% of plots (Oregon Department of State Lands, 2009)<sup>1</sup>.

<sup>1</sup> Oregon Department of State Lands. (2009). Routine Monitoring Guidance for Vegetation. Retrieved from [http://www.oregon.gov/dsl/PERMITS/docs/dsl\\_routine\\_monitoring\\_guidance.pdf](http://www.oregon.gov/dsl/PERMITS/docs/dsl_routine_monitoring_guidance.pdf)

### Wildlife Sightings/Evidence

Canada Geese and Mallards were observed using habitat. Upon arrival, 10-15 geese were observed grazing in Community 2. Significant amount of geese droppings in exposed soil. Barn Swallows (blue-listed, COSEWIC-listed) were observed flying over site.

### Adjacent Land Use

Residential condos and town houses (N). Paved BC Parkway multi-use trail at top of backshore dike. Emergency ramp (E).

### Threatened Plant Species (Provincial/Federal)

No threatened species were sampled in target habitat, but one species was sampled in Community 2: *Eleocharis palustris* (blue-listed), with a mean % cover of 0.9 +/- 1.3.

### Invasive Species

One invasive species was sampled in target habitat: *Lythrum salicaria*, with a mean % cover of 4.7 +/- 3.2. *Phalaris arundinacea*, *Iris pseudacorus*, and *Polygonum cuspidatum* were all observed incidentally.

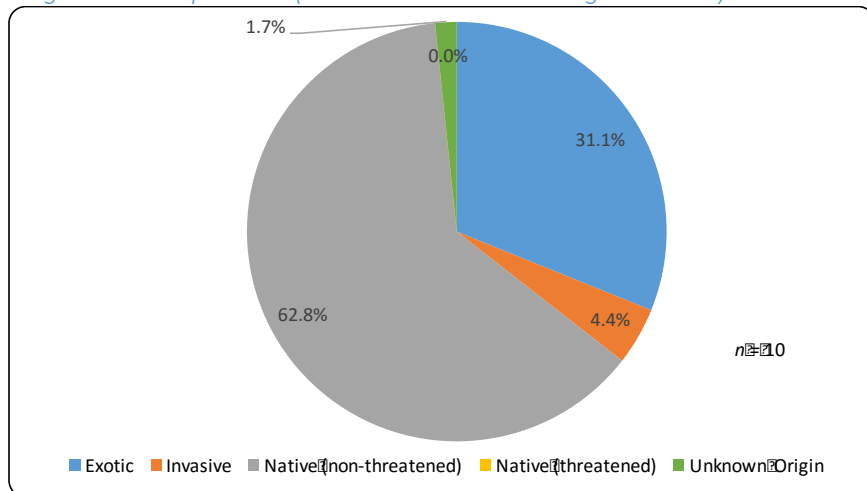
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	1202.0	68.1	7.3 +/- 5.0	None	1.61	10	Marsh habitat (target habitat)
2	562.0	31.9	93.8 +/- 2.6	None	1.07	6	Vegetated Mudflat

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	52.3	12.8	10	56.6
1	creeping bentgrass	<i>Agrostis stolonifera</i>	E	3	30.5	18.4	10	29.7
2	pond water-starwort	<i>Callitriche stagnalis</i>	E	1	1.4	0.9	6	35.4
2	jointed rush	<i>Juncus articulatus</i>	N	1	0.6	0.3	6	14.6
2	pigmyweed	<i>Crassula aquatica</i>	N	1	0.6	0.3	6	14.6
2	small spike-rush	<i>Eleocharis parvula</i>	T	1	0.9	1.3	6	13.8

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
1. Proportion of Target Habitat Established(% of area goal)	100.0*	67.0	Fair	The successful establishment of target habitat for sites 02-007-A to C is 67%; however, including the mudflat habitat, the total area built meets the target marsh gain of 3984 sqm. The presence of the mudflat at this location may be due to a number of stressors or a combination of stressors such as waterfowl grazing, trampling, wave action, erosion, hydrological processes, and/or elevation.
2. Proportion/Relative % Cover Native Species	86.7	62.8	Fair	The total vegetation cover in the target habitat at this site is high (93%), however the relative % cover of native species is below the average of neighbouring reference sites REF-05-001 and REF-02-001.

### Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	5	Control invasive species	<i>Iris pseudacorus</i> (site edges), <i>Polygonum cuspidatum</i> (NE corner) and <i>Phalaris arundinacea</i> are present in site in a single patch, but have the potential to spread. Controlling these species at this stage would be easy and would prevent further spread.
Illegal Dumping	4	Install signage	Garbage and yard waste observed in site.
Dog Trampling	4	Install signage	Dog walkers observed using emergency ramp and dog tracks observed in mud flat. Install signage indicating "Sensitive Habitat" "Do not disturb" to dissuade dogs and humans from entering the site.
Rock Debris	4	Clean up rock debris and repair foreshore riprap	More small rocks in riprap material than seen at other sites and a more undulating top of rip-rap bank. Small rocks spreading into the site possibly an indicator of erosion. Removal and cleanup of stones and rocks from marsh will promote vegetation growth. Repair riprap.
Exotic Species	3	Control and replant with native species	Exotic <i>Agrostis stolonifera</i> is acting aggressively at this site. Exotic species account for 31% of the vegetation present in the target habitat dominated by <i>A. stolonifera</i> (30% relative dominance). This site would benefit from exotic control activities and replanting of native species to increase relative % cover of native species.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Mudflat Expansion	4	Monitor recession/expansion of foreshore vegetated mudflat	Monitor mudflat for expansion via area mapping/photo monitoring. If expansion is occurring, consider determining cause and mitigating expansion. The presence of the mudflat at this location may be due to a number of stressors or a combination of stressors such as waterfowl grazing, trampling, wave action, erosion, hydrological processes, and/or elevation





Site# 02-009  
CPR# 0003F023

---

#### Background

Intertidal marsh (1382 sqm) and intertidal mudflat (1230 sqm) in the Fraser River North Arm was disturbed as a result of ground densification works associated with the seismic upgrade of the Oak Street Bridge south piers. Compensation completed in 2001. Habitat compensation goal = 1230 sqm intertidal mudflats, 1382 sqm marsh habitat.

#### Description

Site consists of the intertidal area located under the Oak Street Bridge. The western edge of the site is continuous with the natural shoreline; to the east the site is delineated by riprap that marks the boundary of 02-014. Lack of riprap at foreshore edge allows for a smooth transition from backshore marsh to low intertidal. The upland boundary is delineated by a riprap dike that borders River Road. The dike is covered in a significant amount of invasive species including *Rubus armeniacus*, *Cirsium arvense*, and *Polygonum cuspidatum*, which are spreading into high marsh habitat.

Currently only 36% of the site represents target marsh habitat (Community 1) dominated by *Juncus balticus* and *Potentilla egedii* with 72% and 10% relative dominance respectively. 56% of the site is comprised of vegetated mudflat (Community 2) with 77% bare ground and sparsely-occurring hydrophytes. 8% of the site is comprised of third community with high vegetation cover, but the community is dominated by low, mat-forming exotic *Agrostis capillaris* and stunted, aquatic vegetation associated with higher inundation rates.

#### Morphological Features

Gradually-sloped marsh habitat from high marsh backshore to lower intertidal. Raised mound on backshore side of bridge pillar has formed by sediment deposition.

#### Impacts & Stressors

Some minor log debris present. Exotic *Agrostis capillaris* appears to be excluding native species in Community 3.

#### Wildlife Sightings/Evidence

None.

#### Adjacent Land Use

River Road and light industrial on upland side of dike (S).

#### Threatened Plant Species (Provincial/Federal)

One threatened species was sampled in target habitat: *Juncus oxymers* (blue-listed), with a mean % cover of 0.3 +/- 0.6. *Lillaea scilloides* (blue-listed) and *Eleocharis parvula* (blue-listed) were sampled in Community 2, with mean % covers of 0.1 +/- 0.1 and 0.3 +/- 0.2 respectively. *Lillaea scilloides* was also sampled in Community 3, with a mean % cover of 1.3 +/- 0.7.

#### Invasive Species

Four invasive species were sampled in target habitat: *Lythrum salicaria*, *Phalaris arundinacea*, *Cirsium arvense*, and *Rubus armeniacus*, totaling a mean % cover of 7.2 +/- 5.0.



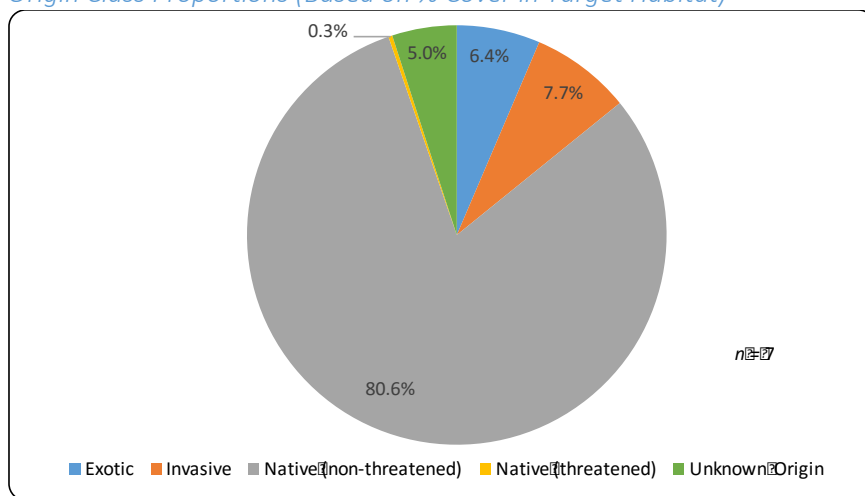
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	392.5	36.1	6.2 +/- 7.8	6.4 +/- 12.6	1.81	7	Marsh habitat (target habitat)
2	607.4	56.0	76.6 +/- 16.6	None	1.00	8	Vegetated mudflat
3	84.9	7.9	6.2 +/- 2.1	None	1.95	3	Bridge footing promotes buildup of sediment upslope of pillar, creating an elevated vegetated mudflat different to the vegetated mudflat of Community 2. This community has higher vegetation cover, but is dominated by stunted vegetation.

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	Baltic rush	<i>Juncus balticus</i>	N	2	57.1	29.2	7	71.6
2	pond water-starwort	<i>Callitriche stagnalis</i>	E	1	21.4	16.4	8	93.7
3	colonial bentgrass	<i>Agrostis capillaris</i>	E	3	42.7	18.4	3	47.4
3	low clubrush	<i>Isolepis cernua</i>	N	1	18.3	3.3	3	20.4
3	sea milkwort	<i>Glaux maritima</i> ssp. <i>maritima</i>	N	1	13.3	8.6	3	14.8

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
1. Proportion of Target Habitat Established(% of area goal)	100.0	28.4	Poor	Only 393 sqm of target habitat is present, 28% of the compensation goal.
2. Proportion/Relative % Cover Native Species	86.7	80.9	Good	The target habitat present is a <i>Juncus balticus</i> marsh habitat with high vegetation cover and a low amount of invasive and exotic species. Relative % cover of native species is only slightly lower than combined average of nearby reference sites REF-02-001 and REF-05-001.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Low target habitat	4	Increase area of target habitat	The presence of the vegetated mudflat at this location may be due to a combination of stressors such as waterfowl grazing, wave action, erosion, hydrological processes, and/or elevation, indicating this habitat may be unable to support a high density of vegetation.
Invasive Species	3	Control invasive species	The dike is covered in a significant amount of invasive species including <i>Rubus armeniacus</i> , <i>Cirsium arvense</i> , and <i>Polygonum cuspidatum</i> which are and may continue to spread into the marsh habitat.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
None			



Site# 02-014  
CPR# 0604F021

---

*Background*

Seismic upgrades lead to the disturbance of 500 sqm of intertidal marsh. Compensation completed in 2008. Habitat compensation goal = 950 sqm of marsh habitat.

*Description*

Linear marsh (approximately 95 m X 17 m) in line with surrounding shoreline. Foreshore edge is armoured with loose riprap. Riprap grade is relatively small, spanning 3-5 m between the marsh and mudflat below. The backshore boundary is delineated by riprap dike. The dike is covered in a significant amount of invasive species including *Rubus armeniacus*, *Cirsium arvense*, and *Polygonum cuspidatum*, which are advancing into the marsh backshore. Although well-vegetated, the site is heavily dominated by invasive *Typha angustifolia*, with 79% relative dominance.

*Morphological Features*

Site is relatively flat, with few noteworthy drainage channels. A single ponded area occurs midway along the foreshore.

*Impacts & Stressors*

A moderate amount of log debris has accumulated. Invasive *Typha angustifolia* represents 79% of marsh vegetative cover, and is likely displacing native species.

*Wildlife Sightings/Evidence*

Marsh Wren in marsh vegetation. Rodent droppings in mud.

*Adjacent Land Use*

River Road and light industrial on upland side of dike (S).

*Threatened Plant Species (Provincial/Federal)*

One threatened species was sampled in target habitat: *Juncus oxymeris* (blue-listed), with mean % cover of 0.1 +/- 0.2.

*Invasive Species*

Five invasive species were sampled in target habitat: *Typha angustifolia*, *Lythrum salicaria*, *Phalaris arundinacea*, *Cirsium arvense*, and *Rubus armeniacus*, totaling a mean % cover of 46.3 +/- 10.4, representing 75% of total vegetation. *Typha angustifolia* is the most dominant marsh species present, representing 79% of vegetative cover. *Polygonum cuspidatum* is present in the backshore riprap dike, just outside of marsh boundary.

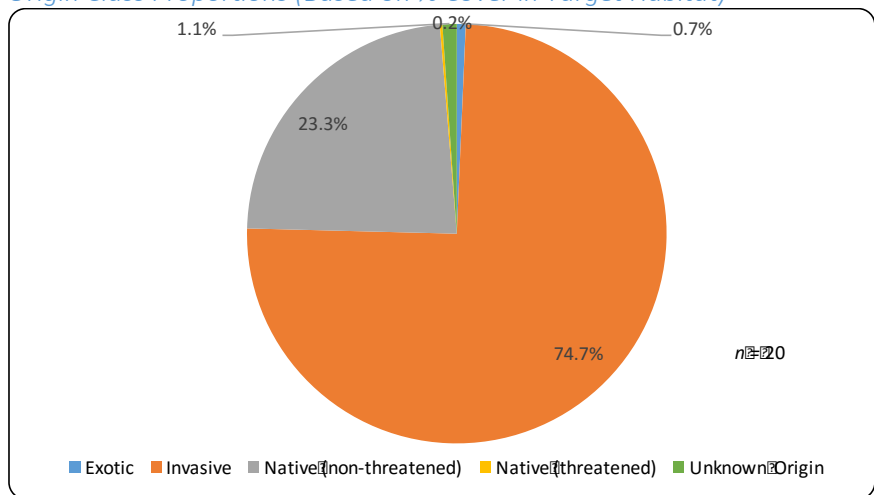
*Community Descriptions*

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI(95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	1651.4	100.0	25.1 +/- 9.1	12.7 +/- 11.2	1.05	20	Marsh habitat (target habitat)

*Dominant Species*

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	lesser cattail	<i>Typha angustifolia</i>	I	1	36.7	10.7	20	79.1

Origin Class Proportions (Based on % Cover in Target Habitat)



Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
1. Proportion of Target Habitat Established(% of area goal)	100.0	174.0	Good	Site has achieved and surpassed habitat compensation area goals. Marsh may have expanded upslope (at base of dike) and downslope (within foreshore riprap), potentially explaining excess of measured habitat.
2. Proportion/Relative % Cover Native Species	86.7	23.5	Poor	Site is heavily dominated by the aggressive invasive <i>Typha angustifolia</i> (79% relative dominance). Native relative % cover of site is significantly lower than combined average of nearby reference sites REF-05-001 and REF-02-001, attributed to <i>T. angustifolia</i> invasion.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	5	Control <i>Typha angustifolia</i> and replace with native species.	The site is heavily dominated by the aggressive invasive <i>Typha angustifolia</i> . This species is highly aggressive and has a tendency to create a homogenous environment where native species are excluded.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
None			



## Site# 03-002

### CPR# 8704-0038

---

#### Background

Losses in subtidal habitat (8106 sqm) were compensated with the creation of an embayed marsh. The marsh was constructed through the excavation and removal of waste fill (approximately 20000 cubic meters) from the end of Richmond Island. A protective berm was constructed along the North Arm boundary of the marsh. Site was created in 1988 and planted in 1989 with 16212 *Carex lyngbyei* golf-cup cutter transplants from Sea and Iona islands within McDonald Slough. *Carex lyngbyei* comprised most of the species planted. Original plantings did not survive and marsh growth was sparse as of June 1996. Transplants were heavily grazed by Canada Geese shortly after planting. Conceptual design and elevations were based on marshes in Eburne Slough. Habitat compensation goal = 4053 sqm of marsh habitat.

Kistriz noted that the site was over-excavated in anticipation of natural infilling. As a result, most of the marsh elevation, backshore excluded, appeared too low to support *Carex* sp.. As of 1996 most of the site remained unvegetated mudflat, although habitat had been observed to support invertebrates, fish, and shorebirds. Compensation shortcomings were attributed to inadequate monitoring before and after construction by both the proponent and agency staff. No post-construction survey was undertaken to ensure site elevation could support marsh vegetation, nor were efforts made to adjust the site over time.

#### Description

An embayed marsh with a complex morphology that includes mudflat, tidal channels, vegetated marsh, and raised sandbars. Located at the end of Richmond Island, the site is surrounded by river on 3 sides. With exception of marsh opening along Eburne Slough, site is bordered on all sides by a tall riprap berm, which isolates and protects the marsh from the North Arm.

There are 3 vegetation communities within this site. Community 1 (target marsh habitat) is dominated by *Carex lyngbyei* (94% relative dominance) but only accounts for 17% of the area and is limited to the marsh backshore. The remainder of the site is sparsely vegetated, including a sandbar with 45% bare ground and a mudflat with 85% bare ground. Similar to 1996 observations by Kistriz, most of site appears unable to host vegetation in its current state, and creation of marsh habitat continues to be unsuccessful.

#### Morphological Features

Complex morphological site created in an embayment. Habitat includes unvegetated mudflat, raised sandbar berms, and unvegetated intertidal channels between the berms. Backshore of site (base of riprap) is slightly higher than unvegetated mudflat, allowing for some establishment of native marsh species. Site likely receives little current or wave erosion, as the marsh only opens into neighbouring Eburne Slough.

#### Impacts & Stressors

Site appears unable to maintain a high density of target marsh vegetation (*Carex* sp., *Juncus* sp.). This may be due to one or a combination of stressors, such as waterfowl grazing, hydrological processes, anaerobic soil conditions or elevation.

#### Wildlife Sightings/Evidence

Shorebirds on mudflat, likely sandpipers. Canada Geese were observed in nearby Eburne Slough.

#### Adjacent Land Use

Richmond Island has been intensely developed in recent years, including the creation of a large boatyard next to the site (SE). Boat traffic was observed to be infrequent in Eburne Slough, however a marina is located further up the slough (E).

### Threatened Plant Species (Provincial/Federal)

Two threatened species were sampled in target habitat: *Eleocharis parvula* (blue-listed), and *Lilaea scilloides* (blue-listed), with a mean % cover of 0.3 +/- 0.7. Both species were also observed in Community 2, with a mean % cover of 7.2 +/- 4.6.

### Invasive Species

No invasive species were sampled in target habitat or Community 2. Six invasive species were sampled in Community 3 (vegetated sandbar): *Cirsium arvense*, *Tanacetum vulgare*, *Rubus armeniacus*, *Lythrum salicaria*, *Phalaris arundinacea* and *Iris pseudacorus*, with a mean % cover of 3.7 +/- 1.7.

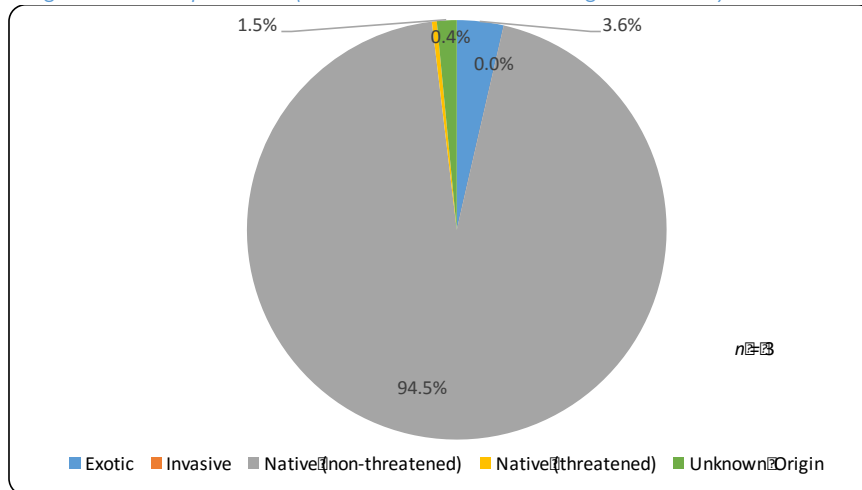
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	789.1	17.2	13.0 +/- 25.5	None	1.03	3	Marsh habitat (target habitat)
2	1581.2	34.4	85.1 +/- 6.0	None	1.00	16	Vegetated mudflat
3	1361.3	29.6	45.3 +/- 15.8	None	1.94	12	Vegetated sandbar
4	869.5	18.9	100.0 +/- 0.0	None	n/a	n/a	Unvegetated mudflat (not sampled)

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	77.0	31.9	3	94.1
2	small spike-rush	<i>Eleocharis parvula</i>	T	1	6.9	4.7	16	58.2
2	pond-water starwort	<i>Callitriche stagnalis</i>	E	1	6.0	5.0	16	37.0
3	pigmyweed	<i>Crassula aquatica</i>	N	1	10.3	9.1	12	29.5
3	stalked birds-foot trefoil	<i>Lotus pedunculatus</i>	E	4	10.9	10.5	12	20.1
3	colonial bentgrass	<i>Agrostis capillaris</i>	E	3	5.8	4.0	12	16.5

### Origin Class Proportions (Based on % Cover in Target Habitat)





Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
1. Proportion of Target Habitat Established(% of area goal)	100.0	19	Poor	Marsh/target Habitat only accounts for 17% of site area, skirting the base of the protective riprap berm. The site appears unable to maintain a high density of marsh vegetation. This may be due to one or a combination of stressors such as waterfowl grazing, hydrological processes, anaerobic conditions or elevation.
2. Proportion/Relative % Cover Native Species	87.3	94.9	Good	Although only a small fraction of the site, existing Community 1 (target marsh habitat) is dominated by <i>Carex lyngbyei</i> (94% relative dominance). The relative % cover of native species is higher in this habitat than the combined average of nearby reference sites.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Low Vegetation Cover	5	Determine cause of unsuccessful vegetation establishment and adjust site to improve conditions.	Measure elevation and compare with nearby natural marshes. If necessary, raise elevation to allow for successful establishment of native marsh species. Monitor habitat use by Canada Geese and other waterfowl in marsh. Test soil to ensure anaerobic conditions are not hindering plant growth.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
None			



Site# 03-003  
CPR# 8909-0075

---

### Background

365 sqm marsh/riparian, and 3195 sqm unvegetated mudflat habitat were lost due to shoreline realignment and riprap. In compensation, a 2 m X 250 m marsh bench was built into a riprap slope. Compensation habitat was constructed in 1990 and planted in 1992. Marsh was planted in 1992 with 2,500 x 30 sqcm *Carex lyngbyei* sods extracted from the blind end of McDonald Slough. No vegetation monitoring documentation is available.

A second marsh was to be created on the other side of Eburne Slough, but as of 1996 works had not been completed. A new marsh bench was observed directly adjacent to this site at the end of the Slough, but its inclusion in this project remains unconfirmed. Habitat compensation goal (needs confirmation) = 4000 sqm unvegetated mudflat and 678 sqm marsh habitats.

### Description

The site is a narrow, linear marsh bench located along the northern edge of Eburne Slough, opposite to the Milltown Marina. The marsh is backed by a steep riprap slope with a sidewalk and road above. The top of the slope has been recently planted with native shrubs and trees, but the riprap slope itself is dominated by low growing exotics and invasive species (*Rubus armeniacus*, *Iris pseudacorus*, *Tanacetum vulgare*, *Lythrum salicaria*, *Lotus pedunculatus*, *Cirsium arvense*, *Convolvulus arvensis*, *Polygonatum biflorum*) that are starting to spread into the marsh. The marsh was originally built as 2 m X 250 m bench, however due to sediment deposition and vegetation expansion site width now averages approximately 5 m. 70% of the site is typical marsh vegetation dominated by *Juncus balticus* (89% relative dominance). The remaining 30% of the site is comprised of a vegetated mudflat (Community 2), dominated by *Glaux maritima* and exotic *Agrostis capillaris*.

### Morphological Features

Gradual slope from backshore to foreshore. No drainage channels except for culvert outflow at east end.

### Impacts & Stressors

Invasive species only represent 8% of vegetative cover, but often occur in dense stands were present (see photo of *Iris pseudacorus* below).

### Wildlife Sightings/Evidence

Two American Beavers were active in and around site. A single River Otter and Harbour Seal were seen in adjacent Eburne Slough. Great Blue Heron (blue-listed, SARA-listed) was observed in marsh. Song Sparrows were seen in marsh vegetation. A single Canada Goose was seen in Eburne Slough.

### Adjacent Land Use

Marina across Eburne Slough (S), road and public pathway (N).

### Threatened Plant Species (Provincial/Federal)

One threatened species was sampled in target habitat: *Eleocharis parvula* (blue-listed), with a mean % cover of 1.8 +/- 2.4. *Eleocharis parvula*, as well as *Lilaea scilloides* (blue-listed) were observed in Community 2 with a mean % cover of 1.2 +/- 0.9. A large patch of *L. scilloides* was present at the eastern boundary of the site.

### Invasive Species

Two invasive species were sampled in target habitat: *Lythrum salicaria* and *Iris pseudacorus*, with a mean % cover of 7.7 +/- 12.1. Several clumps of *I. pseudacorus* were > 2 m in height. In addition to *L. salicaria*, *Tanacetum vulgare* was observed in Community 2.

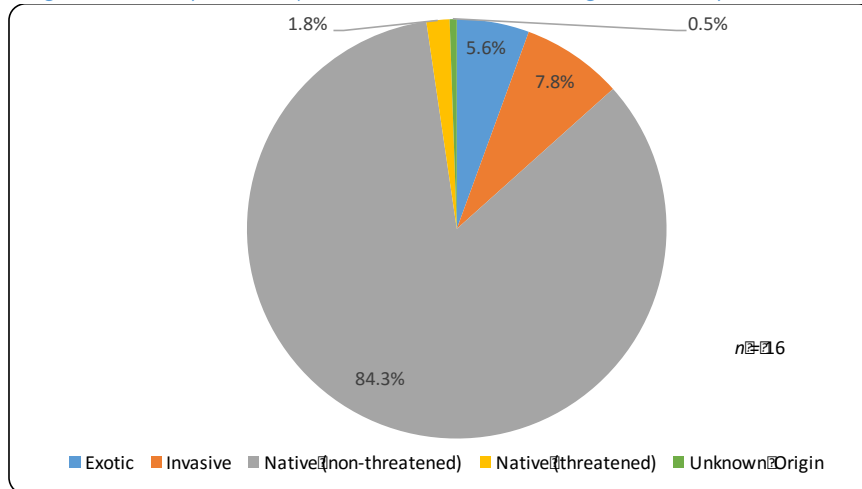
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	654.4	70.1	5.7 +/- 5.1	None	1.98	16	Marsh habitat (target habitat)
2	279.2	29.9	52.3 +/- 15.6	None	2.03	12	Vegetated mudflat along foreshore

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	Baltic rush	<i>Juncus balticus</i>	N	2	76.6	13.2	16	88.9
2	colonial bentgrass	<i>Agrostis capillaris</i>	E	3	22.4	15.0	12	50.8
2	sea-milkwort	<i>Glaux maritima</i> ssp. <i>obtusifolia</i>	N	1	16.8	10.2	12	38.2

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
1. Proportion of Target Habitat Established(% of area goal)	100.0	96.5	Good	The site meets its criteria of approximately 678 sqm of marsh habitat, despite 30% of the site belonging to non-target mudflat habitat. This is likely due to the marsh expansion over time.
2. Proportion/Relative % Cover Native Species	87.3	86.1	Good	The site has high vegetation cover of native species, specifically <i>Juncus balticus</i> (89% relative dominance). High dominance of a single marsh species is common in habitats closer to the mouth of the Fraser River. Relative % cover of native species is similar to combined average of nearby reference sites REF-03-001 and REF-02-001..



Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive species (marsh)	5	Control <i>Iris pseudacorus</i> . Replant with native species.	A few large homogenous patches of <i>Iris pseudacorus</i> exist on this site and should be removed.
Beaver	5	Install beaver guards on riparian vegetation.	New riparian vegetation has been planted above the site. Beavers were observed on site and beaver damage was observed on shrubs. Install protection on riparian vegetation
Beaver	4	Install beaver guard on storm water outflow.	Beavers observed going into storm water outflow at east end of site. Old beaver barrier on pipe has been damaged allowing access for the beavers again.
Invasive species (riprap backshore)	4	Control invasive species on upland riparian slope.	The top the slope has been recently planted with native shrubs and trees, but riprap slope is dominated by low growing exotics and invasive species that may advance into the marsh over time.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
None			



Site# 03-004  
CPR# 9303-0041

---

### Background

Creation of an intertidal "sedge basin" in 1994. Site was created through the excavation of an oval basin from historical dredge spoil. Marsh was planted in 1994 with 22776 *Carex lyngbyei* golf-cup cutter plugs extracted from North Arm and Middle arm marshes. After four years of monitoring, results indicated a near-100% survivorship of transplanted plugs, with *C. lyngbyei* aerial cover of <75%. Habitat compensation goal = 5565 sqm marsh habitat.

### Description

The marsh basin was excavated approximately 10 m behind a sandy elevated bank., which isolates the basin from the nearby North Arm. A 5 m gap in this bank allows for some tidal inflow and outflow to the Fraser River North Arm. The opening is protected by a lattice fence to prevent wood debris from entering the site. The basin contains a vegetated island (592 sqm) dominated by *Salix* spp., but also *Alnus rubra*, *Rosa nutkana*, *Populus balsamifera*, invasive *Rubus armeniacus* and invasive *Cytisus scoparius*. Land surrounding the site is a sandy riparian environment with similar vegetation to the vegetated island. The bank is approximately 3 m high and below it is a sandy beach along the river. Although the site is described as a "sedge basin", it is now nearly a completely homogenous stand of invasive *Typha angustifolia* with 93% relative dominance. Some *Carex* spp. and *Juncus* spp. dominated communities exist in the site, but are restricted to in or near dendritic channels in the marsh. Little to no log debris was observed, indicating that the lattice fence is working effectively.

### Morphological Features

Marsh basin with a 592 sqm riparian island and numerous small drainage channels snaking throughout site. Two larger channels, approximately 0.5 - 1 m wide, drain the east and west areas of the site on either side of the riparian island and drain out of the site through the lattice fence to the Fraser River. Several small drainage channels occur throughout the site. Areas of standing water and small drainage channels are vegetated by *Schoenoplectus tabernaemontani*.

### Impacts & Stressors

Invasive *T. angustifolia* is dominant, represents 93% of marsh vegetation, and is undoubtedly displacing native species and communities. General lack of connectivity to Fraser River may be promoting anaerobic soil conditions that are less-conducive to *Carex lyngbyei* and other desirable species. Little to no log debris present, indicating lattice fence is effective.

### Wildlife Sightings/Evidence

Lots of Cedar Waxwings in riparian habitat. Small fish were seen using main drainage channel. Ruby-Crowned Kinglet was seen using riparian island. Several Black-Capped Chickadees. American Beaver activity observed on trees at upland side of site.

### Adjacent Land Use

Site is located in McDonald Beach Park (City of Richmond) and borders the Fraser River North Arm (N).

### Threatened Plant Species (Provincial/Federal)

None.

### Invasive Species

Three invasive species were sampled in target habitat: *Typha angustifolia*, *Lythrum salicaria* and *Iris pseudacorus*, with a mean % cover of 52.9 +/- 12.8. *Typha angustifolia* is the most dominant of the invasives, with a mean % cover of 51.3 +/- 13.5, representing 93% of all marsh vegetative cover. *Phalaris arundinacea* was observed in the marsh incidentally.

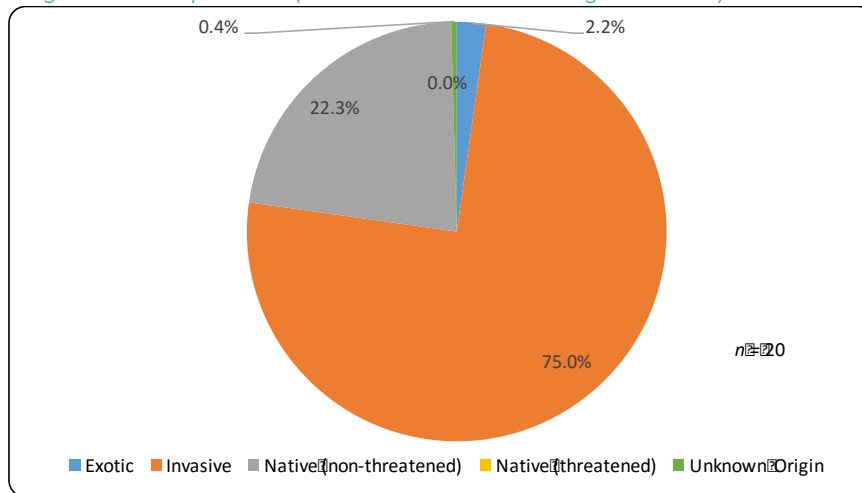
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	5714.5	100.0	34.5 +/- 8.4	None	1.01	20	Marsh habitat (target habitat)

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	lesser cattail	<i>Typha angustifolia</i>	I	1	51.3	13.5	20	92.7

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established(% of area goal)</b>	100.0	102.7	Good	Area of compensation site meets habitat compensation goals.
<b>2. Proportion/Relative % Cover Native Species</b>	87.3	22.3	Poor	Marsh is completely dominated by <i>Typha angustifolia</i> . There is an expansive homogenous stand of lesser cattail near-by across the river at 10U 485114E 5452455N. Seeds may have spread from this site to create the homogenous stand at this site. Relative % cover of native species is significantly lower than combined average of nearby reference sites REF-03-001 and REF-02-001.



Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	5	Control <i>Typha angustifolia</i> infestation.	<i>Typha angustifolia</i> completely dominates this site with 51% mean cover and 93% relative dominance. This site may require drastic measures to rectify this invasion (re-excavation, herbicide use).
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
None			



Site# 03-006  
CPR# 9706F048

---

### Background

Compensation for loss of 1150 sqm riparian, 345 sqm intertidal, and 1455 sqm intertidal mudflat habitat. Project included incorporation of riparian vegetation and marsh bench in a riprap dike slope and creation of 1050 sqm. intertidal mudflat at the base of the slope. Site was created in 1997 and planted in 1998. Habitat compensation goal = 1050 sqm intertidal mudflat, 880 sqm marsh, and 1175 sqm riparian habitat.

### Description

Site is a narrow, linear marsh bench (approx. 5 x 60 m) with a riprap-armoured foreshore. Marsh is inline with surrounding shoreline. Backshore is bordered by riprap dike vegetated by *Rubus armeniacus*, *Cytisus scoparius*, *Phalaris arundinacea*, *Lonicera involucrata* and *Alnus rubra*. Foreshore is protected by an offshore log boom. The site is comprised of a single vegetation community dominated by *Juncus balticus* and *Carex lyngbyei* with 63% and 34% relative dominance respectively.

### Morphological Features

Relatively flat marsh with no discernable drainage channels or depressions. Some minor erosion and soil loss is occurring along marsh foreshore (textile fabric exposed). Significant soil loss is occurring along base of riprap dike, along marsh backshore (see photos).

### Impacts & Stressors

Base of backshore riprap slope is severely eroded (see photo). Invasive species are present, but are not displacing native species (1.5% of total vegetative cover). Some wood debris (large and small) was observed. Some evidence of waterfowl grazing.

### Wildlife Sightings/Evidence

None.

### Adjacent Land Use

Riprap dike with Grauer Road and McArthur Glen shopping centre above (S).

### Threatened Plant Species (Provincial/Federal)

None.

### Invasive Species

Three invasive species were sampled in target habitat: *Lythrum salicaria*, *Iris pseudacorus* and *Phalaris arundinacea*, with a mean % cover of 1.4 +/- 1.4.

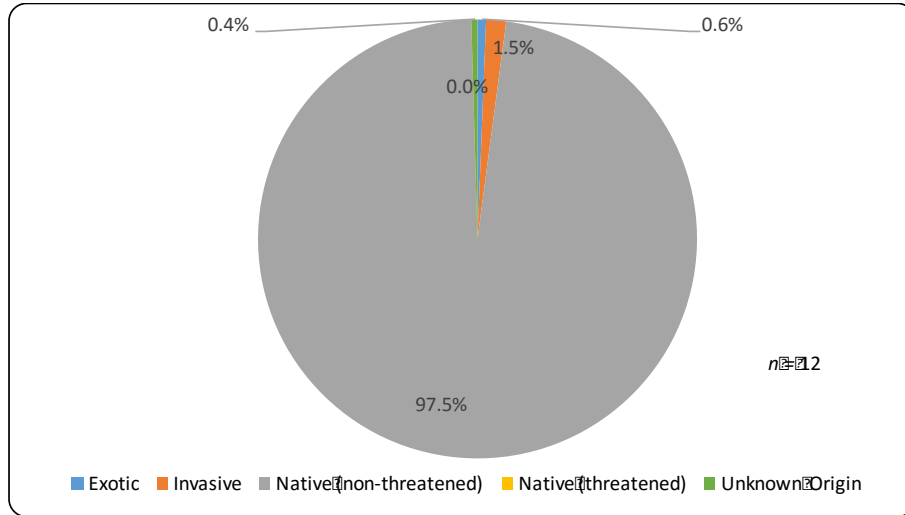
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	353.0	100.0	3.3 +/- 6.5	1.7 +/- 3.3	1.64	12	Marsh habitat (target habitat)

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	Baltic rush	<i>Juncus balticus</i>	N	2	57.5	13.7	12	63.2
1	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	31.3	10.6	12	34.4

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established (% of area goal)</b>	100.0	40.1	Poor	Marsh bench measures approx. 5m X 60m (353 sqm), only 40% of the target compensation goal of 880 sqm. It is uncertain whether missing area is due to non-compliance, or the creation of second marsh bench without our knowledge.
<b>2. Proportion/Relative % Cover Native Species</b>	87.3	97.5	Good	The marsh at this site is a healthy marsh dominated by native <i>Juncus balticus</i> and <i>Carex lyngbyei</i> with 63 and 34% relative dominance respectively. Relative % cover of native species is better than the combined average of nearby reference sites REF-03-001 and REF-02-001.

### Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	2	Control <i>Iris pseudacorus</i>	<i>Iris pseudacorus</i> is present in small clumps. Would be easy to manage to prevent further spread.
Backshore erosion	4	Identify cause of erosion, and address to prevent further soil loss.	Base of riprap slope along marsh backshore is severely eroded in places. Identify cause (e.g. wave erosion) and address.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Backshore erosion	3	Monitor further soil loss and erosion along marsh backshore.	Use monitoring to Identify whether further soil loss is occurring (e.g. photo monitoring).



Site# 04-001  
CPR# 8801-0005

---

### Background

Site was built in compensation for loss of intertidal mudflats (2284 sqm) due to creation of a compensation marsh. Marsh design included riprap and string boom to protect site from waves and wood debris. Site was created in 1990. Vegetation was monitored in 1991 (observed) and 1992 (sampled), and results indicated successful establishment of marsh vegetation dominated by *Carex lyngbyei* and *Schoenoplectus tabernaemontani*, as well as some natural colonization of *Scirpus validus*. Levings & Nishimura (1996) stated that *S. validus* dominated lower elevations at eastern ends of site and *C. lyngbyei* occurred at western end of site at slightly higher elevations. At the time transplanted plugs were still present, however rhizomes were exposed above sediment surface. Kistritz noted that riprap and string boom protection were inadequately protecting the marsh, stating that a higher berm height with fish openings (which had been recommended and dismissed due to costs) would have prevented these stressors. Habitat compensation goal = 3461 sqm marsh habitat 105 sqm riparian habitat.

### Description

Marsh bench with an armoured riprap foreshore. No log boom or string boom was present at time of survey. Marsh is backed by a riprap dike and a strip of planted vegetation above. The marsh is primarily flat, however topography is uneven in areas due to hummocking from *Juncus balticus*, and where small drainage channels and wetted depressions occur. Marsh is dominated by *Carex lyngbyei* and *Juncus balticus* with 83 and 16% relative dominance respectively. Though no invasive species were observed in the sample plots, small patches of *Typha angustifolia* and *Iris pseudacorus* were present, and should be removed while manageable.

### Morphological Features

Site is generally flat, however topography is uneven in areas due to hummocking from *Juncus balticus*, and where small drainage channels and wetted depressions occur.

### Impacts & Stressors

Eastern portion of site is easily accessed by public from public walking trail. Some evidence of human activity (likely dog walkers and fishers).

### Wildlife Sightings/Evidence

None.

### Adjacent Land Use

Gravel public walking trail and Point Grey Golf & Country Club (N). North Arm of Fraser River (S).

### Threatened Plant Species (Provincial/Federal)

None.

### Invasive Species

No invasive species were sampled in target habitat. *Typha angustifolia*, *Iris pseudacorus* and *Phalaris arundinacea* were observed incidentally in habitat, and are present in small patches.



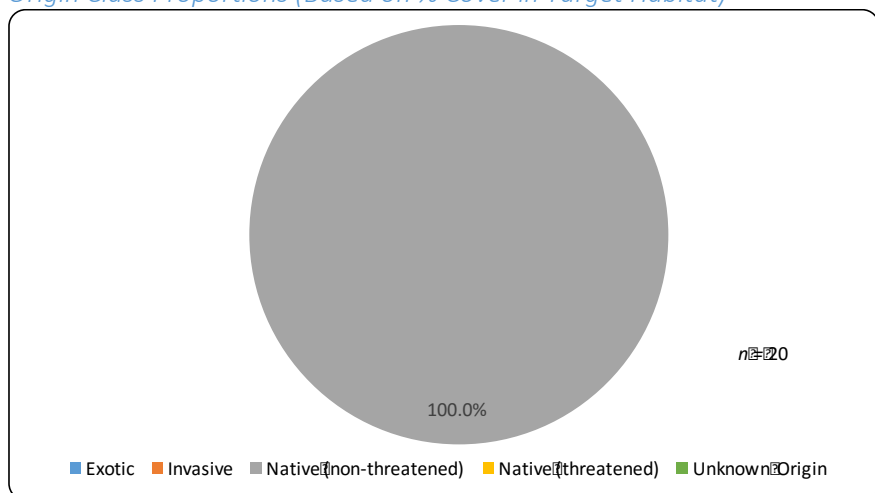
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI(95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	3060.2	100.0	12.6 +/- 11.9	None	1.16	20	Marsh habitat (target habitat)

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	65.9	17.9	20	83.4
1	Baltic rush	<i>Juncus balticus</i>	N	2	22.4	15.5	20	16.4

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
1. Proportion of Target Habitat Established(% of area goal)	100.0	88.4	Good	Area measurements are relatively accurate, as site boundaries were easily discerned and mapped in field. Unknown why habitat area is slightly below compensation goals
2. Proportion/Relative % Cover Native Species	87.3	100.0	Good	This site is functioning very well with high vegetation cover of native species. Vegetation has low diversity and is dominated by <i>Carex lyngbyei</i> and <i>Juncus balticus</i> , with 83% and 16% relative dominance respectively. Low diversity is characteristic of this region of the Fraser River, reflecting saline influence. <i>Juncus balticus</i> hummocks create habitat complexity for various fish and invertebrates. Relative % cover of native species is higher than combined average of nearby reference sites REF-03-001 and REF-02-001.



Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	5	Control invasives and replace with native species.	Though no invasive species were observed in the sample plots, patches of <i>Typha angustifolia</i> and <i>Iris pseudacorus</i> are present in site. <i>Typha angustifolia</i> is well established and aggressive in this region of the Fraser River. Both should be removed while still manageable.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments



Site# 04-005  
CPR# 0504F023

---

*Background*

Compensation for loss of 125 sqm intertidal marsh, 90 sqm riparian, 2700 sqm unvegetated intertidal mudflat and 2300 sqm subtidal mudflat. Intertidal marsh bench was created in 2006 and planted in 2007. Habitat compensation goal = 2000 sqm subtidal, 1300 sqm unvegetated intertidal mudflat, 325 sqm marsh and 3600 linear m or sqm riparian habitat.

*Description*

Small (494 sqm), flat marsh armoured by riprap at the foreshore boundary and backed by riprap dike at the backshore boundary. No log boom present at time of survey. The site is heavily dominated by *Carex lyngbyei*, with 98% relative dominance. High dominance of one or two sedge or rush species and low species diversity is a common habitat characteristic for this region of the Fraser River. Site is functioning well, with no significant stressors impacting site.

*Morphological Features*

Flat marsh with no discernible channels or depressions.

*Impacts & Stressors*

Some log debris along back of marsh and on upland riprap, but not significantly impacting vegetation.

*Wildlife Sightings/Evidence*

None.

*Adjacent Land Use*

Gravel public walking trail and residential houses above marsh (N).

*Threatened Plant Species (Provincial/Federal)*

None.

*Invasive Species*

Three invasive species were sampled in target habitat: *Cirsium arvense*, *Lythrum salicaria*, and *Iris pseudacorus*, with a mean % cover of 3.9 +/- 2.4.

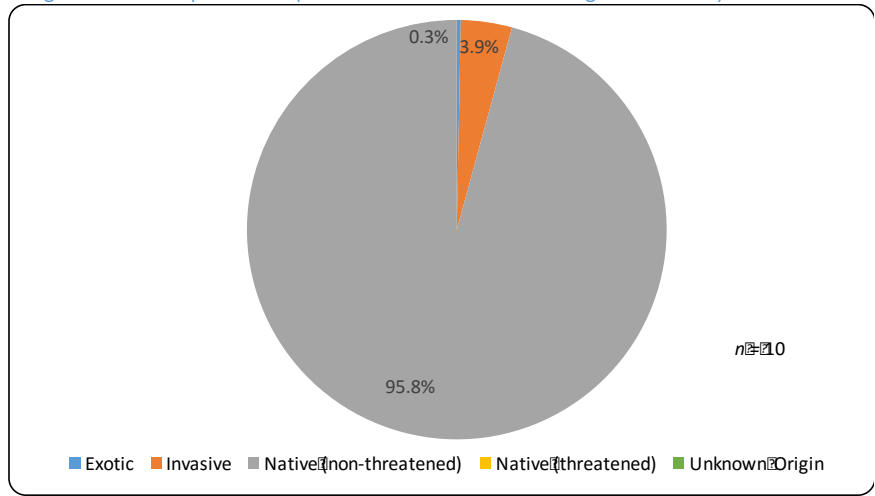
*Community Descriptions*

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	494.3	100.0	2.5 +/- 1.7	None	1.03	10	Marsh habitat (target habitat)

*Dominant Species*

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	91.6	3.8	10	97.9

Origin Class Proportions (Based on % Cover in Target Habitat)



Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
1. Proportion of Target Habitat Established(% of area goal)	100.0	152.1	Good	Marsh meets area requirements outlined in compensation goals. Excess 50% of area can likely be attributed to marsh expansion both up and downslope by <i>Juncus balticus</i> .
2. Proportion/Relative % Cover Native Species	87.3	95.8	Good	The marsh at this site is functioning very well with high vegetation cover of native <i>Carex lyngbyei</i> , with 98% relative dominance. High dominance of <i>C. lyngbyei</i> and low species diversity is a common habitat characteristic for marshes in the region, reflecting salinity. Relative % cover of native species is higher than combined average of nearby reference sites REF-03-001 and REF-02-001.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	3	Control <i>Iris pseudacorus</i>	A small patch of <i>Iris pseudacorus</i> present. Would be easy and inexpensive to control a small patch, but control is not urgent as it currently does not pose a large threat.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Log Debris	3	Monitor log debris	Some log debris present. If log debris builds up it could impact vegetation growth.





Site# 05-001  
CPR# 8805-0061

---

*Background*

Site was created in 1991 and planted in 1992 in compensation for a 20 sqm sedge marsh lost in the installation of a drainage outfall. Site was created two years after habitat was lost. City of Richmond performed all construction work, and elevation apparently had to be redone due to a failure. Substrate consists of mobile sand. No supervision during the construction phase was recorded, nor was there any documentation of post-construction monitoring. Site was planted with 308 *Carex lyngbyei* golf cutter plugs, extracted from nearby natural tidal marsh. Habitat compensation goal = 70 sqm marsh habitat.

*Description*

Small marsh bench (107 sqm) armoured with riprap along foreshore edge. Riprap is partially covered in deposited sediment and expanding marsh vegetation. Backshore of site is bordered by riprap dike. Marsh is dominated by *Juncus balticus* and *Carex lyngbyei* with 57% and 35% relative dominance respectively. Waterfowl grazing is evident at this site as seen by grazed tips on nearly all *C. lyngbyei* at a uniform height.

*Morphological Features*

Flat marsh with no discernible channels, depressions, or mounds. Sediment deposition has covered part of riprap along foreshore.

*Impacts & Stressors*

*Carex lyngbyei* has been grazed by waterfowl to a uniform height throughout the site. Some log debris was present - two medium sized logs and a significant amount of small wood debris (bark and twigs).

*Wildlife Sightings/Evidence*

Small mammal droppings under vegetation. Evidence of waterfowl graze. Small fish were seen in *Carex lyngbyei* at high tide.

*Adjacent Land Use*

Marina under construction (S), Moray Channel Bridge (N).

*Threatened Plant Species (Provincial/Federal)*

One threatened species was sampled in target habitat: *Bidens amplissima* (blue-listed, SARA-listed), with a mean % cover of 0.2 +/- 0.2.

*Invasive Species*

Three invasive species were sampled in target habitat: *Lythrum salicaria*, *Phalaris arundinacea*, and *Iris pseudacorus*, totaling a mean % cover of 1.6 +/- 1.5.

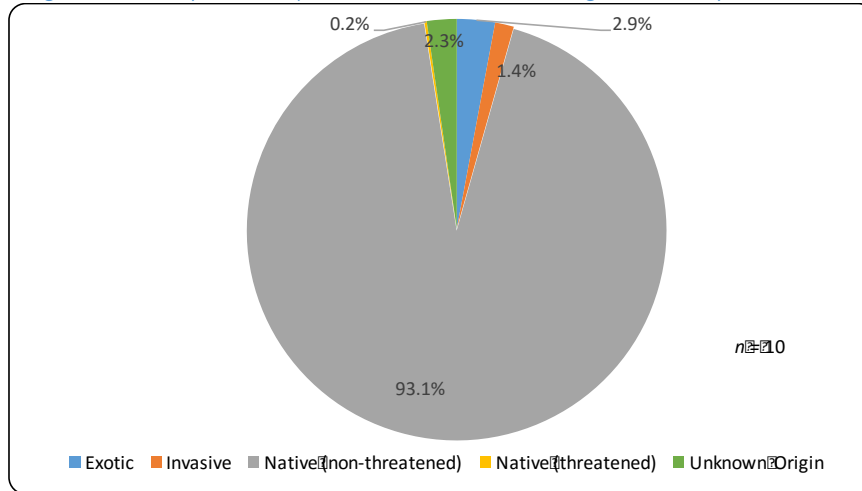
*Community Descriptions*

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI(95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	107.1	100.0	1.5 +/- 2.1	0.7 +/- 1.4	1.60	10	Marsh habitat (target habitat)

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	Baltic rush	<i>Juncus balticus</i>	N	2	58.8	20.9	10	56.5
1	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	32.6	20.3	10	34.8

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
1. Proportion of Target Habitat Established(% of area goal)	100.0	152.9	Good	Site exceeds the area requirements for this project, likely due to aggradation and vegetation expansion.
2. Proportion/Relative % Cover Native Species	87.3	93.3	Good	The site has high vegetation cover of native species dominated by <i>Juncus balticus</i> and <i>Carex lyngbyei</i> , with 57% and 35% relative dominance respectively. Relative % cover of native species is higher than combined average of nearby reference sites REF-03-001 and REF-02-001.

### Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	2	Control invasive species	<i>Lythrum salicaria</i> , <i>Phalaris arundinacea</i> , and <i>Iris pseudacorus</i> are present in low abundances. Consider mitigation to control spread. <i>Iris pseudacorus</i> has the most patchy distribution and therefore would be the easiest to control.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Waterfowl Grazing	3	Monitor waterfowl grazing	Currently nearly all <i>Carex lyngbyei</i> has been impacted by grazing. <i>Carex lyngbyei</i> should be monitored for increased grazing pressure. If grazing begins to limit <i>C. lyngbyei</i> , mitigation efforts should be considered.
Log Debris	2	Monitor log debris	This is a small site and therefore could be significantly impacted by a small increase in log debris. If log debris increases and begins to limit vegetation growth, consider mitigation.





## Site# 09-001-A

### CPR# 8610-0068

---

#### Background

Two marsh platforms (09-001-A and 09-001-B) were created in Deas Slough as compensation for habitat lost on Lulu Island. As of June 1996, the as-built compensation structure (3100 sqm) was 2500 sqm. short of the compensation marsh area of 5600 sqm required in the compensation agreement. This has since been remedied through the creation of a second marsh platform (09-001-B). This site was part of a project undertaken by Dr. C.D. Levings under the Fraser River Action Plan to assess the ecology of compensation marshes in comparison to natural marshes.

Large sections of 'sod' were salvaged from tidal high-marsh habitat along the south foreshore of Lulu Island and placed on site. No specific species within sod are known. Surveys conducted in 1991 indicated that vegetation was relatively uniform, primarily dominated by *Juncus supiniformis*. This report also indicated that mean site elevation was 0.73 m with little variation within the site, while a nearby reference site immediately west of site had a mean elevation of 0.45 m and greater elevation variability within the site. A later report indicated that the bench was dominated by *Phalaris arundinacea* in 1993.

#### Description

The site is a linear high-marsh bench, measuring approximately 3100 sqm. The foreshore is armoured by a steep riprap slope, while the backshore is bordered by a natural, eroding slope consisting of mature riparian vegetation (*Rubus armeniacus*, *Symphoricarpos albus*, *Salix* spp., *Populus balsamifera*, *Cornus stolonifera*). The site appears to be relatively flat, however facultative wetland species are most prolific near the water's edge, and obligate wetland species occur in sporadic wetted areas near the backshore edge where water is trapped.

100% of the site is comprised of typical mid to high marsh vegetation (Community 1), dominated by *Phalaris arundinacea*, *Juncus balticus*, and *Lythrum salicaria*. The dominance of mid to high-marsh vegetation appears to indicate that the elevation is higher than most other compensation sites in the region. Natural marshes in Deas Slough appeared to be as low as 1 m below this site in elevation, including a nearby compensation site (09-015).

Log debris is present in the site, but is not abundant enough to significantly limit vegetation growth. Little evidence of riprap or soil erosion was observed, likely due to the high elevation of the marsh, and lack of large boat traffic in Deas Slough. Although the marsh provides productive habitat, its high elevation likely restricts usage by fish at high tide, and promotes the dominance of facultative wetland invasives, including *P. arundinacea* and *L. salicaria*, which are both capable of displacing native plant species.

#### Morphological Features

The site is a long, narrow bench that protrudes from the surrounding natural shoreline. Bench elevation appears to be up to 1 m higher in elevation than surrounding marsh habitat. The entire foreshore edge (~280 m length) is armoured by a steep riprap slope. The backshore is bordered by a natural, eroding slope of mature riparian vegetation. The marsh elevation appears higher along the foreshore edge, with several wet depressions of standing water along the backshore edge.

#### Impacts & Stressors

Some log debris has accumulated along the backshore edge, but log debris only comprises 3% of site. Most unvegetated areas are the result of shading from encroaching riparian vegetation. The dominant invasive species (*Phalaris arundinacea*, *Lythrum salicaria*, *Iris pseudacorus*) are likely displacing native species (see photos).

*Wildlife Sightings/Evidence*

Garter Snake observed in marsh vegetation. Black-capped Chickadee and other songbirds were using marsh and nearby riparian area. Coyote tracks observed.

*Adjacent Land Use*

Site is attached to Deas Island Regional Park (N). Deas Slough (S) used by rowers and recreational boaters.

*Threatened Plant Species (Provincial/Federal)*

None.

*Invasive Species*

Three species were sampled in target habitat: *Phalaris arundinacea*, *Lythrum salicaria*, and *Iris pseudacorus*, totaling a mean % cover of 38.0 +/- 15.6.

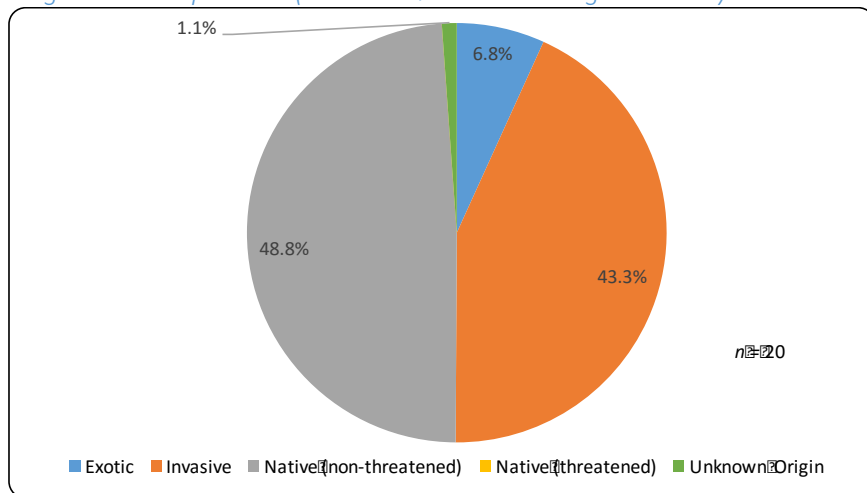
*Community Descriptions*

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI(95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	3100.00	100.0%	23.7 +/- 13.6	3.0 +/- 2.9	1.63	20	Our mapped area was ~700 sqm. The difference between numbers is likely result of poor GPS accuracy at time of mapping, as well as unclear site boundaries, not non-compliance.

*Dominant Species*

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	reed canarygrass	<i>Phalaris arundinacea</i>	I	2	26.4	12.6	20	41.4
1	Baltic rush	<i>Juncus balticus</i>	N	2	13.7	11.9	20	14.3
1	purple loosestrife	<i>Lythrum salicaria</i>	I	2	9.4	4.7	20	12.8

*Origin Class Proportions (Based on % Cover in Target Habitat)*



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
1. Proportion of Target Habitat Established(% of area goal)	100.0*	100.0	Good	The combined areas of 09-001-A and 09-001-B likely meet compensation habitat goals. Mapping accuracy was inadequate at time of survey, so success ranking is based on measurements acquired from aerial imagery.
2. Proportion/Relative % Cover Native Species	78.6	48.8	Poor	The total vegetation cover for the target habitat was 73% and the proportion of native species was 49%. Although the site is well-vegetated, the abundance of <i>Phalaris arundinacea</i> and <i>Lythrum salicaria</i> are likely to limit the expansion of native species in the immediate future. Relative % cover of native species was significantly lower than the combined average of nearby reference sites REF-09-001 and REF-10-001.

### Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Bare Ground	3	Remove existing log debris and re-plant. Also plant shaded marsh with shade-tolerant native species.	Presently 27% of site is unvegetated. To avoid advancement of invasives and to increase the % cover of native vegetation, we suggest the planting of appropriate native species in these areas. Several patches of unvegetated marsh occur under overhanging riparian vegetation. Shaded areas may be planted with shade-tolerant native species, or riparian vegetation may be lightly pruned to allow for greater marsh productivity.
Invasive Species	4	Reduce dominance of invasive species.	Priority should be given to removing <i>Iris pseudacorus</i> , as it is yet to fully establish and is still manageable. Biological control should be considered for treatment of <i>Lythrum salicaria</i> to reduce current population and prevent further expansion. <i>Phalaris arundinacea</i> may be treated, but will likely remain problematic unless high marsh elevation is addressed.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
None			





## Site# 09-001-B

### CPR# 8610-0068

---

#### Background

Two marsh platforms (09-001-A and 09-001-B) were created in Deas Slough as compensation for habitat lost on Lulu Island. As of June 1996, the as-built compensation structure (3100 sqm) was 2500 sqm. short of the compensation marsh area of 5600 sqm. required in the compensation agreement. This has since been remedied through the creation of this marsh platform (09-001-B). This site was part of a project undertaken by Dr. C.D. Levings under the Fraser River Action Plan to assess the ecology of compensation marshes in comparison to natural marshes.

#### Description

The site is a linear high-marsh bench, measuring approximately 2500 sqm. The foreshore is armoured by a steep riprap slope, while the backshore is bordered by mature riparian habitat. The site appears to be relatively flat, however facultative wetland species are most prolific near the water's edge, and obligate wetland species occur in sporadic wetted areas near the backshore edge.

100% of the site is comprised of typical mid to high marsh vegetation (Community 1), dominated by *Phalaris arundinacea*. The dominance of mid to high-marsh vegetation (*P. arundinacea*) appears to indicate that elevation is higher than most other compensation sites in the region. Natural marshes in Deas Slough appeared to be as low as 1 m below this site in elevation, including a nearby compensation site (09-015).

Log debris is present in the site, but is not abundant enough to significantly limit vegetation growth. Little evidence of riprap or soil erosion was observed, likely due to the high elevation of the marsh, and lack of large boat traffic in Deas Slough. Although the marsh provides productive habitat, its high elevation likely restricts usage by fish at high tide, and promotes the dominance of facultative wetland invasives, including *P. arundinacea* and *Lythrum salicaria*, which are both capable of displacing native plant species.

#### Morphological Features

The site is a long, narrow bench that protrudes from the surrounding natural shoreline. Bench elevation appears to be up to 1 m higher in elevation than surrounding marsh habitat. The entire foreshore edge (~200 m length) is armoured by a steep riprap slope. The backshore is bordered by a natural, eroding slope of mature riparian vegetation. The marsh elevation appears higher along the foreshore edge, with several wet depressions of standing water along the backshore edge. The southernmost portion of the marsh interfaces with a large tidal channel and low marsh

#### Impacts & Stressors

Some log debris has accumulated along the backshore edge, but log debris comprises <2% of site area. Most unvegetated areas are the result of shading from encroaching riparian vegetation. The dominant invasive species (*Phalaris arundinacea*, *Lythrum salicaria*, *Iris pseudacorus*) are likely displacing native species (see photos).

#### Wildlife Sightings/Evidence

None.

#### Adjacent Land Use

Site is attached to Deas Island Regional Park (N). Deas Slough used by rowers and recreational boaters.

#### Threatened Plant Species (Provincial/Federal)

One species was sampled in target habitat: *Juncus oxymeris*, totaling a mean % cover of 0.1 +/- 0.1.



### Invasive Species

Four species were sampled in target habitat: *Cirsium arvense*, *Iris pseudacorus*, *Lythrum salicaria* and *Phalaris arundinacea*, totaling a mean % cover of 56.6 +/- 16.9. *Phalaris arundinacea* is the most dominant species of the habitat, with a mean % cover of 45.6 +/- 14.7 and relative dominance of 54.0%.

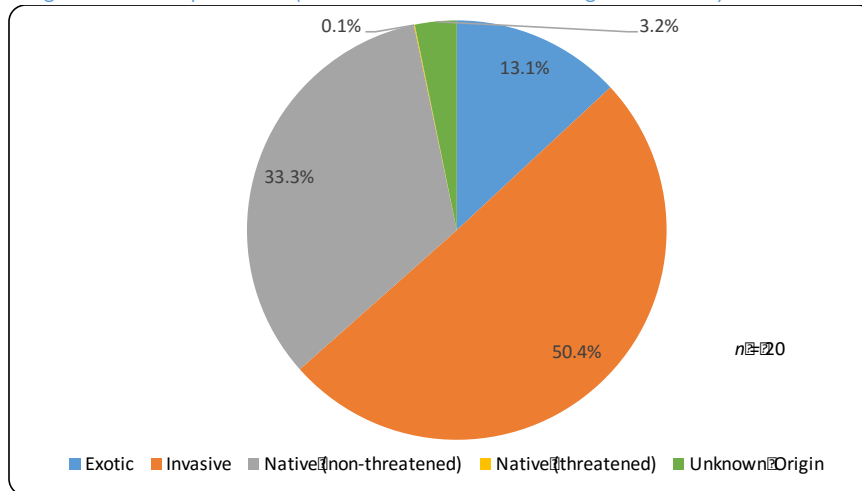
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI(95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	1678.1	100.0	6.7 +/- 5.1	1.6 +/- 2.5	1.72	20	Marsh habitat (target habitat)

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	reed canarygrass	<i>Phalaris arundinacea</i>	I	2	45.6	14.7	20	54.0

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
1. Proportion of Target Habitat Established(% of area goal)	100.0*	100.0	Good	The combined areas of 09-001-A and 09-001-B likely meet compensation habitat goals. Mapping accuracy was inadequate at time of survey, so success ranking is based on measurements acquired from aerial imagery.
2. Proportion/Relative % Cover Native Species	78.6	33.3	Poor	The total vegetation cover for the target habitat was 91% and the proportion of native species was 33%. Relative % cover of native species was significantly lower than combined average of nearby reference sites REF-09-001 and REF-10-001. Although the site remains productive and well-vegetated, the dominance of <i>Phalaris arundinacea</i> is likely to limit the expansion of native species in the immediate future.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	4	Reduce dominance of invasive species.	Priority should be given to removing <i>Iris pseudacorus</i> , as it is yet to fully establish and is still manageable. <i>Phalaris arundinacea</i> may be treated, but will likely remain problematic unless high marsh elevation is addressed.
Bare Ground	1	Remove existing log debris and re-plant. Also plant shaded marsh with shade-tolerant native species.	Presently only 9% of site is unvegetated. This may be decreased through the removal of existing log debris, but primarily with native plantings in unvegetated areas. Several patches of unvegetated marsh occur under overhanging riparian vegetation (see photos). Shaded areas may be planted with shade-tolerant native species, or riparian vegetation may be lightly pruned to allow for greater marsh productivity.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
None			



## Site# 09-002-A

### CPR# 8701-0008

---

#### Background

Three marshes were constructed in compensation for rock groin and beach construction in Garry Point Park by the City of Richmond. Marshes are protected from wave erosion and log debris by a high riprap berm along the foreshore. Sites were planted with 6720 golf cup cutter plugs of *Carex lyngbyei* extracted from a tidal marsh along the south shoreline of Canoe Passage. Plantings were spaced 0.5 m center-to-center. Monitoring observations from 1989-1994 indicated that *C. lyngbyei*, *Scirpus validus*, and *Bolboschoenus maritimus* were most abundant among the three sites, and that foreshore berm was effectively protecting site. Monitoring actions only included visual observations.

We only positively identified two of the three alleged compensation marshes. Kistritz (1996) mentioned that one marsh was too low, resulting in significant scouring and vegetation loss. If this trajectory continued, it may explain why one marsh was difficult to identify near-20 years later. Two potential third marshes were identified: a long marsh bench 30 m N/NW of this site, and an eroded marsh embayment due south of the main Garry Point Park parking lot. Records read since field visit indicate that marsh bench was the likely site. Neither marsh was included in this study. Habitat compensation goal = 1680 sqm of marsh habitat.

#### Description

This site is a 649 sqm marsh embayment, completed in 1989. The foreshore is armoured by a high riprap berm, and the backshore consists of a riprap slope with no significant riparian vegetation.

100% of the site is comprised of typical mid to high marsh vegetation (Community 1), almost exclusively dominated by *Juncus balticus*. The marsh lies in a depression between a backshore riprap slope, and a foreshore riprap berm. A single channel runs through the site, and flows through a low point in berm in the NW corner of the marsh. This site appears to be functioning well with few invasives present, insignificant wood debris, and a well-established native plant community.

#### Morphological Features

Marsh embayment placed in depression between riprap backshore and a foreshore riprap berm. The site is relatively flat, but gradually slopes to a channel that runs through the middle of the site (~0.25 m deep, ~0.75 - 1.5 m wide) and eventually exits in the NW corner.

#### Impacts & Stressors

Sparse log debris, some with large diameters, piled up along back edge of site. Few invasive species present.

#### Wildlife Sightings/Evidence

Small fish observed in main drainage channel. River Otters (2) chased each other through site. Great Blue Heron (blue-listed) was observed in site.

#### Adjacent Land Use

Adjacent to high-use Garry Point Park (E). Heavy boat traffic entering and leaving Steveston Harbour (S).

#### Threatened Plant Species (Provincial/Federal)

None.

#### Invasive Species

Three species were sampled in target habitat: *Lythrum salicaria*, *Phalaris arundinacea* and *Iris pseudacorus*, totaling a mean % cover of 4.7 +/- 2.7.

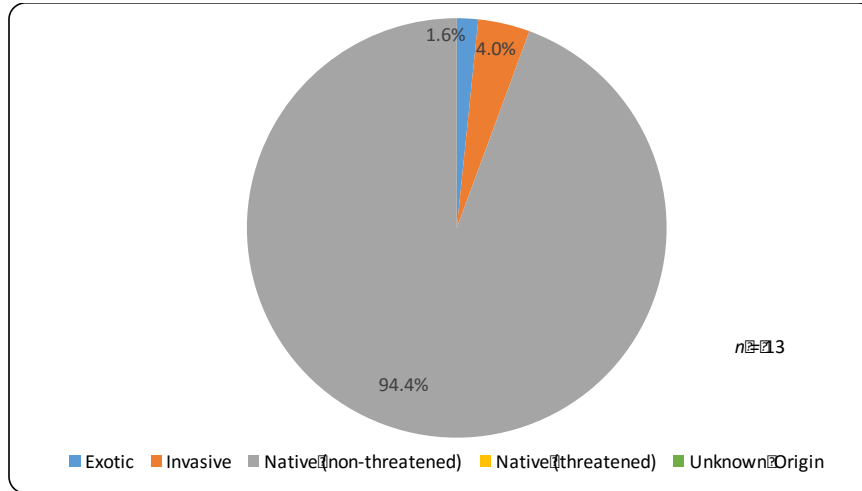
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	649.0	100.0	2.7 +/- 3.9	None	1.88	13	Mid elevation marsh (target habitat)

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	Baltic rush	<i>Juncus balticus</i>	N	2	66.2	13.1	13	86.7

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established(% of area goal)</b>	100.0*	54.0	Poor	The combined target habitat of 09-002-A and 09-002-B comprises 54% of the original habitat conservation goal at 907.2 sqm. A third marsh may exist, and may increase the score of these sites, however no intact marsh was observed elsewhere in Garry Point Park.
<b>2. Proportion/Relative % Cover Native Species</b>	78.6	94.4	Good	Total vegetation cover for the target habitat was 97% and the proportion of native species was 94%. Relative % cover of native species was higher than combined average of nearby reference sites REF-09-001 and REF-10-001.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Unvegetated Riprap	1	Plant backshore riprap with upslope species.	Improve the integration of the marsh bench into upslope habitat through planting of backshore riprap. No riparian vegetation is present, so riprap may be planted to increase habitat value, and improve resilience to nearby upland invasives (e.g. <i>Cytisus scoparius</i> , <i>Rubus armeniacus</i> ).
Invasive Plants	1	Remove invasives both in and around the marsh.	Invasives account for 4% of marsh vegetation. Although not an imminent threat to this habitat, the existing plants are easily removed at this stage in their advancement. Nearby invasives in surrounding park habitat threaten to advance into the marsh, and may be treated as a proactive measure.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive plants	1	Monitor encroachment of invasives surrounding the site.	Although invasives account for 4% of site, site is at risk of long-term encroachment of nearby invasive species. Monitor marsh and backshore riprap for evidence of invasive encroachment.
Log Debris	2	Monitor accumulation of log debris in marsh.	Lots of log debris on upslope riprap, with little on the marsh itself. Monitor to ensure log debris does not accumulate on marsh over time.





## Site# 09-002-B

### CPR# 8701-0008

---

#### Background

Three marshes were constructed in compensation for rock groin and beach construction in Garry Point Park by the City of Richmond. Marshes are protected from wave erosion and log debris by a high riprap berm along the foreshore. Sites were planted with 6,720 golf cup cutter plugs of *Carex lyngbyei* extracted from a tidal marsh along the south shoreline of Canoe Passage. Plantings were spaced 0.5 m center-to-center. Monitoring observations from 1989-1994 indicated that *C. lyngbyei*, *Scirpus validus*, and *Bolboschoenus maritimus* were most abundant among the three sites, and that foreshore berm was effectively protecting site. Monitoring actions only included visual observations.

We only positively identified two of the three alleged compensation marshes. Kistriz (1996) mentioned that one marsh was too low, resulting in significant scouring and vegetation loss. If this trajectory continued, it may explain why one marsh was difficult to identify near-20 years later. Two potential third marshes were identified: a long marsh bench 30 m N/NW of this site, and an eroded marsh embayment due south of the main Garry Point Park parking lot. Records read since field visit indicate that marsh bench was the likely site. Neither marsh was included in this study. Habitat compensation goal = 1680 sqm of marsh habitat.

#### Description

This site is a 258 sqm marsh embayment. The foreshore is armoured by a high riprap berm, and the backshore consists of a riprap slope with no significant riparian vegetation.

100% of the site is comprised of typical mid to high marsh vegetation (Community 1), almost exclusively dominated by *Carex lyngbyei* and *Juncus balticus*, with 73% and 26% relative dominance respectively. The marsh is crescent-shaped, is highest at its center, and gradually slopes downwards to two drainage outlets at the southwest corner and western edge of the site. A network of small drainage channels have formed within the marsh, and are not visible beneath the dense marsh vegetation. This site appears to be functioning well, with few invasives present, insignificant wood debris, and a well-established native plant community.

#### Morphological Features

A crescent-shaped marsh embayment placed between riprap backshore and a foreshore riprap berm. The site is highest at its center, and gradually flows downwards to two drainage outlets where riprap berm is absent. The two drainage outlets are located at the southwest corner and western edge of the marsh. A network of small, dendritic channels has formed throughout marsh.

#### Impacts & Stressors

Sparse log debris, some with large diameters, piled up along back edge of site. Few invasive species are present.

#### Wildlife Sightings/Evidence

None.

#### Adjacent Land Use

Adjacent to high-use Garry Point Park (E). Heavy boat traffic entering and leaving Steveston Harbour (S).

#### Threatened Plant Species (Provincial/Federal)

None.

#### Invasive Species

No invasive plants were sampled in target habitat. *Lythrum salicaria* was observed incidentally.



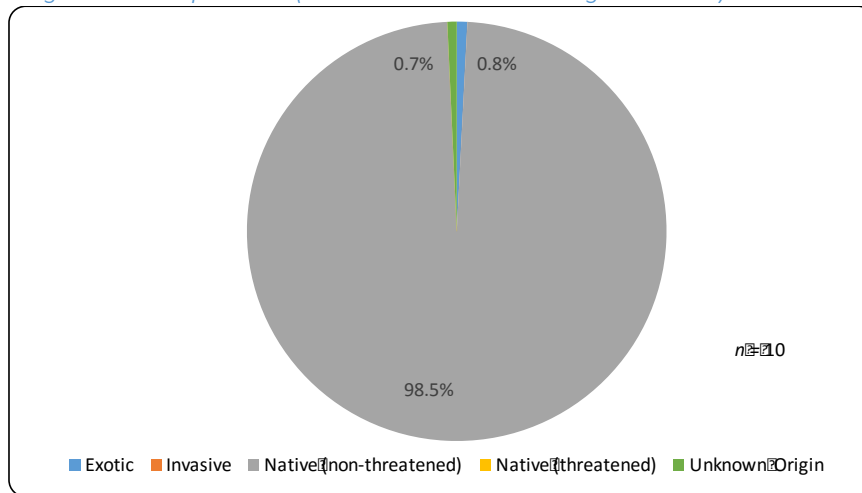
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	258.24	100.0	8.0 +/- 8.9	None	1.26	10	Mid to high marsh (target habitat)

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	54.0	27.1	10	72.7
1	Baltic rush	<i>Juncus balticus</i>	N	2	39.0	27.3	10	26.3

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established(% of area goal)</b>	100.0*	54.0	Poor	The combined target habitat of 09-002-A and 09-002-B comprises 54% of the original habitat conservation goal at 907.2 sqm. A third marsh may exist, and may increase the score of these sites, however no intact marsh was observed elsewhere in Garry Point Park.
<b>2. Proportion/Relative % Cover Native Species</b>	78.6	98.5	Good	Total vegetation cover for the target habitat was 92% and the proportion of native species was 98%. Relative % cover of native species was higher than combined average of nearby reference sites REF-09-001 and REF-10-001.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Unvegetated riprap	1	Plant backshore riprap dike with upslope species.	Improve the integration of the marsh bench into upslope habitat through planting of backshore riprap. No riparian vegetation is present, so riprap may be planted to increase habitat value, and improve resilience to nearby upland invasives (e.g. <i>Cytisus scoparius</i> , <i>Rubus armeniacus</i> ).
Invasive Species	1	Remove invasives around the marsh.	Few invasives were observed in site. Nearby invasives in surrounding park habitat threaten to advance into the marsh, and may be treated as a proactive measure.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive plants	1	Monitor encroachment of invasives surrounding the site.	Site is at risk of long-term encroachment of nearby invasive species. Monitor marsh and backshore riprap for evidence of invasive encroachment.
Log Debris	2	Monitor accumulation of log debris in marsh.	Log debris was abundant on upslope riprap, with only a single, large log in the marsh itself. Monitor to ensure log debris does not accumulate on marsh over time.



Site# 09-004

CPR# 8902-0010

---

### Background

Creation of a 3 x 145 m marsh bench in compensation for dike reconstruction actions. Marsh constructed in 1990. Site planted in 1991 with 7020 *Carex lyngbyei* transplant plugs, acquired from natural tidal marshes adjacent to site. Plugs were acquired via fencepost spade; roughly 10 x 10 x 20 cm. Plugs were planted at 0.75 m intervals. Site visits between 1990-1994 indicated that vegetative cover had reached >90%, with *C. lyngbyei* as the dominant species. Habitat compensation goal = 410 sqm marsh habitat.

### Description

This site is a linear marsh embayment (3 x 145 originally) running parallel to a riprap dike. This riprap slope backs the entire site and has no vegetation in it other than marsh species that have expanded upslope, and exotic ornamentals that have expanded downslope from nearby gardens. Our measurements indicated that marsh vegetation has expanded upslope as much as 2 m. As a result, the marsh appears to have superseded area requirements significantly. The eastern extent of the site is delineated by a public lookout structure. The foreshore is armoured with riprap, which descends into an unvegetated intertidal mudflat below. The western boundary transitions into a natural marsh community.

100% of the site is comprised of typical mid to high marsh vegetation (Community 1), dominated by native *Carex lyngbyei* and exotic *Agrostis stolonifera*. The site appears flat, and no pooling or drainage channels are present. There was no evidence of soil or riprap erosion, likely due to protection by adjacent marina docks. Invasive plants are only moderately impacting the site (relative dominance of 24%), however the presence of *Typha angustifolia* and *Phalaris arundinacea* is concerning to the long-term diversity of the marsh.

### Morphological Features

The site is a relatively uniform, flat marsh with no significant drainage channels or areas of standing water. Marsh expansion appears to be occurring slightly upslope from the original marsh.

### Impacts & Stressors

Lots of Canada Geese in area, but none were observed on or near site and no evidence of graze was observed. Invasive species are not abundant, but presence of a *Typha angustifolia* colony is concerning.

### Wildlife Sightings/Evidence

Great Blue Heron (3; blue-listed) on marina dock adjacent to site. Pair of Mute Swan foraging in front of site.

### Adjacent Land Use

Nearby Ladner Slough is heavily used by boaters (N). Marina in water directly adjacent to site. Large residential development on landward side of site (S).

### Threatened Plant Species (Provincial/Federal)

One threatened species was sampled in target habitat: *Lilaea scilloides*, (blue-listed), with mean % cover of 0.1 +/- 0.2.

### Invasive Species

Three invasive species were sampled in target habitat: *Lythrum salicaria*, *Phalaris arundinacea* and *Typha angustifolia*, for a total mean % cover of 25.6 +/- 21.6. *Phalaris arundinacea* is most dominant invasive species, with a mean % cover of 17.3 +/- 18.8 and a relative dominance of 16.4%. *Rubus armeniacus* is growing in the upslope riprap slope.

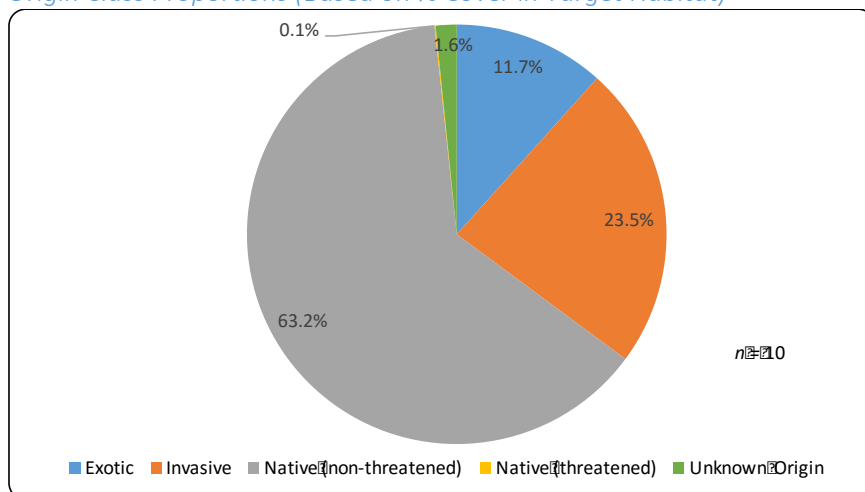
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	899.0	100.0	10.1 +/- 9.5	None	1.44	10	Mid to high marsh (target habitat)

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	48.2	23.4	10	52.1
1	reed canarygrass	<i>Phalaris arundinacea</i>	I	2	17.3	18.8	10	16.4
1	creeping bentgrass	<i>Agrostis stolonifera</i>	E	3	12.7	7.6	10	13.7

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
1. Proportion of Target Habitat Established (% of area goal)	100.0	219.3	Good	The target habitat comprises > 100% of the original habitat compensation goal of 410 sqm. Excess habitat is likely due to downslope expansion of marsh vegetation along foreshore, and upslope expansion along backshore.
2. Proportion/Relative % Cover Native Species	78.6	63.3	Fair	The total vegetation cover for the target habitat was 90% and the proportion of native species was 63%. Relative % cover of native species was moderately less than combined average of nearby reference sites REF-09-001 and REF-10-001.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	2	Remove colony of <i>Typha angustifolia</i> , and reduce abundance of other invasive species.	Priority should be given to removing <i>Typha angustifolia</i> , as it is limited to one colony and is still removable. Biological control may be considered for treatment of <i>Lythrum salicaria</i> to reduce current population and prevent further expansion. <i>Phalaris arundinacea</i> may be treated, but is not a priority for this site.
Bare Ground	1	Plant backshore riprap with appropriate upslope species.	Improve the integration of the marsh bench into upslope habitat through planting of backshore riprap. No riparian vegetation is present, so riprap may be planted to increase habitat value, and improve resilience to nearby upland invasives (e.g. <i>Rubus armeniacus</i> ).
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	4	Monitor encroachment of aggressive invasives within the site.	Monitor spread and advancement of <i>Typha angustifolia</i> and <i>Phalaris arundinacea</i> , unless removed.





## Site# 09-008-A

### CPR# 9004-0052

---

#### Background

Creation of an intertidal marsh bench in compensation for intertidal habitat impacted by dredging and backfill works. Site completed in 1991. The site is a linear bench, and is divided into two marshes (09-008-A and 09-008-B) by a Ladner Yacht Club building, which interrupts the shoreline. Due to a dispute over the property line and a boat ramp (125 sqm) at the NE end of the site, all or part of the disputed area was not restored. This area was supposed to be compensated elsewhere on-site through riparian plantings. As of June 1996 there was no on-site evidence of this required planting. Combined habitat compensation goal for 09-008-A and 09-008-B = 810 sqm marsh habitat.

#### Description

The site is a linear, narrow (~65 x 4 m) intertidal bench, constructed along a steep gradient (~25 degrees). The foreshore is armoured by a wooden retaining wall, which is supported by subtidal pilings and chains anchored upslope. The top of the slope is a ~1 m strip of mowed grass, separating the site from a parking lot and boat ramp above. Nearly no upslope riparian vegetation is present. The foreshore edge of the site appears to be eroding in places, and as a result, a small unvegetated intertidal mudflat has formed (33 sqm).

87% of the site is comprised of typical mid to high marsh vegetation (Community 1), dominated by invasive *Phalaris arundinacea*, exotic *Agrostis stolonifera*, invasive *Lythrum salicaria* and native *Carex lyngbyei*. Evidence of soil erosion was observed, and appears most problematic in areas where the wooden retaining wall is lower in height, or where engineered drainage gaps in the wall exist. The grass strip along the top of the slope is frequently mowed by Ladner Yacht Club, and one native riparian shrub (*Cornus stolonifera*) has been reduced through repeated hedging. Several exotic and invasive plants have successfully colonized the site and threaten to further displace native vegetation.

#### Morphological Features

Marsh is integrated into a very steep slope (~25 degrees). Erosive soil loss has to lead to steep cutbanks and the formation of an unvegetated intertidal community. No drainage channels were identified.

#### Impacts & Stressors

Soil erosion along the foreshore edge has reduced the target habitat area by 13%. Marsh vegetation is limited in upslope expansion through mowing by Ladner Yacht Club. Several native high-marsh species were mown (e.g. *Scirpus microcarpus*). Invasive and exotic plants are prolific, potentially limiting the expansion of native species.

#### Wildlife Sightings/Evidence

Song Sparrows and other songbirds in the vicinity. Barn Swallows (blue-listed, COSEWIC-listed) appear to be nesting under the nearby Ladner Yacht Club building.

#### Adjacent Land Use

Ladner Yacht Club parking lot upslope of site (S). Docks with moored boats in adjacent Ladner Slough (N).

#### Threatened Plant Species (Provincial/Federal)

No threatened species were sampled in target habitat. One threatened species was observed incidentally: *Lilaea scilloides*, (blue-listed).



### Invasive Species

Five invasive species were sampled in target habitat: *Cirsium arvense*, *Iris pseudacorus*, *Lythrum salicaria*, *Phalaris arundinacea* and *Rubus armeniacus*, totaling a mean % cover of 50.4 +/- 39.3. *Cytisus scoparius* and *Convolvulus arvensis* were observed incidentally in the marsh.

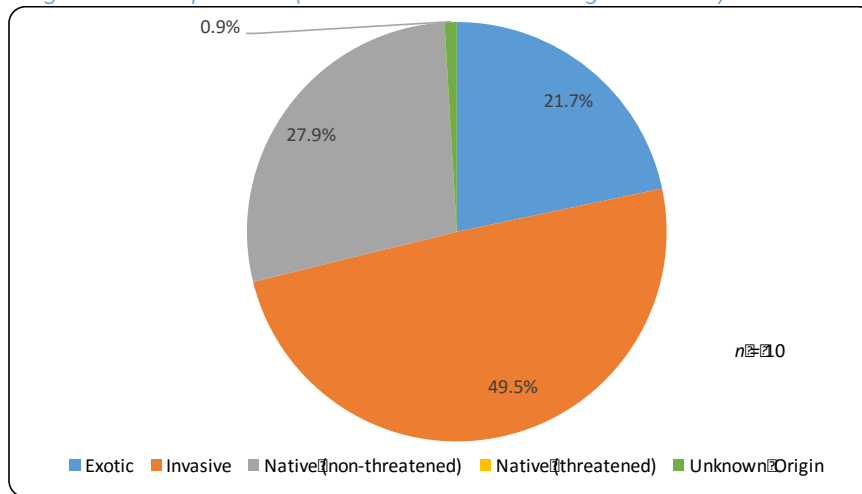
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	220.5	86.8	3.6	None	1.92	10	Mid to high marsh (target habitat)
2	33.5	13.2	100	None	n/a	0	Unvegetated mudflat (unsampled)

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	reed canarygrass	<i>Phalaris arundinacea</i>	I	2	26.7	17.4	10	26.1
1	creeping bentgrass	<i>Agrostis stolonifera</i>	E	3	22.0	17.3	10	26.0
1	purple loosestrife	<i>Lythrum salicaria</i>	I	1	18.2	15.1	10	19.8
1	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	14.4	13.6	10	16.1

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established(% of area goal)</b>	100.0	51.5*	Poor	The combined target areas of 09-008-A and 09-008-B comprises 52% of the original habitat compensation goal of 810 sqm. This low % can likely be explained by two factors: (1) the area lost in the boat ramp at the east end of the site has likely not been compensated and (2) large areas of unvegetated mudflat at the foreshore edge of the two marshes.
<b>2. Proportion/Relative % Cover Native Species</b>	78.6	27.9	Poor	The total vegetation cover for the target habitat of this specific site was 96% and the proportion of native species was 28%. Relative % cover of native species is far below combined average of nearby reference sites REF-09-001 and REF-10-001. Invasive and exotic species are hindering establishment of native vegetation.

### Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	5	Remove invasive species.	Invasive species currently comprise 50% of site vegetation. Priority should be given to removing <i>Iris pseudacorus</i> , <i>Cytisus scoparius</i> , <i>Rubus armeniacus</i> and <i>Cirsium arvense</i> , as they are yet to establish and are still easily removed. <i>Phalaris arundinacea</i> may be treated, but is not easily addressed at this site.
Erosion	5	Adjust current retaining wall system to allow for better protection of low marsh.	Soil loss is occurring along the foreshore edge, most noticeably where drainage gaps in the wall exist (see photos). To increase vegetative cover and reduce the impacts of erosion, the retaining wall may have to be raised in sections, and soil added to amend eroded areas.
Bare Ground	1	Plant eroded areas with appropriate native species.	Bare ground can only be addressed by mitigating soil erosion. Once erosion is mitigated, bare ground should be replanted with appropriate low-marsh native species.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Erosion	4	Monitor expansion of unvegetated, scoured areas along the foreshore edge.	Revisit and monitor eroded areas to determine whether further erosion is occurring or whether an equilibrium has been met. Monitor condition and function of wooden retaining wall long-term.



## Site# 09-008-B

### CPR# 9004-0052

---

#### Background

Creation of an intertidal marsh bench in compensation for intertidal habitat impacted by dredging and backfill works. Site completed in 1991. The site is a linear bench, and is divided into two marshes (09-008-A and 09-008-B) by a Ladner Yacht Club building, which interrupts the shoreline. Due to a dispute over the property line and a boat ramp (125 sqm) at the NE end of the site, all or part of the disputed area was not restored. This area was supposed to be compensated elsewhere on-site through riparian plantings. As of June 1996 there was no on-site evidence of this required planting. Combined habitat compensation goal for 09-008-A and 09-008-B = 810 sqm marsh habitat.

#### Description

The site is a linear, narrow (~5 m wide) intertidal bench, constructed along a steep gradient (~22 degrees). The foreshore is armoured by a wooden retaining wall, which is supported by subtidal pilings and chains anchored upslope. The top of the slope is a ~1 m strip of mowed grass, dividing the site from an upslope parking lot. Nearly no upslope riparian vegetation is present. The foreshore edge of the site appears to be eroding in places, and as a result several small, wet, unvegetated depressions have formed. A small portion of this marsh (~40 sqm) was inaccessible for sampling due to a large chain-link fence.

100% of the site is comprised of typical mid to high marsh vegetation (Community 1) dominated by the exotic (*Agrostis capillaris*, invasive *Phalaris arundinacea* and native *Eleocharis palustris*). Evidence of soil erosion was observed along foreshore, and appears most problematic in areas where the wooden retaining wall is lower in height, or where engineered drainage gaps in the wall exist. The grass strip at the top of the slope is frequently mowed by Ladner Yacht Club, and one native riparian shrub (*Cornus stolonifera*) has been reduced through repeated hedging. Several exotic and invasive plants have successfully colonized the site and threaten to further displace native vegetation.

#### Morphological Features

The wooden retaining wall along the foreshore edge of the marsh varies in height. As a result, slope steepness varies from the east side of the site (~17 degrees) to the west side (~28 degrees). Several small, wet depressions have formed in areas where the retaining wall is lower in elevation, likely due to erosive soil loss.

#### Impacts & Stressors

Soil erosion in exposed areas along the foreshore edge. Marsh is limited in upslope expansion through mowing by Ladner Yacht Club. Several native marsh species were mown, including *Typha latifolia* and *Scirpus microcarpus*. Invasive and exotic plants are prolific, potentially limiting the expansion of native species.

#### Wildlife Sightings/Evidence

Song Sparrows and other songbirds in the vicinity. Barn Swallow (blue-listed, COSEWIC-listed) appear to be nesting under the nearby Ladner Yacht Club building.

#### Adjacent Land Use

Ladner Yacht Club parking lot upslope of site (S). Docks with moored boats in adjacent Ladner Slough (N).

#### Threatened Plant Species (Provincial/Federal)

Two threatened species were sampled in target habitat: *Eleocharis parvula* (blue-listed) and *Lillaea scilloides* (blue-listed), with a mean % cover of 1.1 +/- 1.9.

### Invasive Species

Three invasive species were sampled in target habitat: *Iris pseudacorus*, *Lythrum salicaria* and *Phalaris arundinacea*, totaling a mean % cover of 23.2 +/- 19.3.

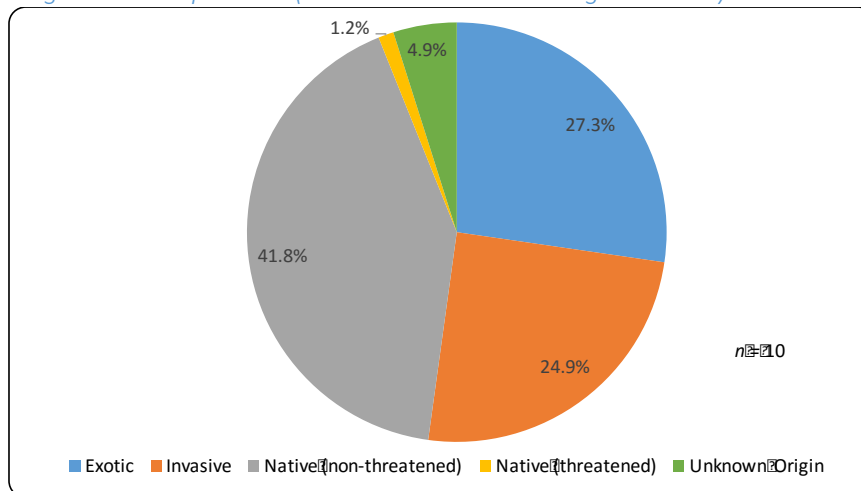
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	197.0	100	20.9 +/- 10.7	None	1.89	10	Mid to high marsh (target habitat)

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	creeping bentgrass	<i>Agrostis stolonifera</i>	E	3	23.7	17.9	10	31.6
1	reed canarygrass	<i>Phalaris arundinacea</i>	I	2	18.6	17.2	10	24.8
1	common spike-rush	<i>Eleocharis palustris</i>	N	1	12.4	10.2	10	12.4

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established (% of area goal)</b>	100.0	51.5*	Poor	The combined target areas of 09-008-A and 09-008-B comprise 52% of the original habitat compensation goal of 810 sqm. This low % can likely be explained by two factors: (1) the area lost in the boat ramp at the east end of the site has not been compensated and (2) large areas of unvegetated mudflat at the foreshore edge of the two marshes.
<b>2. Proportion/Relative % Cover Native Species</b>	78.6	42.9	Poor	The total vegetation cover for the target habitat of this specific site was 79% and the proportion of native species was 43%. Relative % cover of native species is far below combined average of nearby reference sites REF-09-001 and REF-10-001. Invasive and exotic species are hindering establishment of native vegetation.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	3	Remove <i>Iris pseudacorus</i> and <i>Lythrum salicaria</i> .	Priority should be given to removing <i>Iris pseudacorus</i> and <i>Lythrum salicaria</i> , as they are yet to establish and are still easily removed. <i>Phalaris arundinacea</i> may be treated, but is not a priority for this site.
Bare Ground	4	Plant eroded areas with appropriate native species.	Bare ground can only be addressed by mitigating soil erosion. Once erosion is mitigated, bare ground should be replanted with appropriate low-marsh native species. At present, the high mean % cover of invasive species (23.2 +/- 19.3) indicates that bare ground is at risk of invasive species encroachment.
Erosion	4	Adjust current retaining wall system to allow for better protection of low marsh.	Soil loss is occurring in areas where wooden retaining wall is lower in height, or where drainage gaps in the wall exist. To increase vegetative cover and reduce the impacts of erosion, the retaining wall may have to be raised in sections, and soil added to amend eroded areas.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Erosion	3	Monitor expansion of unvegetated, scoured areas along the foreshore edge.	Revisit and monitor eroded areas to determine whether further erosion is occurring or whether a soil loss equilibrium has been reached.



Site# 09-009

CPR# 9301-006

---

### Background

Creation of protruding marsh bench, constructed in 1993 in compensation for the construction of a sewage outfall pipe. Site was planted with 1,800 *Carex lyngbyei* and 400 *Juncus balticus* golf-cup cutter plugs taken from marsh at the foot of No. 2 Road in Richmond. In May 1996 it was recommended that additional riprap be placed along foreshore due to a berm failure that resulted in loss of substrates and some transplants. This was undertaken in June 1996, and included a re-transplant of 70% of the bench. Habitat compensation goal = 750 sqm marsh habitat.

### Description

The site is a protruding marsh bench 750 sqm in size. The marsh is widest in the west (~10 m) and gradually narrows to its eastern limit. The backshore is bordered by a riprap dike, and the entire foreshore edge has been armoured by a riprap berm. Marsh gradient is relatively flat, gradually sloping downwards to the foreshore edge. Wave erosion, in combination with hummocking of native vegetation, has led to the formation of an extremely uneven, heterogeneous marsh surface.

100% of the site is comprised of typical mid to high marsh vegetation (Community 1), dominated by native *Juncus balticus* and *Carex lyngbyei*. No high-priority threats or stressors were identified within the site. At present, invasive plants only total a mean % cover of 0.1 +/- 0.3. Rock substrate was exposed in several places, likely indicating wave erosion from prolific boat traffic. Further monitoring is required to identify the impacts of wave erosion.

### Morphological Features

At present it is difficult to discern whether foreshore is lowering in elevation due to erosion, or whether backshore marsh is raising due to aggradation. The current heterogeneity of the marsh surface is likely the result of both processes. Areas of exposed coarse marsh substrate (i.e., rock, cobble) along the foreshore edge appear to indicate wave erosion. Wave erosion appears most problematic where the site narrows to the east. Meanwhile, large areas of hummocked Baltic rush indicate that sediment deposition is occurring. Together, these processes have created an extremely uneven marsh surface where substrate is being both added and lost.

### Impacts & Stressors

Wave erosion appears to be impacting the narrow, eastern portion of the marsh. Several large tugboats were observed passing the site, inundating the site with large, high-energy waves. Some log debris is present, but is not significantly reducing site productivity. Very few invasives were observed.

### Wildlife Sightings/Evidence

Great Blue Heron (blue-listed, SARA-listed) in neighbouring marsh habitat. Mallards in marsh at high-tide. Local claimed site was excellent for crabbing at high tide.

### Adjacent Land Use

South Dike Trail at top of riprap slope, with small picnic area and parking lot (N).

### Threatened Plant Species (Provincial/Federal)

None.

### Invasive Species

One invasive species was sampled in target habitat: (*Lythrum salicaria*, totaling a mean % cover of 0.1 +/- 0.3. *Iris pseudacorus* was observed incidentally within the backshore riprap.



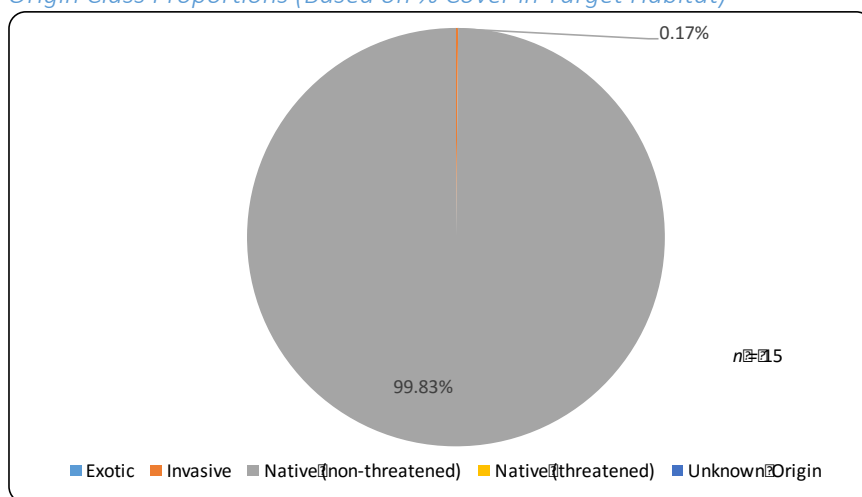
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	751.3	100.0	13.9 +/- 6.1	7.7 +/- 8.7	1.87	15	Mid to high marsh (target habitat)

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	Baltic rush	<i>Juncus balticus</i>	N	2	64.8	11.7	15	86.8
1	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	13.4	7.7	15	13.2

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established(% of area goal)</b>	100.0	100.0	Good	The target habitat comprises 100% of the original habitat compensation goal of 750 sqm.
<b>2. Proportion/Relative % Cover Native Species</b>	78.6	99.8	Good	The total vegetation cover for the target habitat was 78%, due to a combination of log debris, bare ground, and exposed rock. 99.8% of the sampled marsh vegetation was native in origin. Relative % cover of native species was significantly higher than combined average of nearby reference marshes REF-09-001 and REF-10-001..

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Log Debris	1	Remove log debris and replant with native vegetation.	Log debris covers approximately 7.7% of the site. Although not significant, site productivity may be improved through removal of log debris along the backshore, followed by native plantings.
Invasive Species	1	Remove sparse patches of <i>Lythrum salicaria</i> and <i>Iris pseudacorus</i> .	Remove all <i>Iris pseudacorus</i> and <i>Lythrum salicaria</i> , as they are yet to establish and are still easily removed.
Bare Ground	1	Plant eroded areas with appropriate native species.	Bare ground may be replanted with appropriate marsh native species. Wave erosion and/or log debris may have to be monitored and addressed before planting (see Monitoring).
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Erosion/Aggradation	3	Monitor erosion and/or aggradation of marsh.	At present, it is difficult to discern whether foreshore is lowering in elevation due to erosion, or whether backshore marsh is lifting due to aggradation. Recommend a monitoring program that aims to identify elevation and vegetation changes in the marsh over time.



Site# 09-013

CPR# 9502-0019

---

### Background

Creation of subtidal, intertidal marsh, and riparian habitat to compensate for disturbance in the Captain's Cove Marina Ltd. marina facility. A sub/intertidal marsh bench was constructed in 1997, with riparian plantings on top of rip-rap slope. Marsh was planted with 4,920 *Carex lyngbyei* golf-cup plugs acquired from marshes in Ladner Reach, and planted at 0.75 m centre-to-centre intervals. Monitoring was scheduled for 5 growing seasons. There was no compensation for subtidal habitat lost. Habitat compensation goal = 2780 sqm marsh, 325 m/sqm riparian, 23790 subtidal habitat.

### Description

This site is a ~2700 sqm rectangular marsh that protrudes from the surrounding shoreline. The backshore edge of the site is bordered by a riprap dike, which was planted as part of this compensation project (see riparian file). The entire foreshore perimeter is armoured by riprap. The marsh contains several well-distributed pools of standing water, many of which remain wet at low tide. A large, naturally-formed drainage channel flows through the center of the marsh.

100% of the site is comprised of typical marsh vegetation (Community 1), dominated by native *Carex lyngbyei* and exotic *Agrostis stolonifera*. Native species diversity is higher in this marsh than other nearby compensation projects, likely due to habitat heterogeneity from pools of standing water and lower invasive species cover. No high-priority stressors or impacts were identified, although invasive plants (specifically *Iris pseudacorus*) should be closely monitored and/or mitigated to ensure native plant community is sustained.

### Morphological Features

The site is a flat marsh bench, well-elevated above the surrounding sub-tidal. Much of the site remains saturated at low tide, and the marsh contains several well-distributed pools of standing water. A network of small drainage channels has formed, including two channels that run along the base of the backshore riprap slope. These channels join at the center of the backshore to form a large channel that bisects the site and drains out to the river. These drainage channels are approximately 0.5 m wide and 0.1 - 0.2 m deep. The NE and NW corners of the marsh are slightly higher than the rest of the site.

### Impacts & Stressors

No high-priority stressors or impacts were identified. Invasive species total a mean % cover of 12.6 +/- 11.8 and are not a major stressor at this time.

### Wildlife Sightings/Evidence

Wildlife trail leading from rivers edge into site. Potentially a River Otter or other Mustelid.

### Adjacent Land Use

Millennium trail runs along top of dike (S). New residential development under construction immediately south of site. East edge bordered by drainage channel and Highway 99, west edge bordered by docks and moored boats of Captain's Cove Marina.

### Threatened Plant Species (Provincial/Federal)

Two threatened plant species were sampled in target habitat: *Eleocharis parvula*, (blue-listed) and *Juncus oxymeris*, (blue-listed), totaling a mean % cover of 1.3 +/- 1.8.

### Invasive Species

Three invasive species were sampled in target habitat: *Lythrum salicaria*, *Phalaris arundinacea* and *Iris pseudacorus*, totaling a mean % cover of 12.6 +/- 11.8.

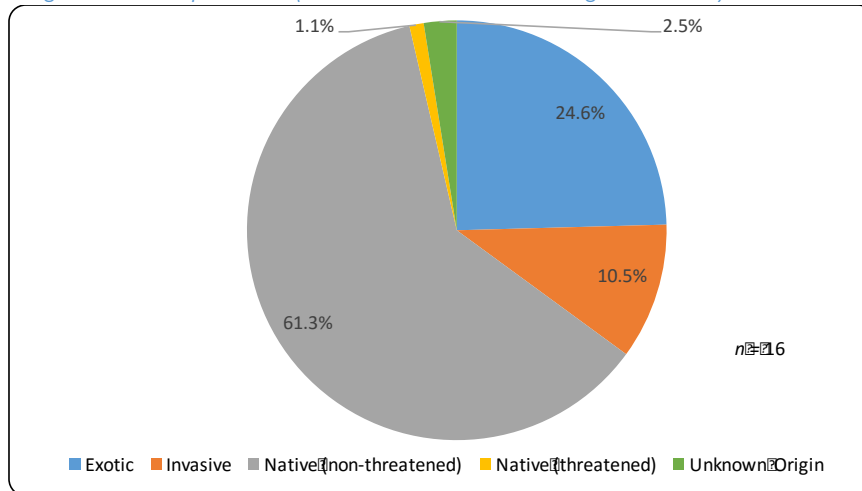
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	2650.0	100.0	2.9 +/- 2.3	0	1.67	16	Mid elevation marsh (target habitat)

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	45.9	15.7	16	49.1
1	creeping bentgrass	<i>Agrostis stolonifera</i>	E	3	29.4	7.8	16	31.4

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established(% of area goal)</b>	100.0	96.3	Good	The target habitat comprises 95% of the original habitat compensation goal of 2780 sqm. The remaining 5% can be likely be attributed to on-site boundary interpretation (e.g. foreshore riprap was excluded from the marsh area, which may have been included originally) or GPS inaccuracy.
<b>2. Proportion/Relative % Cover Native Species</b>	78.6	62.4	Fair	The total vegetation cover for the target habitat was 97% and the proportion of native species was 62%. Relative % cover of native species was lower than combined average of nearby reference sites REF-09-001 and REF-10-001.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	3	Control patches of <i>Iris pseudacorus</i> and <i>Lythrum salicaria</i> .	Priority should be given to removing <i>Iris pseudacorus</i> and <i>Lythrum salicaria</i> , as they are yet to fully establish and are still easily removed. <i>Iris pseudacorus</i> is concentrated in a few large clumps. <i>Phalaris arundinacea</i> may be treated, but the saturated nature of the site likely limits its expansion already.
Bare Ground	1	Replant areas of exposed ground.	Low priority. Most bare ground occurs in areas of pooled standing water, which is natural to such conditions. Wherever appropriate and possible, plant native species to reduce risk of invasive species encroachment.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	2	Monitor dynamics of invasive species within the marsh	Although invasive species only comprised ~12% of the total site area, the site is at risk of yellow flag and purple loosestrife expansion. Monitor site to ensure invasives are not expanding into new areas (e.g. exposed ground in wetted areas) and that native species are not diminishing.





Site# 09-015

CPR# n/a

---

### Background

Intertidal mudflat (2200 sqm) was disturbed as a result of bank stabilization works on the south shore of Deas Slough. Compensation actions were completed in 2000. Habitat compensation goal = 900 sqm intertidal marsh, 50 sqm riparian, and enhancement of 120 sqm of riparian habitat.

### Description

The site is a linear marsh bench 1565.87 sqm in size, protruding from the shoreline of Deas Slough. The site is backed by a vegetated dike, elevated ~2-3 m above high water. Dike vegetation varies from mature riparian forest with tall *Populus balsamifera* (east) to immature shrubs, planted as part of this project (see riparian description). The foreshore edge of the site is armoured with riprap. Textile used in the creation of the marsh is visible along portions of the foreshore, likely indicating foreshore soil loss. The field-measured area of the marsh was significantly higher than the alleged marsh area, likely indicating an expansion of marsh vegetation both up and downslope site since the year of creation.

100% of the site is comprised of typical marsh vegetation (Community 1), primarily dominated by native *Carex lyngbyei* and *Juncus balticus*. No high-priority threats or stressors were identified within the site. Erosion appears to be a moderate issue along the foreshore bank, where textile is exposed at the lip of the riprap (see photos). Sections of the mature riparian slope, located at the eastern portion of the site, are undercutting due to erosion. Although important to monitor, neither of these two erosive processes appear to be impacting site productivity or function. At present, invasive plants total a mean % cover of 4.3 +/- 5.0, with most plants concentrating in slightly elevated areas near the backshore of the marsh. Although not prolific, monitoring and treating these invasives will ensure long-term success of the marsh.

### Morphological Features

Exposed textile along foreshore edge indicates some erosion and/or soil loss has occurred, however marsh productivity has not been impacted, as little to no bare ground exists along the foreshore edge. Riparian banks at eastern backshore of the site are severely undercut, and at risk of caving in. Marsh is lower in elevation than nearby compensation sites (09-001-A and 09-001-B), and the dominant plant community indicates greater periods of inundation. Site is relatively flat, with a few small, elevated areas near the center of the site that host higher marsh species (e.g. *Phalaris arundinacea*).

### Impacts & Stressors

Erosion of both foreshore edge and mature riparian bank. Erosion is yet to impact site productivity, but may prove problematic long-term. Invasive species are present but not abundant.

### Wildlife Sightings/Evidence

None.

### Adjacent Land Use

Millennium trail at top of dike above site with farmland beyond (SE). Deas Slough is well-used by recreational boaters and rowers (NW).

### Threatened Plant Species (Provincial/Federal)

One threatened species was sampled in target habitat: *Juncus oxymers* (blue-listed), totaling a mean % cover of 5.5 +/- 3.7.



### Invasive Species

Two invasive species were sampled in target habitat: *Lythrum salicaria* and *Phalaris arundinacea*, totaling a mean % cover of 4.3 +/- 5.0. *Iris pseudacorus* was observed incidentally.

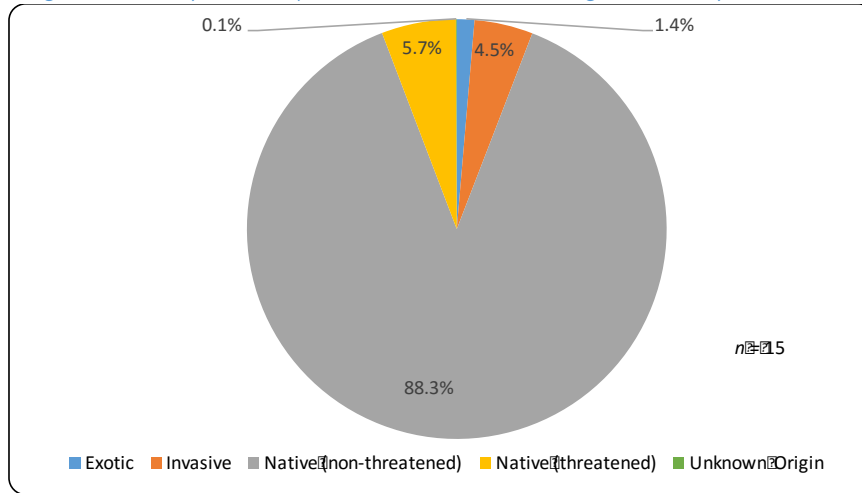
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	1565.9	100.0	7.7 +/- 5.1	0.5 +/- 1.0	1.15	15	Mid to high marsh (target habitat)

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	63.4	15.1	15	81.6

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established(% of area goal)</b>	100.0	174.0	Good	The target habitat comprises over 100% of the original habitat compensation goal at 1566 sqm. Current marsh area has likely exceeded original marsh area due to expansion of marsh vegetation both up and downslope of the site.
<b>2. Proportion/Relative % Cover Native Species</b>	78.6	94.1	Good	The total vegetation cover for the target habitat was 91%, and the proportion of native species was 94%. Relative % cover of native species was significantly higher than combined average of nearby reference sites REF-09-001 and REF-10-001.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Log Debris	1	Remove log debris and replant with native vegetation.	Some log debris has accumulated along the backshore. Removal of wood and re-planting with appropriate natives may improve site productivity. Low priority.
Invasive Species	2	Remove sparse patches of <i>Lythrum salicaria</i> , <i>Phalaris arundinacea</i> and <i>Iris pseudacorus</i> .	Remove all invasive species, as none are yet to establish and are still easily removed. Manual removal recommended.
Bare Ground	1	Plant eroded areas with appropriate native species.	Bare ground may be replanted with appropriate native marsh species. Erosion causes (e.g. wave erosion, low berm height) may have to be addressed before planting is possible.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Erosion	3	Monitor erosion of marsh.	Monitor condition of foreshore edge in areas where textile is exposed. Monitor undercut riparian banks at east end of site to ensure long-term stability of upslope habitat.



## Site# 10-002-A

### CPR# n/a

---

#### Background

Creation of two marsh lagoons (10-002-A and 10-002-B) in compensation for bank stabilization work for Richmond Landfill site. Sites were completed in 1979, apparently in violation of DFO, as they were (1) built in red-coded habitat and (2) well-removed from the impact site. Mean surface elevation of compensation bench was noted to be higher than original marsh of site. Site was built smaller than specifications.

Large tires were installed as debris barriers at all site inflows/outflows. A past report indicated that the debris barriers needed to be improved, but there is no indication that such actions took place. Combined habitat compensation goal of 10-002-A and 10-002-B = 10000 sqm marsh habitat.

#### Description

The site is a rectangular marsh lagoon, 15300 sqm in size, protected behind a vegetated riprap jetty that parallels the Fraser River along the southern marsh boundary. The marsh is surrounded by a riprap slope on every side, and is connected to the Fraser river by two small gaps in the jetty. These gaps allow for fish access and tidal flushing of the marsh. Large tire structures have been installed as debris barriers in each of the two gaps. The lagoon is very complex, with a 700 sqm permanent pond located in the SE corner, and a network of dendritic drainage channels throughout. The site is not well-drained, and remains saturated at low tide.

96% of the site is comprised of typical marsh vegetation (Community 1), dominated by native *Typha latifolia*, invasive *Typha x glauca* and native *Equisetum fluviatile*. The remaining 4% of habitat is a permanent pond located in the SE corner. Some log and garbage debris is present in the lagoon, but not enough to significantly impact site productivity. Invasive plants are abundant within the marsh, and established aggressive invasives, including *Typha angustifolia* and *Typha x glauca* threaten to overwhelm the site long-term.

#### Morphological Features

A 700 sqm permanent pond is located in the SE corner. The pond is connected to the Fraser River through a tidal channel. A network of dendritic drainage channels are found in the southern half of the site. Main channels were measured at ~0.60 m deep and ~1 m wide. Site is saturated and not well-drained. As a result, the lagoon is an extremely complex habitat of standing water, pooled areas, low marsh depressions, and dense cattail marsh.

#### Impacts & Stressors

Garbage was found throughout (e.g. plastic containers, a pallet). Although site has a lot of bare ground, this is likely the result of hydrologic conditions, not stress. Invasive plants are prevalent, and displacing potential of *Typha angustifolia* and *Typha x glauca* are high.

#### Wildlife Sightings/Evidence

Sandpiper (2) observed in SE pond. A single Great Blue Heron (blue-listed, SARA-listed) was observed in marsh during both site visits.

#### Adjacent Land Use

Site is relatively isolated from similar habitats. Land north of site is currently undeveloped and used to store mounds of river sand. Lagoon is connected to South Arm of the Fraser River.

#### Threatened Plant Species (Provincial/Federal)

One threatened plant species was sampled in target habitat: *Juncus oxymeris* (blue-listed), with a mean % cover of 0.1 +/- 0.2.

### Invasive Species

Six invasive plant species were sampled: *Typha x glauca*, *Rubus armeniacus*, *Typha angustifolia*, *Lythrum salicaria*, *Phalaris arundinacea*, and *Iris pseudacorus*, totaling a mean % cover of 30.4 +/- 14.3.

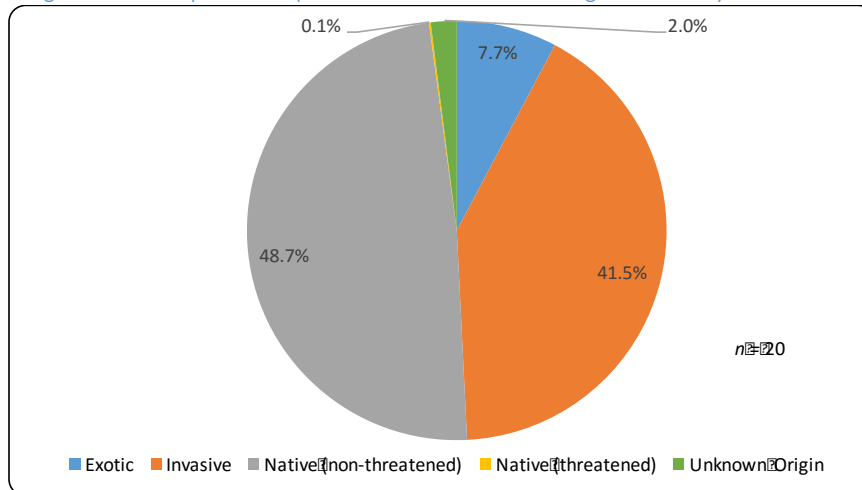
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI(95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	15300	95.6	30.9 +/- 12.3	1.3 +/- 1.7	1.15	20	Mid elevation marsh (target habitat)
2	700	3.4	100.0	None	n/a	n/a	Unsampled pond in SE corner of site.

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	common cattail	<i>Typha latifolia</i>	N	1	9.1	8.0	20	25.3
1	blue cattail	<i>Typha x glauca</i>	I	1	16.1	13.3	20	22.4
1	swamp horsetail	<i>Equisetum fluviatile</i>	N	1	9.0	10.0	20	15.0

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established (% of area goal)</b>	100.0	175.5*	Good	Together, the target habitat of 10-002-A and 10-002-B comprise > 100% of the original compensation goal at 17548 sqm. At this point, we are uncertain as to why our area was significantly larger than the alleged area, given both 10-002-A and 10-002-B have easily-distinguished boundaries.
<b>2. Proportion/Relative % Cover Native Species</b>	68.3	48.8	Fair	The total vegetation cover for the target habitat was 67% (likely reflecting wet growing conditions) and the proportion of native species was 49%. Relative % cover of native species was lower than the combined averages of nearby reference sites REF-12-001 and REF-10-001.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	4	Control aggressive invasive species.	Six invasives were identified within the site, each with differing mitigation priority. If complete site restoration is desired, invasive <i>Typha angustifolia</i> and <i>Typha x glauca</i> need to be removed. If these species are not addressed, they will likely continue to spread and displace native vegetation, as well as hybridize with native <i>Typha latifolia</i> . Other invasives, including <i>Lythrum salicaria</i> , <i>Iris pseudacorus</i> and <i>Rubus armeniacus</i> are still easily treated, as they are yet to fully establish.
Bare Ground	1	Plant areas of bare ground with appropriate native species.	Bare ground totaled a mean % cover of 32.1 +/- 12.5. In most other marshes this amount of bare ground would be high mitigation priority. However in this case, the high % of bare ground is more the result of site hydrology, which has created plant communities that are naturally more sparse, and better-suited to saturation. Some planting is possible within the site, but this should be considered low priority.
Garbage	1	Remove garbage and anthropogenic debris.	Lots of small garbage (e.g. plastic containers, boat debris) has accumulated within the cattail marsh. A pallet was discovered near the edge of SE pond.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	4	Monitor expansion of invasive plants into new areas of the lagoon.	Approximately 32% of the site is bare ground, and 42% of vegetative cover is invasive species. These conditions may allow for expansion of several wet-marsh invasives, including <i>Iris pseudacorus</i> and <i>Typha</i> spp.. Monitor dynamics of invasive species long-term to ensure native plant communities are not being further displaced (e.g. photo monitoring).







## Site# 10-002-B

CPR# n/a

---

### Background

Creation of two marsh lagoons (10-002-A and 10-002-B) in compensation for bank stabilization work for Richmond Landfill site. Sites were completed in 1979, apparently in violation of DFO, as they were (1) built in red-coded habitat and (2) well-removed from the impact site. Mean surface elevation of compensation bench was noted to be higher than original marsh of site. Site was built smaller than specifications.

Large tires were installed as debris barriers at all site inflows/outflows. A past report indicated that the debris barriers needed to be improved, but there is no indication that such actions took place. Combined habitat compensation goal of 10-002-A and 10-002-B = 10000 sqm marsh habitat.

### Description

The site is an irregularly-shaped marsh lagoon, 4248 sqm in size, protected behind a riprap jetty that parallels the Fraser River along the southern boundary. The marsh is surrounded by a riprap slope on every side, and is connected to the Fraser by two small gaps in the jetty, located in the southwest and east boundaries of the site. These gaps allow for fish access and tidal flushing of the marsh. Large tire structures have been installed as debris barriers in each of the two gaps (see photos). The marsh is diverse elevationally, with depressions of standing water, tidal channels, high marsh, and an island of riparian vegetation at the center of the site.

62% of the marsh is comprised of typical marsh vegetation (Community 1), dominated by native *Carex lyngbyei*. The remaining marsh area (38%) is heavily impacted by log debris (see photos). This community (Community 2) is sparsely vegetated, and dominant species include *Bidens cernua*, *Sagittaria latifolia* and *Typha latifolia*. Overall, log and garbage accumulation is the biggest stressor to the marsh, and is significantly impacting habitat value and site productivity. Invasive species are present, but are yet to fully establish.

### Morphological Features

The site is extremely diverse elevationally. Community 1 lies in a depression between the foreshore berm and a riparian island at the center of site. The marsh contains several small drainage channels, pools of standing water, and is gradually sloped to the SW and E berm openings. Community 2 is a sheltered deposition zone that is prone to trap logs and garbage due to inadequate flushing and site topography. A backshore tidal connects channel connects accumulation areas in the NE and NW corners of the site. A mounded riparian island exists in the middle of the site (637 sqm), which may or may not have been part of the original marsh design.

### Impacts & Stressors

~38% of total marsh area is currently impacted by log debris accumulation. Invasive species account for 13% of marsh vegetation.

### Wildlife Sightings/Evidence

None.

### Adjacent Land Use

Site is relatively isolated from similar habitats. Land NW of site is currently undeveloped and used to store mounds of river sand. Light industrial warehouses to the NE. Lagoon is connected to South Arm of the Fraser River.

### Threatened Plant Species (Provincial/Federal)

One threatened species was sampled in target habitat: *Juncus oxymeris* (blue-listed), totaling a mean % cover of 1.3 +/- 1.8. *Lilaea scilloides* (blue-listed) was observed in the marsh incidentally.

### Invasive Species

Three invasive species were sampled in target habitat: *Lythrum salicaria*, *Phalaris arundinacea*, and *Iris pseudacorus*, totaling a mean % cover of 15.6 +/- 13.9. *Phalaris arundinacea* was most abundant, with a mean % cover of 11.7 +/- 13.4.

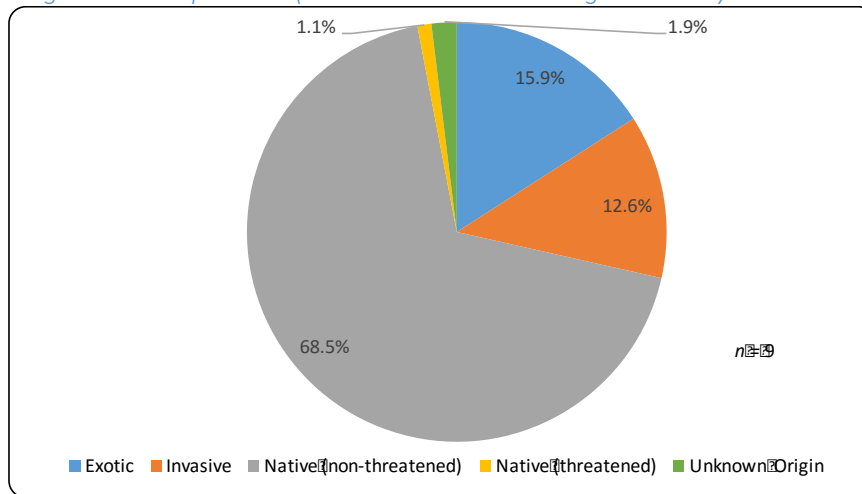
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	2248.0	62.3	2.1 +/- 3.8	None	1.36	9	Mid to high marsh (target habitat)
2	1363.0	37.8	27.9 +/- 11.2	56.0 +/- 16.7	1.07	9	Log and other debris deposition zone

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	44.9	23.9	9	55.6
2	nodding beggarticks	<i>Bidens cernua</i>	N	2	4.0	3.6	9	30.2
2	broad-leaved arrowhead	<i>Sagittaria latifolia</i>	N	1	3.4	2.9	9	26.0
2	common cattail	<i>Typha latifolia</i>	N	1	6.1	9.8	9	23.1

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established(% of area goal)</b>	100.0	100.0*	Good	Together, the target habitat of 10-002-A and 10-002-B comprise > 100% of the original compensation goal at 17548 sqm. At this point, we are uncertain as to why our area was significantly larger than the alleged area, given both 10-002-A and 10-002-B have easily-distinguished boundaries.
<b>2. Proportion/Relative % Cover Native Species</b>	68.3	68.5	Good	The total vegetation cover for the target habitat was 98% and the proportion of native species was 70%. Relative % cover of native species is higher than combined average of nearby reference sites REF-12-001 and REF-10-001.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Log Debris	5	Remove log debris, and replace with appropriate native plants. Modify existing debris barriers.	~38% of site is severely impacted by log debris. Remove excess wood, and re-plant areas with appropriate natives. Tire debris barriers appear ineffective and will have to be modified to properly address the problem long-term.
Invasive Species	2	Remove patches of <i>Iris pseudacorus</i> and <i>Lythrum salicaria</i> .	Priority should be given to removing <i>Iris pseudacorus</i> and <i>Lythrum salicaria</i> , as they are yet to establish and are still manageable. <i>Phalaris arundinacea</i> is yet to fully establish, and is likely limited by a lack of suitable habitat within the marsh (i.e. soil is too saturated).
Bare Ground	1	Plant unvegetated areas with appropriate native species.	Planting of bare ground is likely not possible without addressing the debris issue of the site. Most unvegetated ground appeared to be the result of log damage at high tide.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Log Debris/Garbage	3	Monitor accumulation of log debris and garbage.	Revisit marsh during several periods of inundation (e.g. freshet, high tide etc.) to better identify why current debris structures are ineffective.



Site# 10-003

CPR# 8807-0073

---

### Background

Creation of intertidal marsh habitat in compensation for losses from road widening, bank protection, and fill. Site completed in 1989. Replanting did not immediately follow works. As of June 1996, vegetation was yet to fully establish due to continuous stress from log grounding. *Carex* sp. transplants were used in original planting works. Habitat compensation goal = 180 sqm marsh and 120 sqm intertidal mudflat habitat.

### Description

The site is a 496 sqm marsh bench built in-line with the surrounding shoreline. True site boundaries were difficult to discern, due to lack of records and lack of distinguishable boundaries on-site. Sampled area is bordered by riprap to the east (industrial lot) and south (River Road dike). Foreshore is not armoured with riprap, with a moderate slope of gravel extending into the subtidal. Western boundary is natural shoreline, with a well-established marsh plant community. A mature riparian community exists between the site and River Road, with several large *Populus balsamifera*, *Salix* spp. and *Cornus stolonifera*. No log boom protection is currently present, however pilings are in the vicinity and the site may be protected periodically.

80% of the site is comprised of typical mid to high marsh vegetation (Community 1), dominated by *Equisetum fluviatile* and *Juncus balticus*. A sparsely-vegetated gravel bar (Community 2) is located along the foreshore edge, and is dominated by native *Carex lyngbyei*, invasive *Phalaris arundinacea* and invasive *Lythrum salicaria*. The entire marsh is impacted by log debris, which is severely reducing site productivity (see photos). Much of the backshore (Community 1) is covered in log debris, while the foreshore (Community 2) is likely being grounded by logs at high tide. The foreshore edge shows signs of significant erosion, likely due to a combination of high boat traffic in this portion of the River and lack of wave protection (e.g. riprap, log boom).

### Morphological Features

Marsh is flat with no drainage channels. The entire foreshore edge is an unarmoured, gradual slope of gravel and sand. Erosion appears to be affecting the foreshore, evident in scouring, lack of fine silts/clays in the foreshore substrate, and lack of foreshore vegetation. Site is slightly mounded in NE corner, along industrial park boat ramp.

### Impacts & Stressors

Erosion appears to be undercutting marsh foreshore (see photos), limiting vegetative colonization, and scouring all fine particles from substrate. No waterfowl were observed nearby, but *Carex lyngbyei* appears to be grazed. Log debris is reducing site productivity through grounding and smothering marsh vegetation.

### Wildlife Sightings/Evidence

None.

### Adjacent Land Use

Small industrial lot (E). River Road (S). Natural marsh bench runs parallel to River Road west of site. Marsh located along southern shore of South Arm of Fraser River.

### Threatened Plant Species (Provincial/Federal)

No threatened species were sampled in target habitat. One threatened species was observed incidentally in the marsh: *Bidens amplissima* (blue-listed, SARA-listed).

### Invasive Species

Four invasive species were observed: *Rubus armeniacus*, *Lythrum salicaria*, *Phalaris arundinacea*, and *Iris pseudacorus*, totaling a mean % cover of 4.9 +/- 5.8.

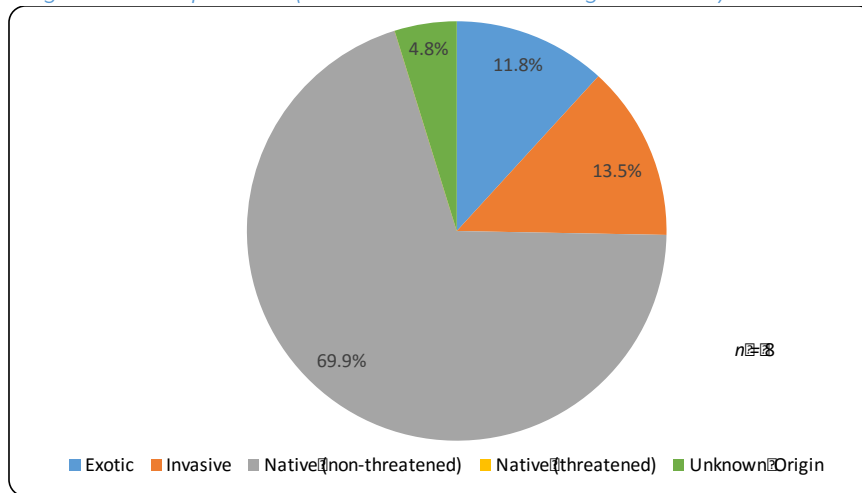
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI(95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	398.4	80.3	16.9 +/- 9.1	54.3 +/- 27.6	1.43	8	Mid to high marsh (target habitat)
2	97.6	19.7	94.2 +/- 10.0	None	1.44	3	Foreshore vegetated gravel bar

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	swamp horsetail	<i>Equisetum fluviatile</i>	N	1	2.4	2.3	8	21.2
1	Baltic rush	<i>Juncus balticus</i>	N	2	8.8	17.1	8	12.7
1	common cattail	<i>Typha latifolia</i>	N	1	2.8	3.6	8	12.0
2	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	3.3	6.5	3	36.4
2	reed canarygrass	<i>Phalaris arundinacea</i>	I	2	3.3	6.5	3	36.4
2	purple loosestrife	<i>Lythrum salicaria</i>	I	1	2.0	3.9	3	21.8

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established(% of area goal)</b>	100.0	275.6	Good	The target habitat comprises >100% of the original habitat compensation goal at 180 sqm, although this reflects uncertainty of boundaries more than compensation success. This number should be adjusted over time once true boundaries are established.
<b>2. Proportion/Relative % Cover Native Species</b>	68.3	69.9	Good	Vegetation cover was greatly reduced by log debris and foreshore erosion. Mean % cover of <i>Carex lyngbyei</i> was 3.0 +/- 4.3 in Community 1 and 3.3 +/- 6.5 in Community 2, indicating that original sedge plugs have not effectively established. However, relative % cover native species was equal to combined average of nearby reference sites REF-12-001 and REF-10-001.



Recommendations

<b>Mitigation</b>			
<b>Impact</b>	<b>Priority Rank (1 Low - 5 High)</b>	<b>Action Required</b>	<b>Comments</b>
Log Debris	5	Remove log debris, and replace with appropriate native plants. Install debris barriers.	Log debris covers ~54% of the target marsh community. Remove log debris and replant to increase site productivity. Design and location of marsh likely makes it a trap for debris. Using existing infrastructure, address log problem long-term through installation of debris barrier.
Erosion	5	Reduce impacts of wave erosion on marsh foreshore.	Wave erosion is scouring foreshore, removing all fine sediments from foreshore substrate, and reducing vegetative cover. Discuss with engineer/expert. Log boom may be adequate for reducing wave energy.
Bare Ground	2	Plant unvegetated areas with appropriate native species.	Planting of bare ground should not occur unless log debris and erosion are first addressed. Most bare ground the result of these stressors.
Invasive Species	1	Remove invasive plants from marsh.	Invasive plants are currently ~4.9% of total site area. Since invasives are yet to establish, focus efforts on full eradication of all invasives while abundance is still manageable.
<b>Monitoring</b>			
<b>Impact</b>	<b>Priority Rank (1 Low - 5 High)</b>	<b>Action Required</b>	<b>Comments</b>
Foreshore erosion	3	Monitor expansion of unvegetated gravel foreshore and/or colonization of marsh vegetation.	Native plants have colonized portions of gravel foreshore. Monitor to assess whether plants are expanding, slowly resolving erosion issue without supplemental mitigation. Likewise, monitor dynamics of gravel foreshore, noting whether gravel bar is expanding or diminishing.



## Site# 10-004

### CPR# 9401-0014

---

#### Background

Loss of habitat due to dredging resulted in the creation of an intertidal marsh bench and planting of upslope riparian habitat. Habitats were created in 1996, and both marsh and riparian habitats were planted in April/May 1997. Marsh was planted with 6100 *Carex lyngbyei* golf-cup plugs extracted from nearby natural tidal marshes, and planted at 0.50 m centre-to-centre density. Monitoring was scheduled to occur annually from 1997-2002. Habitat compensation goal = 1525 sqm marsh, 30 m/sqm riparian habitat.

#### Description

The site is a semicircular marsh bench 1499 sqm in size. The marsh is in line with surrounding shoreline, and is seamlessly integrated into natural marsh shoreline to the west. Marsh foreshore is armoured with riprap and backshore is bordered by riprap dike with mature riparian plantings above (see riparian file). Foreshore is bordered by adjacent Seaspan terminal, which likely protects marsh from log debris accumulation and wave erosion. The marsh is generally flat, with a few wet depressions in the southern third, a small drainage channel exiting at the eastern boundary, and patches of high marsh at the toe of backshore riprap slope.

100% of the site is comprised of typical marsh vegetation (Community 1), dominated by native *Carex lyngbyei* and exotic *Agrostis capillaris*. Log debris is minimal and is not impacting marsh productivity. Invasive species total a mean % cover of 15.8 +/- 12.3, but most are restricted to the backshore toe of riprap slope, and are not impacting most of the marsh.

#### Morphological Features

Marsh is generally flat. A series of small, wetted depressions occur in the southern third of the site. These depressions remain inundated much longer than surrounding marsh. A small drainage channel runs from wetted depressions to eastern boundary of site. Marsh elevation appears higher at base of backshore dike, where several high marsh species are dominant (e.g. *Phalaris arundinacea*).

#### Impacts & Stressors

Invasive species are not well-established, but are likely displacing native species along marsh backshore (base of riprap dike).

#### Wildlife Sightings/Evidence

None.

#### Adjacent Land Use

Seaspan terminal surrounds site to north, east, and south. Natural marsh bench seamlessly integrates into western marsh boundary. South Arm of Fraser River heavily used for shipping and recreation.

#### Threatened Plant Species (Provincial/Federal)

One threatened species was sampled in target habitat: *Juncus oxymeris* (blue-listed), totaling a mean % cover of 0.4 +/- 0.6. *Lilaea scilloides* (blue-listed) was incidentally observed in the marsh.

#### Invasive Species

Two invasive species were sampled in target habitat: *Lythrum salicaria* and *Phalaris arundinacea* with a mean % cover of 15.8 +/- 12.3. *Iris pseudacorus* was observed incidentally. Most invasives are restricted to backshore, along edge of riprap dike.

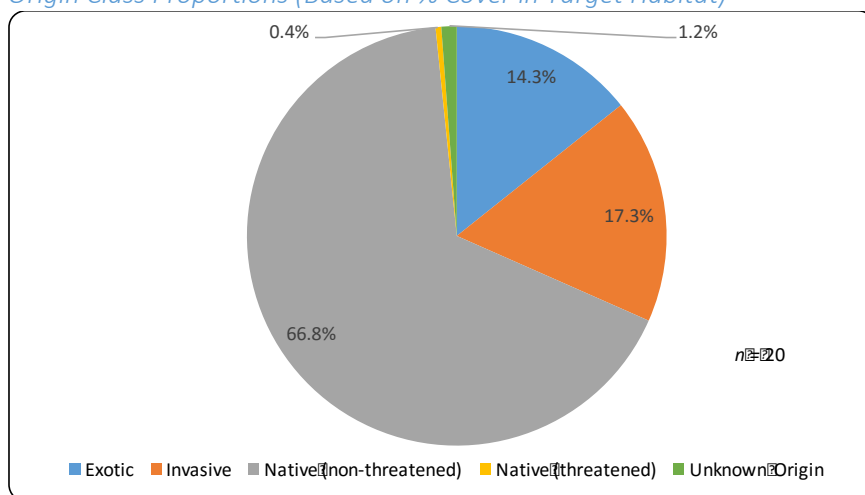
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	1498.7	100.0	11.7 +/- 7.9	None	1.41	20	Mid elevation marsh (target habitat)

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	51.4	16.0	20	69.0
1	colonial bentgrass	<i>Agrostis capillaris</i>	E	3	13.0	6.6	20	16.4

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established (% of area goal)</b>	100.0	98.3	Good	The target habitat comprises 98% of the original habitat compensation goal at 1499 sqm.
<b>2. Proportion/Relative % Cover Native Species</b>	67.2	68.3	Good	The total vegetation cover for the target habitat was 87% and the proportion of native species was 68%. <i>Carex lyngbyei</i> was used in original site plantings, and now has a mean % cover of 51.4 +/- 16.0, indicating successful establishment of plugs. Relative % cover of native species is slightly higher than combined average of nearby reference marshes REF-12-001 and REF-10-001.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	2	Control patches of <i>Phalaris arundinacea</i> , <i>Lythrum salicaria</i> , and <i>Iris pseudacorus</i> .	Three invasive species were identified and none are yet to fully establish in site. Mitigation actions should aim to eradicate all invasives while they are still manageable.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Bare Ground	2	Monitor expansion of invasive plants into less-vegetated areas of marsh.	Sparsely-vegetated wet areas in southern third of site may be threatened by expansion of wet-marsh invasives (e.g. <i>Iris pseudacorus</i> , <i>Typha angustifolia</i> ). Monitor dynamics of invasive species long-term to ensure native plant communities are not being displaced (e.g. photo monitoring).





## Site# 11-002

### CPR# 8610-0071

---

#### Background

Creation of a 12 x 112 m intertidal bench in front of existing marsh. Site built in 1989 and planted in 1991. Compensation actions were completed in advance of dredging and pile impacts at Brightwater Maritime Village. Original compensation requirement was for 1707 sqm of marsh and 225 m of riparian habitat. The known as-built area is 1866 sqm marsh and 171 m of riparian habitat at the foot of Carter Street. A 50% credit was also given for cleaning up 564 sqm of marsh. As-built area is not consistent with original 12 x 112 m dimensions given in the BIEAP-FREMP Atlas, nor with clean-up credit when added to total. Levings & Nishimura notes different dimensions, describing the site as “a constructed marsh bench approximately 30 m wide...which sloped gradually from the natural riparian zone toward a riprap berm.” Further background information required to confirm true gain/loss numbers.

Site was planted with 9,600 *Carex lyngbyei* transplant plugs (10 x 10 x 20 cm) extracted from natural marshes 200-300 m downstream of site, on north shore of Annacis Island. Some of plugs were nursery stock as well. Monitoring indicated that by the third growing season three vegetation zones had formed, with aerial cover ranging between 25% to 100% between them. Surveys reported by Levings & Nishimura (1996) indicated that upper elevations of site were dominated by *C. lyngbyei*, *Scirpus cyperinus*, *Phalaris arundinacea*, *Juncus supiniformis* and *Juncus effusus* whereas lower elevations were dominated by *Juncus* spp., *Ranunculus* spp. and *Isoetes* spp.. Lower elevation vegetation had been impacted by waterfowl use as of 1991. This site is part of a project undertaken by Dr. C.D. Levings under the Fraser River Action Plan to assess the ecology of compensation marshes in comparison to natural marshes. Habitat compensation goal = 1866 sqm marsh, 171 sqm riparian habitat.

#### Description

This site is a protruding marsh bench, ~1500 sqm in size, built in front of an existing marsh community. Backshore boundary is well-integrated and difficult to discern from pre-existing marsh. A chained log-boom has been installed at the foreshore edge, and appears to ground for most of the tidal cycle. Foreshore edge was originally armoured with riprap, most of which is now covered with sediment and no longer visible. Sediment deposition has extended beyond riprap foreshore and a downslope vegetated mudflat zone has formed, increasing foreshore by ~1209 sqm (see photos). The majority of the marsh is flat, although several small wetted depressions are located along the foreshore boundary. Wetted areas are dominated by wetland-obligate species (e.g. *Typha latifolia*, *Eleocharis palustris*, *Myriophyllum ussuriense*).

100% of the site is comprised of typical mid to high marsh vegetation (Community 1), dominated by native *Carex lyngbyei*, exotic *Myosotis scorpioides*, exotic *Agrostis capillaris* and native *Eleocharis palustris*. Impacts of invasive species are low to moderate, however invasives are abundant in pre-existing backshore marsh and risk expanding into compensation area. Grounding of log booms may be limiting growth and productivity of vegetation along foreshore edge.

#### Morphological Features

Aerial imagery and historical photos indicate that original riprap foreshore has been covered with river sediment since time of creation. Aggradation of sediment has expanded site foreshore, creating a ~1209 sqm vegetated mudflat immediately south of site (image 11-002 (2)). No drainage channels present in marsh, and several small wetted depressions occur near the foreshore boundary.

#### Impacts & Stressors

Log boom may be grounding marsh foreshore, limiting vegetation and scouring substrate in localized areas. Invasive species present but not well-established.

#### Wildlife Sightings/Evidence

Great Blue Heron (blue-listed, SARA-listed) in site.



*Adjacent Land Use*

Houseboat complex (E). Residential neighbourhoods and playing field (N). Some natural marsh (NE,SW).

*Threatened Plant Species (Provincial/Federal)*

Two threatened species were sampled in target habitat: *Juncus oxymers* (blue-listed) and *Eleocharis parvula* (blue-listed), totaling a mean % cover of 0.9 +/- 0.7.

*Invasive Species*

Three invasive species were sampled in target habitat: *Lythrum salicaria*, *Phalaris arundinacea*, and *Iris pseudacorus*, totaling a mean % cover of 8.2 +/- 8.6.

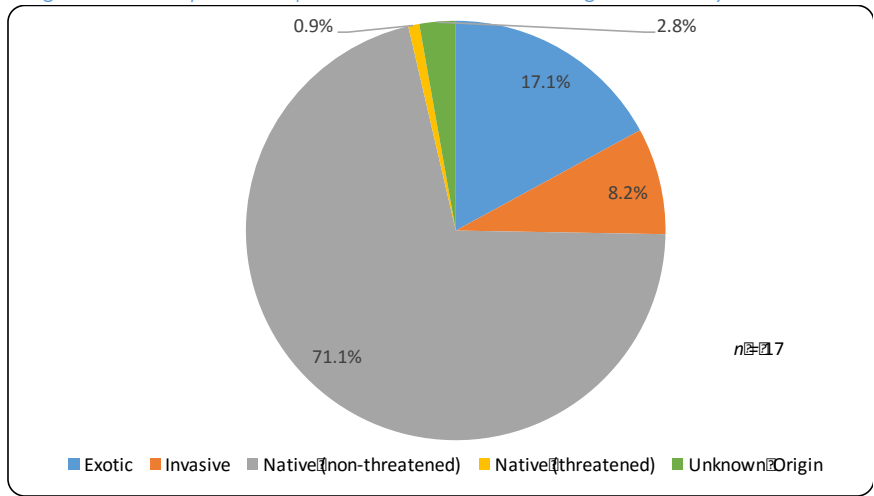
*Community Descriptions*

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	1574.82	100.0	11.7 +/- 9.0	4.4 +/- 5.9	1.51	17	Mid elevation marsh (target habitat)

*Dominant Species*

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	27.2	17.6	17	35.0
1	European forget-me-not	<i>Myosotis scorpioides</i>	E	2	7.4	5.3	17	12.4
1	colonial bentgrass	<i>Agrostis capillaris</i>	E	3	7.0	4.1	17	11.7
1	common spike-rush	<i>Eleocharis palustris</i>	N	1	9.9	7.3	17	11.5

*Origin Class Proportions (Based on % Cover in Target Habitat)*



Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established(% of area goal)</b>	100.0	100.0	Good	The target habitat comprises 84.3% of the original habitat creation goal at 1575 sqm of 1866 sqm. However, site is well-integrated into pre-existing backshore marsh, making field measurements of compensation area difficult to properly estimate. Missing 291 sqm is likely the result of inaccurate boundary estimates, not non-compliance. At this point, it is assumed that Actual % is closer to 100% than current measurements.
<b>2. Proportion/Relative % Cover Native Species</b>	59.2	71.9	Good	The total vegetation cover for the target habitat was 84% and the proportion of native species was 72%. Relative % cover native species is significant higher than combined average of nearby reference marshes REF-11-001 and REF-12-001.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	4	Remove sparse patches of <i>Lythrum salicaria</i> , <i>Iris pseudacorus</i> , and <i>Phalaris arundinacea</i> .	Invasive species are yet to establish and should be eradicated while still manageable.
Bare Ground	1	Plant unvegetated areas with appropriate native plants.	Most bare ground within the marsh is the result of soil saturation, not outside stress. Planting of aggraded foreshore mudflat would increase marsh size and productivity.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Foreshore Log Grounding	3	Monitor movement and impacts of foreshore log boom.	Evidence of log boom grounding along foreshore. Visit site during varying tides and/or seasons to evaluate.



Site# 11-010

CPR# 9410-116

---

### Background

Restoration of marsh vegetation damaged from seismic upgrading of bridge piers. Site substrate planted with plugs transplanted from adjacent marsh. Habitat was impacted and restored in 1994. Site was planted with 360 *Carex lyngbyei* golf-cup plugs extracted from tidal marshes in the North Arm and transplanted at densities of 0.5 m centre-to-centre. Observations made one year after plantings indicated 75% survivorship of transplants, with some *Juncus articulatus* colonization occurring. Habitat compensation goal = 80 sqm marsh habitat.

### Description

The site is a narrow 134 sqm marsh bench located directly beneath the Queensborough bridge. No foreshore armoring is present, and site possesses natural downslope gradient of nearby natural marshes. Foreshore slope is a combination of mud and cobble substrates. Southern boundary is backed by a steep riprap dike, that is partially vegetated by native and non-native shrubs (e.g. *Cornus stolonifera*, *Rubus armeniacus*). East and west boundaries are in-line with neighbouring marsh habitats.

74% of the site is comprised of typical mid to high marsh vegetation (Community 1), dominated by native *Juncus articulatus*, native *Juncus balticus*, and native *Carex lyngbyei*. A sparsely-vegetated gravel/mudflat accounts for 26% of site area, with trace vegetation dominated by stunted *Carex lyngbyei*. Canada Geese were observed within the marsh upon arrival, and foreshore marsh plants showed evidence of graze. Invasive species are not abundant in the site, but are more abundant nearby riparian and marsh habitats, and may threaten to invade site over time.

### Morphological Features

The site is located on a gentle slope of gravel and mud substrate. No channels are present. Exposed gravel and rock may be the result of fine sediment erosion and scouring.

### Impacts & Stressors

Marsh vegetation significantly grazed by Canada Geese. Evidence of foreshore soil loss, likely the result of grazing and wave erosion. Invasive species present but not abundant.

### Wildlife Sightings/Evidence

Raccoon and Canada Goose scat identified. Geese seen grazing on marsh vegetation and at top of bank upon arrival.

### Adjacent Land Use

Access road/walking trail along top of dike (S). Southeast of site is underside of Queensborough bridge, with a long drainage ditch that drains through pump station to east. Auto wrecker to (S). North Arm of Fraser River heavily used by tugs and other industry.

### Threatened Plant Species (Provincial/Federal)

One threatened plant species was sampled in target habitat: *Juncus oxymyris* (blue-listed), totaling a mean % cover of 0.1 +/- 0.1.

### Invasive Species

Four invasive species were sampled in target habitat: *Solanum dulcamara* (seeding from plants on dike), *Lythrum salicaria*, *Phalaris arundinacea* and *Clematis vitalba* (seeding from plants on dike), totaling a mean % cover of 4.4 +/- 2.7. Invasives were most abundant along marsh backshore.

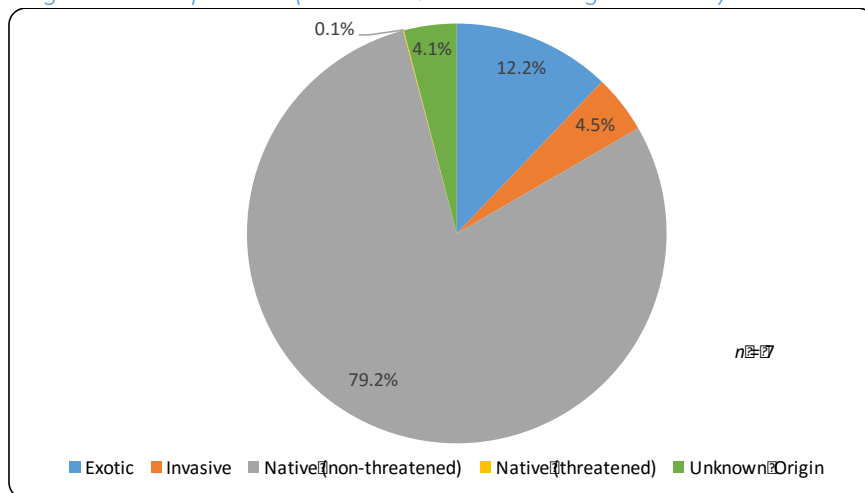
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	99.0	73.8	24.0 +/- 11.7	None	1.47	7	Mid to high marsh (target habitat)
2	35.0	26.1	96.3 +/- 3.5	None	1.07	3	Vegetated mud/gravel flat

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Status	CI (95%)	n	Relative Dominance (%)
1	jointed rush	<i>Juncus articulatus</i>	N	1	23.9	5.7	7	28.0
1	Baltic rush	<i>Juncus balticus</i>	N	2	20.7	11.6	7	20.3
1	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	14.7	8.0	7	20.2
2	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	3.7	4.0	3	81.5

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established(% of area goal)</b>	100.0	73.8	Fair	The target habitat comprises 74% of the sampled area. Although the target habitat area exceeds the habitat compensation goal (99 sqm of 80 sqm required), this is due to boundary uncertainty, and does not reflect true size of this habitat within the compensation area. Total sampled area is representative of marsh beneath bridge, so 74% target community has been applied to success calculations.
<b>2. Proportion/Relative % Cover Native Species</b>	72.8	79.3	Good	Plugs planted from adjacent marsh were likely <i>Carex</i> , so 20% relative dominance of <i>Carex lyngbyei</i> indicates poor establishment. However, relative % cover of native species is slightly higher in site than combined average of nearby reference marshes REF-11-001 and REF-02-001, mostly due to the establishment of other natives ( <i>Juncus balticus</i> , <i>Juncus articulatus</i> ) and general lack of invasives.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Erosion	3	Install erosion protection structures.	Nearby natural marsh is not as eroded, and protected by log boom structures (see bottom photo). High boat traffic was observed. Current appears to be strengthened and directed to foreshore by bridge piling.
Bare Ground	2	Plant unvegetated areas with appropriate native species.	Bare ground should not be addressed without first addressing erosion issues. Large areas of exposed substrate present, totaling a mean % cover of 24.0 +/- 11.7 in target habitat.
Invasive Species	1	Remove invasive species in and around compensation site.	Few invasives were observed on site, totaling a mean % cover of 4.4 +/- 2.7. Invasives should be removed while still unestablished. Nearby invasives in surrounding riparian and marsh habitat threaten to advance into the marsh, and may be treated as a proactive measure.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Erosion	3	Monitor changes in eroded foreshore over time.	Identify whether area of unvegetated gravel slope is increasing with erosion, or decreasing with vegetative encroachment.



Site# 11-012-A

CPR# 9903F032

---

### Background

Creation and restoration of intertidal marsh on Purfleet Point in compensation for riparian habitat (2952 sqm), intertidal marsh (2227 sqm) and intertidal mudflat (2877 sqm) disturbed during seismic upgrading of BC Hydro transmission tower. Site was constructed in 2000 and planted in 2001. Compensation habitat goal = 2107 sqm marsh habitat restored, 3304 sqm marsh habitat created.

### Description

This site is a 3887 sqm marsh embayment located at the westernmost point of Annacis Island. The northern foreshore is a sparsely-vegetated slope of small-grade riprap/cobble that extends to an exposed mudflat at low tide. Marsh backshore is armoured by a vegetated riprap berm, which shelters the habitat from the main arm of Fraser to the south. Eastern boundary is delineated by a small tidal channel, and mature riparian forest. A large transmission tower lies in the middle of the marsh. Four large concrete pads have been placed in the marsh to support tower legs. Marsh elevation appears highest beneath hydro tower, where *Phalaris arundinacea* and other upland marsh species dominate. Site slopes downwards to northern foreshore, and to east boundary, where a tidal channel drains northward.

100% of the site is comprised of typical mid to high marsh vegetation (Community 1), dominated by *Phalaris arundinacea* and *Carex lyngbyei*. There is evidence of moderate erosion along foreshore edge, with little fine sediment in substrate and only sparse vegetation present. Invasive species total a mean % cover of 30.5 +/- 11.8, and are most concentrated in and around the transmission tower, where *P. arundinacea* almost exclusively dominates. Marsh biodiversity is significantly diminished in this area.

### Morphological Features

Site appears to be highest in elevation within footprint of transmission tower. Marsh slopes downwards to east boundary, where a small drainage channel drains to the north, and also slopes to northern foreshore. Foreshore is a gentle slope of exposed small-grade riprap and cobble. Lack of fine sediments and vegetation in foreshore slope may be an indicator of erosion.

### Impacts & Stressors

Invasive species total a mean % cover of 30.5 +/- 11.8 and are severely impacting marsh diversity in and around transmission tower. Log debris is present but is not significantly impacting marsh productivity.

### Wildlife Sightings/Evidence

American Beaver damage on *Populus balsamifera* and *Salix* sp. growing on backshore berm. Bushtits were observed feeding on *Lythrum salicaria* seeds.

### Adjacent Land Use

Purfleet Point Nature Reserve separates the site from commercial development to the east. Site is bordered by Fraser River on three sides, with heavily-used main channel to south.

### Threatened Plant Species (Provincial/Federal)

One threatened species was sampled in target habitat: *Juncus oxymeris* (blue-listed), totaling a mean % cover of 0.1 +/- 0.1.

### Invasive Species

Three invasive species were sampled in target habitat: *Lythrum salicaria*, *Phalaris arundinacea*, and *Iris pseudacorus*, totaling a mean % cover of 30.5 +/- 11.8.



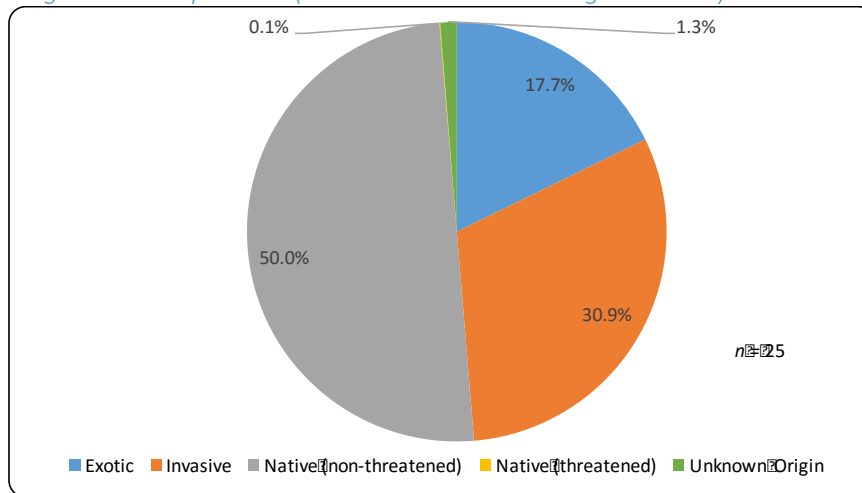
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	3886.5	100.0	16.6 +/- 9.9	1.4 +/- 1.8	1.77	25	Mid to high marsh (target habitat)

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	reed canarygrass	<i>Phalaris arundinacea</i>	I	2	23.4	11.9	25	39.7
1	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	14.2	8.3	25	13.1

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established (% of area goal)</b>	100.0	83.1*	Good	Together, the combination of 11-012-A and 11-012-B likely account for 100% of the original habitat compensation goal of 5411 m. Field measurements of target habitat totaled 4499 m, but this was likely due to uncertain site boundaries in the SE of 11-012-A, not inadequate compensation. For this reason, it is assumed that ~5411 m of marsh was created for compensation rankings.
<b>2. Proportion/Relative % Cover Native Species</b>	68.3	50.1	Fair	The total vegetation cover for the target habitat was 82%, and the proportion of native species was 50%. Relative % cover of native species was lower than combined average of nearby reference sites REF-10-001 and REF-12-001, primarily due to dominance of <i>Phalaris arundinacea</i> .

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	4	Remove patches of <i>Iris pseudacorus</i> , and mitigate impacts of dominant species.	<i>Iris pseudacorus</i> is yet to fully establish in marsh and should be eradicated while still manageable. <i>Phalaris arundinacea</i> , although a major problem, is well-established and difficult to mitigate without drastically altering site hydrology.
Bare Ground	3	Plant unvegetated areas with appropriate native species.	Some unvegetated areas are natural, sparsely vegetated wet areas that do not require mitigation. Site foreshore is eroded, and may be planted with appropriate native species (e.g. <i>Juncus balticus</i> ) with aim to boost foreshore site productivity and reduce erosional energy.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Foreshore erosion	2	Monitor changes in unvegetated foreshore over time.	Unvegetated foreshore may be expanding due to erosion or shrinking due to colonization of marsh vegetation. Monitor over time to identify whether erosion mitigation is required.



## Site# 11-012-B CPR# 9903F032

---

### Background

Creation and restoration of intertidal marsh on Purfleet Point in compensation for riparian habitat (2952 sqm), intertidal marsh (2227 sqm) and intertidal mudflat (2877 sqm) disturbed during seismic upgrading of BC Hydro transmission tower. Site was constructed in 2000 and planted in 2001. Compensation habitat goal = 2107 sqm marsh habitat restored, 3304 sqm marsh habitat created.

### Description

The site is a 701 sqm marsh located at the southern edge of Purfleet Point, Annacis Island, alongside the main arm of the Fraser River. Marsh is semi-circular in the west, with a narrow, linear extension to the east. Eastern foreshore protrudes into the River, and western foreshore is in line with nearby riprap shoreline. Western backshore is bordered by a tall, vegetated riprap berm. Northern and eastern backshore is bordered by mature riparian vegetation with no riprap armouring. The entire foreshore has been armoured by riprap. Marsh elevation appears relatively uniform, with no drainage channels, and only minor hummocking of Baltic rush.

87% of the site is comprised of typical mid to high marsh vegetation (Community 1), dominated by *Carex lyngbyei* and invasive *Phalaris arundinacea*. Remaining 13% of site area is an unvegetated garbage and log debris accumulation zone (see photos). Debris is biggest stressor to site, and is significantly reducing marsh productivity in and around accumulation zone. Invasives are present, but are not established enough to significantly reduce compensation success.

### Morphological Features

Site is relatively flat, gently sloping downwards to foreshore. No drainage channels identified. Some localized hummocking of *Juncus balticus* is occurring.

### Impacts & Stressors

Debris accumulation zone accounts for 13% of total marsh area, and is limiting site productivity. Invasive species are present but not abundant.

### Wildlife Sightings/Evidence

None.

### Adjacent Land Use

Purfleet Point Nature Reserve separates the site from commercial development to the east. Site faces heavily-used main channel of Fraser River to south.

### Threatened Plant Species (Provincial/Federal)

One threatened species was sampled in target habitat: *Juncus oxymers* (blue-listed), totaling a mean % cover of 1.6 +/- 2.6.

### Invasive Species

Three invasive species were sampled: *Lythrum salicaria*, *Phalaris arundinacea*, and *Iris pseudacorus*, totaling a mean % cover of 20.0 +/- 15.1.

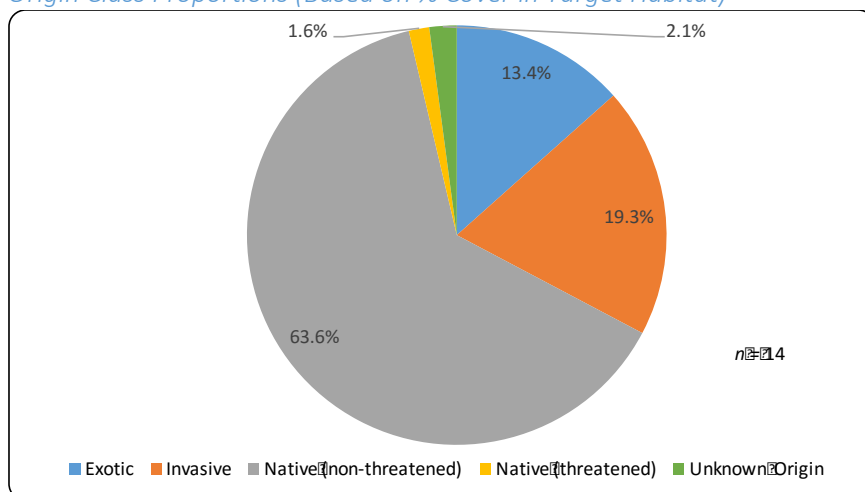
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	612.7	87.4	10.7 +/- 5.0	None	1.49	14	Mid to high marsh (target habitat)
2	88.7	12.6	0	100	n/a	n/a	Unvegetated accumulation zone of logs and garbage

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	30.3	13.8	14	29.3
1	reed canarygrass	<i>Phalaris arundinacea</i>	N	2	18.7	14.3	14	18.1

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established(% of area goal)</b>	100.0	83.1*	Good	Together, the combination of 11-012-A and 11-012-B likely account for 100% of the original habitat compensation goal of 5411 m. Field measurements of target habitat totaled 4499 m, but this was likely due to uncertain site boundaries in the SE of 11-012-A, not inadequate compensation. For this reason, it is assumed that ~5411 m of marsh was created for compensation rankings.
<b>2. Proportion/Relative % Cover Native Species</b>	68.3	65.2	Good	The total vegetation cover for the target habitat was 89%, and the proportion of native species was 65%. Relative % cover of native species was only slightly lower than combined average of nearby reference marshes REF-12-001 and REF-10-001.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Log Debris	4	Remove excessive log debris and garbage. Replant with appropriate native species.	Accumulation zone currently covers 12.6% of site area. Increase site productivity through removal of debris and replanting of native species. Consider long-term solution to address problem permanently (e.g. log boom protection).
Invasive Species	2	Control poorly-established invasive species.	<i>Iris pseudacorus</i> and <i>Lythrum salicaria</i> are yet to establish and should be eradicated while still manageable. <i>Phalaris arundinacea</i> may be removed, but treatment will be difficult at this stage of establishment.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Log Debris	4	Monitor changes in debris accumulation zone.	Design and location of site is likely responsible for high debris accumulation. Monitor area of accumulation zone to evaluate whether it is increasing over time.



## Site# 11-013

### CPR# 0404F036

---

#### Background

Compensation for loss of riparian habitat, intertidal marsh and intertidal mudflat. Works completed in 2004. During 2015 site visit, landowner stated that marsh was built in compensation for residential development, and that only appropriate native species were planted. Habitat compensation goal = 1050 sqm marsh, 200 m/sqm riparian habitats.

#### Description

The 1280 sqm marsh is comprised of a semi-circular bay, located in an indentation in the dike, as well as two linear benches that parallel dike foreshore in the SW and NE. The entire site backshore is bordered by riprap dike, and foreshore is unarmoured. Foreshore varies from a steep mud bank along linear benches to a gradual slope at the mouth of the bay. Site is well-integrated into similar marsh habitats in NE and SW. No protective log booms are in place, but off-shore marina shelters entire foreshore. To increase habitat value, large woody debris has been intentionally added to marsh and secured to dikes. Linear benches are moderately sloped from riprap dike to foreshore edge, and appear higher and better-drained than embayed habitat. The bay is lower in elevation and saturated, with a very slight downslope gradient to river edge. One small drainage channel drains the bay backshore.

82% of the site is comprised of typical mid to high marsh vegetation (Community 1), dominated by *Juncus articulatus*, and native *Typha latifolia*. A vegetated mudflat accounts for the remaining 18%, where sparse vegetation is dominated by exotic *Callitriche stagnalis*, native *J. articulatus*, and native *Crassula aquatica*. Invasive species are not a significant stressor to target habitat, totaling a mean % cover of 2.8 +/- 1.5. Bare ground accounts for 44.2 +/- 18.1% of target habitat. Much of the bare ground is the natural result of saturated conditions, however actions may be taken to increase vegetative cover and marsh productivity in areas of the marsh foreshore.

#### Morphological Features

Linear benches to SW and NE appear higher in elevation than embayed habitat. Benches are moderately sloped from toe of dike to foreshore edge. Bay habitat lies in a poorly-drained depression. As a result, bay soil is saturated, with wetted areas of standing water throughout. Bay is gradually sloped to foreshore edge. Community 2 is located along bay foreshore, and appears to be inundated for longer periods of time than remaining marsh.

#### Impacts & Stressors

Target habitat contains a high % cover of bare ground (44.2 +/- 18.1). Some bare ground is result of saturation, which naturally limits species composition and abundance. Other bare ground may be result of erosion, inadequate planting, or age of site. Invasive species are yet to establish within site.

#### Wildlife Sightings/Evidence

Great Blue Heron (blue-listed, SARA-listed) and Raccoon tracks in mud.

#### Adjacent Land Use

~10-year-old condo development directly upland from marsh (N). Marina on river directly in front of marsh (S).

#### Threatened Plant Species (Provincial/Federal)

One threatened species was sampled in target habitat: *Eleocharis parvula* (blue-listed), totaling a mean % cover of 0.0 +/- 0.1. *Eleocharis parvula* was also sampled in Community 2, with a mean % cover of 0.1 +/- 0.2. *Juncus oxymeris* (blue-listed) and *Lilaea scilloides* (blue-listed) were incidentally observed in the marsh.



### Invasive Species

Two invasive species were sampled in target habitat: *Lythrum salicaria* and *Phalaris arundinacea*, totaling a mean % cover of 2.8 +/- 1.5.

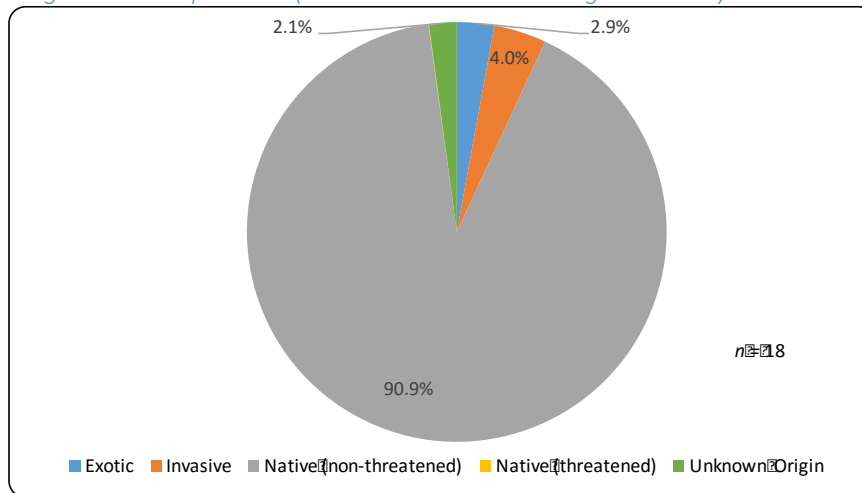
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	1043.5	81.6	44.2 +/- 18.1	None	1.12	17	Mid to high marsh (target habitat)
2	236.1	18.4	55.3 +/- 16.7	None	1.02	6	Vegetated mudflat

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	jointed rush	<i>Juncus articulatus</i>	N	1	26.8	14.6	18	59.2
1	common cattail	<i>Typha latifolia</i>	N	1	10.3	7.5	18	16.2
2	pond water-starwort	<i>Callitriche stagnalis</i>	E	1	26.5	23.3	6	58.9
2	jointed rush	<i>Juncus articulatus</i>	N	1	9.7	9.7	6	20.2
2	pigmyweed	<i>Crassula aquatica</i>	N	1	6.3	6.3	6	11.5

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established(% of area goal)</b>	100.0	99.4	Good	The target habitat comprises 99% of the original habitat compensation goal at 1044 sqm. Boundaries were difficult to discern in field, but compensation actions appeared to adequately fulfill project goals.
<b>2. Proportion/Relative % Cover Native Species</b>	59.2	91.0	Good	The total vegetation for the target habitat was 55%, and the proportion of native species was 91%. Low vegetation cover was likely the result of saturated soil conditions. Relative % cover of native species was significantly higher than combined average of nearby reference sites REF-11-001 and REF-12-001.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Bare Ground	4	Plant unvegetated areas with appropriate native species.	Although some bare ground is naturally-occurring, consider planting foreshore of linear benches to increase site productivity and reduce risk of foreshore erosion.
Invasive Species	1	Remove sparse invasives from marsh.	Few invasives were observed on site. Eradicate small patches of <i>Lythrum salicaria</i> and <i>Phalaris arundinacea</i> before they can establish.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Bare Ground/Vegetation	3	Monitor changes in unvegetated areas.	Use photo monitoring to identify whether mudflat is increasing (due to erosion) or decreasing (due to vegetation encroachment) in size over time. May be performed as a precursor to mitigation activities.



Site# 12-001  
CPR# n/a

---

#### Background

Marsh bench created in compensation for marsh and mudflat habitat losses from Gunderson Slough shoreline protection actions. Marsh created in 1982 and planted in 1983. Habitat compensation goal = 625 sqm marsh habitat.

#### Description

The site is a protruding marsh bench 673 sqm in size, located at the head of Gunderson Slough. The site is backed by a vegetated riprap dike, which is dominated by invasive *Rubus armeniacus* and the occasional native riparian shrub (*Salix* spp., *Cornus stolonifera*). Marsh foreshore is armoured by a high, steep riprap slope. Marsh elevation appears to resemble that of high marshes nearby, and is likely only briefly inundated at high tide. Waters surrounding the marsh are extremely stagnant, as several docks and log booms limit flushing from the nearby Fraser River.

100% of the site is comprised of typical mid to high marsh vegetation (Community 1), dominated by invasive *Phalaris arundinacea* and exotic *Myosotis scorpioides*. Native plants have been severely displaced by non-native species, and now only comprise 24.7 +/- 10.4 of marsh area. Location of marsh makes it prone to debris accumulation. A significant amount of garbage (e.g. buoys, oil containers, metal drum, Styrofoam, bottles) were found within the marsh, likely increasing contaminant levels and reducing vegetative cover.

#### Morphological Features

Site is a relatively flat and well elevated over sub tidal. Field observations suggest that marsh elevation is higher than nearby mid-elevation marshes. No erosion observed.

#### Impacts & Stressors

Invasive and exotic plants account for 73% of marsh vegetation cover, and appear to have displaced native species. Marsh is prone to debris accumulation, which increases risk of contaminants and smothering of marsh vegetation.

#### Wildlife Sightings/Evidence

None.

#### Adjacent Land Use

Marina in adjacent slough (SW) . Alaska Way and Fraser Surrey Docks to north and west.

#### Threatened Plant Species (Provincial/Federal)

One threatened plant species was sampled in target habitat: *Juncus oxymyris* (blue-listed), totaling a mean % cover of 0.2 +/- 0.4.

#### Invasive Species

Four invasive species were sampled in target habitat: *Rubus armeniacus*, *Lythrum salicaria*, *Phalaris arundinacea*, and *Iris pseudacorus*, totaling a mean % cover of 43.0 +/- 17.2.

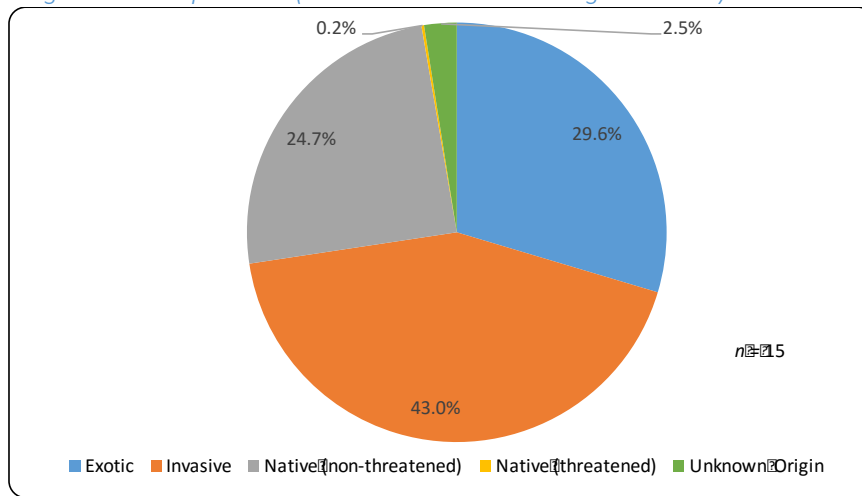
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	673.5	100	11.0 +/- 7.7	0.7 +/- 1.3	1.76	15	Mid to high marsh (target habitat)

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	reed canarygrass	<i>Phalaris arundinacea</i>	I	2	34.0	17.8	15	47.1
1	European forget-me-not	<i>Myosotis scorpioides</i>	E	2	12.3	12.8	15	11.0

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established(% of area goal)</b>	100.0	107.8	Good	The target habitat comprises 107.8% of the original habitat compensation goal at 673 sqm.
<b>2. Proportion/Relative % Cover Native Species</b>	59.2	24.9	Poor	The total vegetation cover for the target habitat was 88% and the proportion of native species was 25%. Relative % cover of native species was significantly lower than combined average of nearby reference sites REF-11-001 and REF-12-001. Lack of native species is the most significant obstacle to project success.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	5	Remove patches of <i>Iris pseudacorus</i> <i>Rubus armeniacus</i> . Mitigate impacts of <i>Lythrum salicaria</i> and <i>Phalaris arundinacea</i> .	<i>Iris pseudacorus</i> may be removed manually or with injection of glyphosate. <i>Rubus armeniacus</i> plants are small and easily removed from marsh. <i>Lythrum salicaria</i> and <i>Phalaris arundinacea</i> are likely too established to be entirely eradicated. Site elevation and/or hydrology likely has to be altered to reduce <i>P. arundinacea</i> long-term. Some exotics ( <i>Myosotis scorpioides</i> along the foreshore) should be considered for removal as well.
Garbage	3	Remove garbage and replace with native plants (where necessary).	Garbage varies in size from small plastic containers to a large metal drum. Remove debris and replant bare ground with native plants (where necessary). Frequent removal likely not necessary, as site is 30 years old and debris accumulation is not severe.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Garbage	3	Monitor accumulation of garbage long-term.	Location of marsh makes it prone to debris accumulation. Infrequently visit site to ensure garbage is not hindering site productivity.



## Site# 12-004 CPR# 9111-0115

---

### Background

Creation of marsh basin in compensation for losses of subtidal habitat, mudflat and small ribbon marshes within the area occupied by bridge abutments. Basin excavated out of sand island, which serves as bridge abutment. The basin was planted in 1992 with 10 sqcm *Carex lyngbyei* sods that were dug using garden spades from a nearby tidal marsh on the north foreshore of Annacis Channel. Monitoring of vegetation establishment was documented. Habitat compensation goal = 8560 sqm marsh habitat.

### Description

The site is a 7474 sqm marsh basin located under and adjacent to Alex Fraser Bridge. With the exception of the western opening, the entire basin is bordered by a riprap slope. Mature riparian vegetation surrounds most of the site, including stands of *Alnus rubra* and *Populus balsamifera* that overhang marsh perimeter. Basin exits through a narrow opening in the west, where a vegetated mudflat gradually slopes downwards to the Fraser. Entrance of basin is protected by logs booms stored by nearby sawmill. Marsh is most elevated around perimeter, gradually sloping to center where mudflat communities occur. A single central drainage channel flows from the eastern marsh to western exit.

70% of the site is comprised of typical mid to high marsh vegetation (Community 1), dominated by exotic *Myosotis scorpioides*, native *Carex lyngbyei* and exotic *Agrostis capillaris*. A vegetated mudflat (Community 2) accounts for 24% of marsh area, and is dominated by exotic *Callitriche stagnalis*. An unvegetated mudflat (Community 3) accounts for the remaining 6% of the marsh. Invasive species are yet to significantly impact target habitat, occupying a total mean % cover of 13.9 +/- 8.9. The biggest stressor to site productivity is site hydrology. Because of design, basin currently operates as a slough, with little tidal flushing and generally poor drainage. At present 30% of site is either too saturated, too inundated, or soil is too anaerobic to support significant marsh vegetation. A small colony of invasive *Typha angustifolia* should be removed, as species is not restricted by hydrology, and likely capable of colonizing entire habitat.

### Morphological Features

Marsh is most elevated around perimeter, gradually sloping downwards to saturated center of site where vegetated and unvegetated mudflat communities occur. A single drainage channel flows from the eastern marsh to western exit. No evidence of significant erosion.

### Impacts & Stressors

Invasive species are yet to significantly impact marsh vegetation. Biggest stressor/influencer of site productivity is site hydrology. 30% of site appears too wet to support marsh vegetation.

### Wildlife Sightings/Evidence

Songbirds observed in marsh vegetation. Great Blue Heron (blue-listed, SARA-listed) tracks in mudflat.

### Adjacent Land Use

Basin is connected to heavily-used main channel of Fraser River. Sawmill just west of basin entrance. Site is surrounded by public walking trail along dike, with dog walking park to south. A pedestrian bridge crosses over basin entrance to west.

### Threatened Plant Species (Provincial/Federal)

Two threatened plant species were sampled in target habitat: *Juncus oxymers* (blue-listed) and *Lilaea scilloides* (blue-listed), totaling a mean % cover of 0.3 +/- 0.3.



### Invasive Species

Three invasive species were sampled in target habitat: *Lythrum salicaria*, *Phalaris arundinacea*, and *Iris pseudacorus*, totaling a mean % cover of 13.9 +/- 8.9. *Typha angustifolia* was incidentally observed within the site but was not sampled, as it was limited to a single, concentrated patch (see photo).

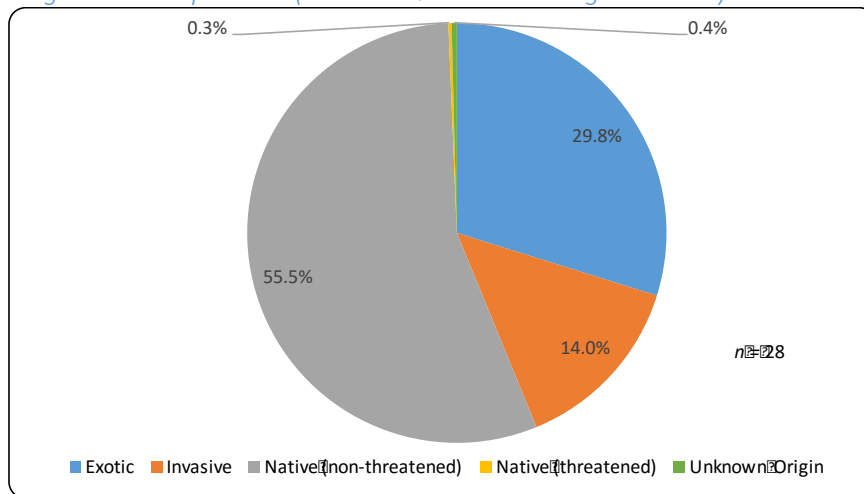
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	5228.4	70.0	14.6 +/- 7.1	None	1.63	28	Mid to high marsh (target habitat)
2	1767.0	23.6	65.6 +/- 21.5	None	1.01	11	Vegetated Mudflat
3	479.0	6.4	100.0	None	n/a	0	Unvegetated mudflat

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	European forget-me-not	<i>Myosotis scorpioides</i>	E	2	18.7	6.2	28	33.5
1	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	22.9	12.1	28	23.7
1	colonial bentgrass	<i>Agrostis capillaris</i>	E	3	10.9	7.0	28	11.3
2	pond water-starwort	<i>Callitriche stagnalis</i>	E	1	30.4	22.7	11	86.4

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
1. Proportion of Target Habitat Established(% of area goal)	100.0	61.1	Poor	The target habitat comprises 61% of original habitat compensation goal at 5228.4 sqm. This low % can be partially attributed to poor establishment of native vegetation in 39% of site. However, total sampled area (all communities) only accounted for 87% of alleged marsh size, and we are uncertain as to where the missing area is located (marsh boundaries were easy to delineate).
2. Proportion/Relative % Cover Native Species	59.2	55.8	Good	The total vegetation cover for the target habitat was 85% and the proportion of native species was 56%. The only known transplants at project creation were <i>Carex</i> . Sedges have established the target habitat adequately (relative dominance of 23.7%), but are absent from 39% of the site. Relative % cover of native species is comparable to combined average of nearby reference marshes REF-11-001 and REF-12-001.

### Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Bare Ground	4	Plant unvegetated areas with appropriate native species.	Mean % cover of bare ground totals 14.6 +/- 7.1 in target habitat. 30% of site is sparsely-vegetated or unvegetated mudflat. Actions should be considered, depending on project goals, to increase productivity of marsh. Appropriate low-marsh species may be planted in saturated areas, or site hydrology altered to promote vegetative encroachment.
Invasive Species	3	Remove patches <i>Iris pseudacorus</i> , <i>Lythrum salicaria</i> and <i>Typha angustifolia</i> . Mitigate impacts of <i>Phalaris arundinacea</i> .	<i>Iris pseudacorus</i> and <i>Typha angustifolia</i> (see photo) are still highly localized and easy to remove manually or with chemical treatment. Both species are capable of expanding range in marsh if untreated. Biological control may be considered to reduce <i>Lythrum salicaria</i> . <i>Phalaris arundinacea</i> dominates portions of the northern backshore, and may be mitigated to increase diversity of vegetated areas.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Mudflat expansion/recession	3	Monitor the size of vegetated/unvegetated mudflat.	Determine whether mudflats are expanding, receding, or are stable. Use photo monitoring or detailed mapping. May be performed as a precursor to bare ground mitigation.



Site# 12-007

CPR# 0604F020

---

### *Background*

Construction of barge terminal resulted in loss of riparian habitat, intertidal marsh, unvegetated intertidal mudflat and subtidal habitats. In compensation, riparian habitat (725 sqm) and unvegetated intertidal mudflat (1760 sqm) was withdrawn from the Port Metro Vancouver Timberland Basin Habitat Bank and an intertidal marsh bench was built. Marsh constructed in 2006. Habitat compensation goal = 625 sqm marsh habitat.

### *Description*

The site is a rectangular marsh bench (approximately 15 x 60 m) built parallel to a barge terminal on-ramp. Orientation of barge terminal does not resemble that of surrounding shoreline (angles into flow). As a result, marsh protrudes from natural shoreline and is exposed to Fraser River on 3 sides. Bench foreshore is armoured by riprap on every side. Backshore is armoured by an unvegetated riprap dike. A single railway track and paved on-ramp is located at top of bank. Site appears to be a deposition area for river sands. Mud substrate along eastern backshore is covered in a thick layer of sand, and several small, unvegetated sandbars have formed in this area. Substrate is less sandy near foreshore, where a small vegetated mudflat occurs.

71% of the site is comprised of typical mid to high marsh vegetation Community 1, dominated by native *Juncus balticus*. A vegetated mudflat along the foreshore (Community 2) accounts for 29% of the site, and is dominated by exotic *Pericaria hydropiper* and native *Crassula aquatic*. Bare ground is the biggest hindrance to marsh success. Vegetation in both communities is not well established, which may be the result of site age (< 10 years), backshore deposition of river sands, and foreshore erosion. Western backshore of site has less sand deposition, and establishment of native species is significantly higher in this area. Large patches of bare sand occur in eastern backshore, where only weedy exotic species have successfully colonized. Foreshore bare ground may be result of erosive soil loss, evident in exposed textile at top of foreshore riprap slope. Anthropogenic impacts are not significant, however site is used recreationally by local workers, and an abandoned fire pit was discovered along the backshore.

### *Morphological Features*

Marsh is relatively flat with no discernable drainage channels. High sand deposition in eastern half of site, primarily near backshore where unvegetated sand bars occur. Exposure of textile along foreshore edge may indicate soil loss due to erosion. A small vegetated mudflat occurs along foreshore. Vegetated mudflat along western edge is noticeably lower in elevation than backshore marsh (see photos).

### *Impacts & Stressors*

Sand deposition appears to be impeding native plant establishment in eastern area of marsh. Some minor erosion along foreshore edge is eroding substrate. Anthropogenic impacts are not significant, however site is used recreationally by local workers and an abandoned fire pit was discovered along the backshore. Invasive species are present but not abundant.

### *Wildlife Sightings/Evidence*

Some minor evidence of waterfowl grazing.

### *Adjacent Land Use*

Railway and paved lot immediately upslope of site, extending into barge terminal along shoreline to west. Warehouses to north and west. Intact marsh shoreline to northeast. Marsh located on northern bank of main arm of Fraser River, heavily used by shipping and recreational boaters.

Threatened Plant Species (Provincial/Federal)

None.

Invasive Species

Three invasive species were sampled in target habitat: *Rubus armeniacus*, *Phalaris arundinacea*, and *Lythrum salicaria*, totaling a mean % cover of 1.2 +/- 1.9. *Iris pseudacorus* and *Cirsium arvense* were also observed in marsh.

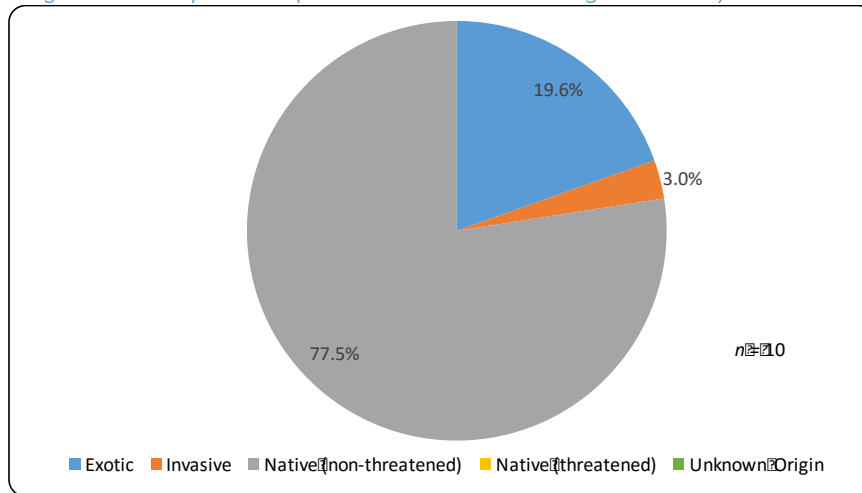
Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	649.0	71.1	68.3 +/- 14.7	None	1.92	10	Mid to high marsh (target habitat)
2	264.0	28.9	61.6 +/- 15.1	None	1.15	7	Vegetated mudflat

Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	Baltic rush	<i>Juncus balticus</i>	N	2	23.0	16.2	10	76.8
2	marshpepper smartweed	<i>Persicaria hydropiper</i>	E	1	12.0	14.4	7	41.4
2	pigmyweed	<i>Crassula aquatica</i>	N	1	4.4	3.7	7	18.3

Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established(% of area goal)</b>	100.0	103.8	Good	The target habitat comprises 104% of the original habitat compensation goal at 649 sqm. Field measurements indicated that marsh was created significantly larger than what was mandated (913 sqm), so marsh still met compensation goal, despite the presence of a vegetated mudflat.
<b>2. Proportion/Relative % Cover Native Species</b>	59.2	77.5	Good	The total vegetation cover for the target habitat was 32%, which can be attributed to poor establishment by native species, likely due to river sand deposition. Relative % cover of native species was significantly higher than combined average of nearby reference sites REF-11-001 and REF-12-001.

### Recommendations

<b>Mitigation</b>			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Bare Ground	5	Plant areas of sand deposition with appropriate native species OR alter deposition regime of site.	Sand bar may be replanted with native species better-adapted for sandy substrate. Deposition regime may be altered by changing velocity of current in east boundary of marsh (e.g. installation of log boom structure, raising of riprap etc.).
Erosion/Aggradation	1	Install erosion protection structure (e.g. log boom) and/or re-plant foreshore edge.	In addition to mitigating sand deposition, a log boom may reduce substrate erosion along the foreshore edge. Present foreshore is not severely degraded, but log boom may be considered a proactive measure to ensure site success long-term. Some native species (e.g. Baltic rush) may also be capable of mitigating foreshore erosion.
<b>Monitoring</b>			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Mudflat and sandbar expansion	5	Monitor size of vegetated mudflat and sand deposition zone to identify erosion and aggradation dynamics of site.	Vegetated mudflat may expand due to erosive soil loss. Monitor size long term (e.g. photo monitoring, detailed mapping) to identify dynamics of this community. Simultaneously, aggradation of river sands may lead to expansion of sand deposition zone. Monitor similarly, perhaps also measuring sand depth. Monitoring may be a precursor to mitigation actions.





## Site# 13-001

### CPR# 8611-0076

---

#### Background

Creation of a 4 x 48 m marsh in compensation for 3150 sqm of marsh lost due to infilling and riprap at the end of Fifth Street Basin. Bench was created along foreshore by pulling back old bank and installing a rock riprap basin lined with textile. Marsh built in 1987 and planted in 1988. Site was planted with transplant propagules acquired from a tidal marsh on northern foreshore of nearby Poplar Island. Planting propagules consisted of *Carex rostrata* (232), *Carex lyngbyei* (38), *Scirpus cyperinus* (53), *Scirpus microcarpus* (113), *Juncus articulatus* (42), *Iris pseudacorus* (26), and *Typha latifolia* (34). Monitoring of transplant establishment was not well-documented, but post-construction monitoring from early 1990s revealed encroachment of woody species (*Alnus rubra*, *Salix* sp.) was occurring, indicating high marsh elevation. Habitat compensation goal = 192 sqm marsh habitat.

#### Description

The site is a narrow, linear marsh bench 208 sqm in size (approximately 4 x 50 m). The site is backed by a ~2 m high gabion wall, which is vegetated almost exclusively by invasive *Rubus armeniacus* and invasive *Buddleja davidii*. The marsh protrudes into the Fraser from the surrounding shoreline, and the entire bench foreshore is armoured by a riprap slope. Similar to past observations (see Site Background), present plant communities indicate that marsh is high enough to support tree and shrub species. Several woody species have now colonized the site, at a density of approximately one woody plant for every 2-3 m of marsh length. Colonized tree and shrub species include native *Salix lucida*, *Alnus rubra*, *Physocarpus capitatus*, *Salix* sp., invasive *Rubus armeniacus*, and exotic *Rosa multiflora*. No erosion protection structures are in place, but high elevation appears to limit erosion potential in marsh.

86% of the site is comprised of typical mid to high marsh vegetation (community 1), dominated by native *Juncus balticus*, native *Carex lyngbyei* and invasive *Phalaris arundinacea*. The remaining 14% can be attributed to an unvegetated log debris accumulation zone along the backshore (see Images 13-001 (1-2)). Site is functioning well, however high marsh elevation will continue to encourage encroachment of woody riparian species, and marsh habitat is likely to diminish over time. Infestation of *R. armeniacus* and *B. davidii* along upslope gabion wall threatens to advance into marsh long-term. Invasive species account for 14.8% of marsh vegetation and are locally displacing marsh species, particularly along the elevated foreshore.

#### Morphological Features

Marsh is relatively flat, with a slight berm along the foreshore edge that appears to trap water and wood debris along the backshore as tides recede. Most woody species occur along raised foreshore. A few wetted pools of standing water occur along backshore.

#### Impacts & Stressors

Log debris is smothering vegetation in 14% of site area (28.2 sqm). Invasive species account for 14.7% of marsh vegetation cover and are displacing marsh species, particularly along the elevated foreshore.

#### Wildlife Sightings/Evidence

A pile of freshly-chewed willow branches indicate American Beaver activity. Some evidence of beaver damage on *Salix* trees in site, but no distinct beaver run identified. Mallards were observed grazing along foreshore edge at high tide.

### Adjacent Land Use

Waterfront Esplanade park and walking trail located 2-3 m upslope of site on top of dike (N). Several condo developments (N). Marsh located along northern bank of heavily-used region of Fraser River (confluence of Annacis Channel, North Arm and South Arm).

### Threatened Plant Species (Provincial/Federal)

One threatened species was incidentally observed but was not sampled: *Juncus oxymers* (blue-listed).

### Invasive Species

Four invasive species were sampled in target habitat: *Rubus armeniacus*, *Lythrum salicaria*, *Phalaris arundinacea* and *Iris pseudacorus*, totaling a mean % cover of 19.6 +/- 14.3.

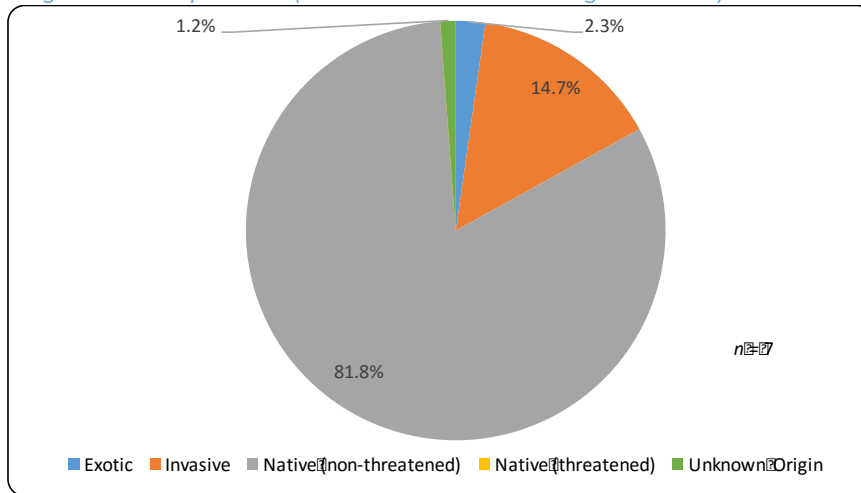
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	179.8	86.4	1.9 +/- 1.9	2.1 +/- 2.9	1.75	7	Mid to high marsh (target habitat)
2	28.2	13.6	None	100.0	n/a	n/a	Accumulation zone of log debris

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	Baltic rush	<i>Juncus balticus</i>	N	2	48.6	28.6	7	44.1
1	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	13.4	13.0	7	14.6
1	reed canarygrass	<i>Phalaris arundinacea</i>	I	2	11.0	6.2	7	12.0

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
1. Proportion of Target Habitat Established(% of area goal)	100.0	93.7	Good	The target habitat comprises 94% of the original habitat compensation goal at 180 sqm. Over time, target habitat may resemble low riparian habitat due to successional encroachment of woody species.
2. Proportion/Relative % Cover Native Species	72.8	81.8	Good	The total vegetation cover for the target habitat was 96% and the proportion of native species was 80%. Relative % cover native species was higher than combined average of nearby reference sites REF-11-001 and REF-02-001.

### Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Log Debris	3	Remove log debris and replant with appropriate native species.	Log debris accumulation zone accounts for 14% of site area. Increase marsh productivity through removal of woody debris and planting of appropriate marsh species.
Invasive Species	3	Remove patches of invasive and exotic species in and around site.	Remove patches of <i>Rubus armeniacus</i> , <i>Iris pseudacorus</i> , and <i>Lythrum salicaria</i> from marsh before they can fully establish. Large patches of invasive <i>R. armeniacus</i> and invasive <i>Buddleja davidii</i> threaten to advance from upslope gabion wall to marsh. Gabion wall should be treated and replanted to ensure marsh integrity long-term. Exotic <i>Rosa multiflora</i> should be removed from marsh, as they are known to rapidly propagate in our region.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Woody Vegetation Encroachment	4	Monitor succession of woody vegetation in marsh over time.	Marsh elevation appears to be too high to limit encroachment of woody vegetation. Monitor site, (e.g. # of woody plants present, woody plant vigor) to determine whether site is transitioning from marsh to low riparian habitat. Depending on results and project goals, mitigation of woody species encroachment may be considered.





## Site# 13-005 CPR# 9506-049

---

### Background

Marsh bench built in compensation for shoreline protection and development works. A riprap berm was placed at the mouth of an existing subtidal embayment to create an intertidal marsh bench. Intertidal marsh planting conducted in Spring 1997 with donor stock from adjacent marsh. Habitat compensation goal = 1530 sqm marsh, 7136 riparian habitat.

### Description

The site is a 1571 sqm marsh constructed within a semi-circular dike embayment. Marsh is entirely backed by a riprap dike, with riparian plantings above (see riparian file). Marsh foreshore has been armoured by a riprap berm. A ~3 m high pedestrian bridge crosses over the marsh (see photos). The underside of the bridge has lattice extending to the ground, creating a partial barrier to debris and water flow. Marsh behind bridge is significantly more saturated, with several areas of standing water and saturated mud. Site is protected from significant wave erosion by extensive log booms in adjacent Annacis Channel.

100% of the site is comprised of typical mid to high marsh vegetation (Community 1), dominated by native *Carex lyngbyei*, native *Carex obnupta*, and exotic *Myosotis scorpioides*. No significant stressors are present within the marsh. Invasive and exotic species currently account for 24% of site vegetation, and may be displacing native species in localized areas. *Carex* spp. and *Juncus* spp. appeared to be moderately grazed along foreshore.

### Morphological Features

Lattice beneath bridge likely limits flushing and drainage of backshore marsh. Result is that marsh behind bridge is significantly wetter than foreshore, with several permanent pools of standing water and areas of saturated mud. No significant erosion along foreshore edge.

### Impacts & Stressors

No significant stressors observed. Invasive and exotic species account for 23.7% of marsh vegetation and are likely displacing native species in localized areas. *Carex* spp. and *Juncus* spp. appeared to be moderately grazed long foreshore.

### Wildlife Sightings/Evidence

Some evidence of waterfowl graze near foreshore.

### Adjacent Land Use

New residential development (N,W). Mature riparian forest (SW). Public walking trail along dike. Extensive log boom storage in adjacent Annacis Channel.

### Threatened Plant Species (Provincial/Federal)

One threatened species was sampled in target habitat: *Juncus oxymers*, (blue-listed), totaling a mean % cover of 2.5 +/- 2.2.

### Invasive Species

Three invasive species were sampled in target habitat: *Lythrum salicaria*, *Phalaris arundinacea*, and *Iris pseudacorus*, totaling a mean % cover of 12.9 +/- 8.0.



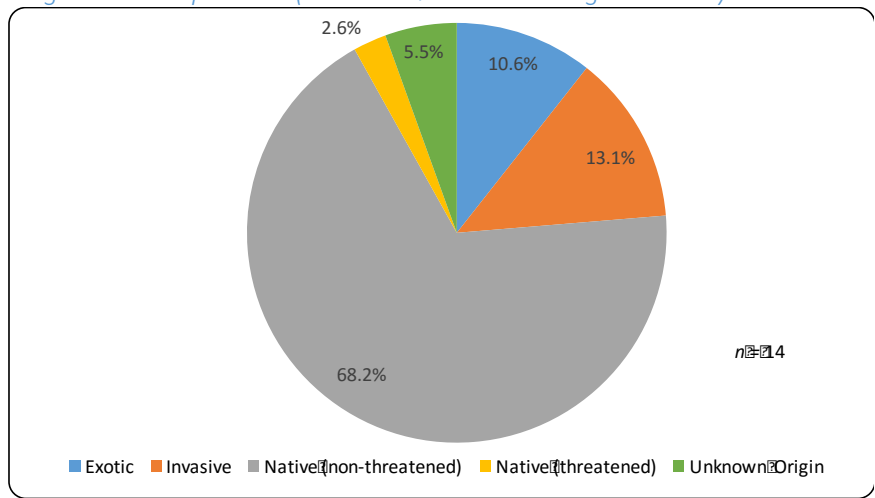
Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	1570.4	100	14.4 +/- 8.0	None	1.32	14	Mid to high marsh (target habitat)

Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	Lyngbye's sedge	<i>Carex lyngbyei</i>	N	1	24.4	16.7	14	26.1
1	slough sedge	<i>Carex obnupta</i>	N	1	17.4	12.7	14	18.6
1	European forget-me-not	<i>Myosotis scorpioides</i>	E	2	8.9	5.6	14	15.0

Origin Class Proportions (Based on % Cover in Target Habitat)



Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
1. Proportion of Target Habitat Established(% of area goal)	100.0	102.6	Good	The target habitat comprises 103% of the original habitat compensation goal at 1570 sqm. Some minor expansion may be occurring along marsh foreshore.
2. Proportion/Relative % Cover Native Species	59.2	70.8	Good	Relative % cover of native species was higher than combined average of nearby reference marshes REF-11-001 and REF-12-001. Site has diverse, well-established marsh community.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	3	Control patches of invasive <i>Iris pseudacorus</i> , <i>Lythrum salicaria</i> and <i>Phalaris arundinacea</i> , as well as exotic <i>Myosotis scorpioides</i> .	Invasive species should be treated while still unestablished. <i>Phalaris arundinacea</i> is still sparse enough that manual removal may be possible. Dense patches of exotic European forget-me-not may be removed and replanted with appropriate marsh species.
Bare Ground	1	Plant bare ground with appropriate native species.	Species better-suited to wet conditions may be planted behind bridge to encourage further colonization of backshore marsh, and increase resistance to invasive plant encroachment. Grazed foreshore may be planted with plants less-preferred by grazing waterfowl (e.g. Baltic rush) to supplement existing vegetation.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Waterfowl Grazing	1	Monitor changes in grazing impacts over time.	Grazing impacts may vary from year to year. Use photo monitoring/height measurements to record changes in grazing impacts over time. Mitigate if necessary.



## Site# 13-010

### CPR# 9805F035

---

#### Background

Creation of bench for planting of riparian and intertidal marsh vegetation. Constructed in compensation for riparian habitat and intertidal marsh habitat disturbed as a result of upgrade works to Front Street. Site completed in 1998. Alleged total marsh gain = 175 sqm marsh, 210 sqm riparian habitat.

#### Description

The site is a linear marsh bench 197 sqm in size (approximately 8 x 25 m). The marsh protrudes from the surrounding shoreline, and the foreshore is unarmoured. Site is backed by a vegetated riprap dike, which was created as part of this project (see riparian file). Marsh gradually slopes from backshore dike to subtidal. Substrate of the entire marsh is coarse rock, with little to no fine sediment near the substrate surface. Foreshore is protected by several barges that are moored in adjacent river.

100% of the site is comprised of poorly-established mid to high marsh vegetation (Community 1), dominated by native *Juncus articulatus*, exotic *Agrostis capillaris*, native *Hypericum scouleri* ssp. *scouleri*, and exotic *Trifolium repens*. Native vegetation has yet to establish in site, only accounting for 17.6 +/- 6.0 of total marsh area, while several weedy exotic species (19 in total) have colonized the unoccupied habitat, accounting for 24.6 +/- 10.3% of total marsh area. Remaining 57% of marsh area can be attributed to log debris, unvegetated bare ground and exposed rock. Reason for lack of native vegetation is uncertain, but may be the result of inadequate planting, poor soil substrate, excessive grazing, or loss of substrate and vegetation due to erosion.

#### Morphological Features

Marsh substrate is primarily coarse rock with finer sediment beneath. Bench gradually slopes from backshore dike to subtidal. Lack of fine sediments at surface of substrate may be result of erosion. No drainage channels present. An unvegetated mudflat is exposed below bench foreshore at low tide.

#### Impacts & Stressors

Site is predominantly unvegetated. Difficult to discern stressor responsible, may be result of inadequate native species planting, poor soil substrate, excessive grazing, or loss of soil and vegetation due to erosion. Invasive and exotic species account for ~60% of marsh vegetation, but are not responsible for failure in native plant establishment.

#### Wildlife Sightings/Evidence

Great Blue Heron (blue-listed, SARA-listed) tracks in mud.

#### Adjacent Land Use

Railway and Front Street (W). Several barges moored in river along site (SE). Marsh located on north bank of Fraser River, heavily used for shipping and recreation.

#### Threatened Plant Species (Provincial/Federal)

None.

#### Invasive Species

Six invasive species were sampled in target habitat: *Hypericum perforatum*, *Convolvulus arvensis*, *Lythrum salicaria*, *Phalaris arundinacea*, *Clematis vitalba*, and *Iris pseudacorus*, totaling a mean % cover of 1.9 +/- 1.5. *Rubus laciniatus* was observed incidentally in the marsh, but was not sampled.

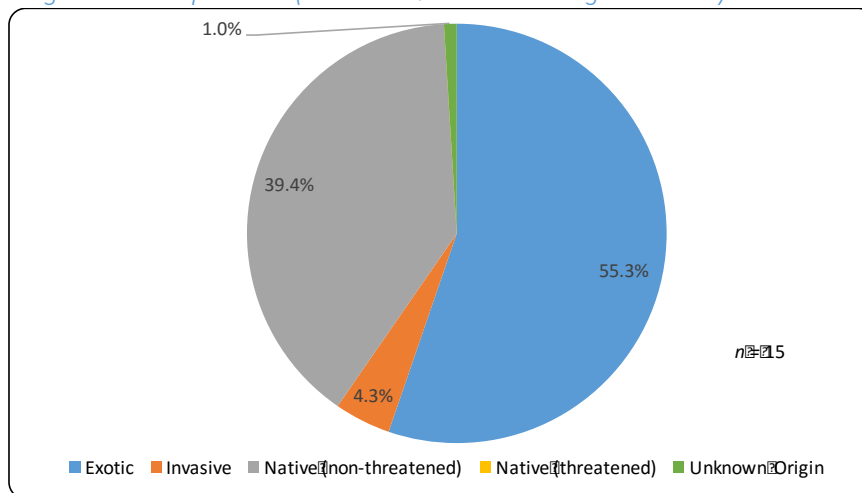
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	196.0	100	52.9 +/- 12.9*	2.8 +/- 3.7	2.36	14	Mid to high marsh (target habitat). *Note: rock and bare ground were combined for 'Unvegetated Ground' field, as bare rock was primary substrate.

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	jointed rush	<i>Juncus articulatus</i>	N	1	5.9	2.7	15	23.5
1	colonial bentgrass	<i>Agrostis capillaris</i>	E	3	5.4	2.7	15	15.9
1	western St. John's-wort	<i>Hypericum scouleri</i> ssp. <i>scouleri</i>	N	2	3.4	1.2	15	12.7
1	white clover	<i>Trifolium repens</i>	E	3	5.6	6.1	15	11.9

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established (% of area goal)</b>	100.0	112.0	Good	The target habitat comprises 112% of the original habitat compensation goal at 196.60 sqm. Excess 12% was the likely result of uncertain boundary delineation at time of survey.
<b>2. Proportion/Relative % Cover Native Species</b>	59.2	39.4	Fair	Relative % cover of native species was below combined average of nearby reference sites REF-11-001 and REF-12-001. More importantly, the total vegetation cover for the target habitat was only 44% (including exotic and invasive species). Low vegetative cover and low % cover of native species greatly limits value of created habitat.



Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Bare Ground	5	Plant bare ground with appropriate native species.	Site is only 44% vegetated, and 39% of vegetation is native. Aggressively plant unvegetated substrate with native species to reduce risk of invasive plant encroachment, increase marsh productivity, and increase habitat value.
Invasive Species	1	Remove patches of existing invasive species.	Invasive species are not well-established, only comprising 4.3% of all marsh vegetation. Eradicate all invasive species before they can establish. All species may be removed manually.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Bare Ground/Vegetation	3	Monitor establishment of vegetation in marsh, identifying potential stressors and forming mitigation solutions.	Cause of vegetation failure unknown. Even if bare ground is planted (see Mitigation section), site should be monitored to ensure that vegetation is establishing. Monitor whether barges are frequently moored in front of marsh, or whether marsh is frequently exposed to river erosion. Investigate benefits of a higher foreshore berm.



## Site# 13-012-A CPR# 9606F058

---

### Background

Site constructed in compensation for riparian, intertidal marsh, and intertidal mudflat habitat disturbed during construction of Skytrain Millennium Line along the Fraser River. Intertidal marsh channel and benches were created and surrounding upslope habitat was planted with riparian vegetation. Habitat was constructed in 2000 and planted in 2001. Habitat compensation goal = 1781 sqm marsh, 5260 sqm riparian habitat.

### Description

The site is a 739 sqm chain of 4 embayed marshes, placed within the indentations of a crenulate riprap foreshore. The site is backed by a riprap dike, with native and ornamental plantings and public walking trails above. Marsh foreshore is armoured with small-grade riprap. Marshes are separated by 3 lookout structures, which project from public walking trail to river edge. No log booms or erosion protection in place.

100% of site is comprised of poorly-established mid to high marsh vegetation (Community 1), dominated by native *Juncus articulatus* and exotic *Schedonorus arundinacea*. Native vegetation has yet to fully establish in site, only accounting for 28.2 +/- 10.5% of total marsh area, while several weedy exotic species have colonized the unoccupied habitat, accounting for 23.0 +/- 12.0% of total marsh area. Reason for lack of native vegetation is uncertain, but may be the result of inadequate planting, marsh elevation, waterfowl grazing, or wave erosion.

### Morphological Features

Marsh is relatively flat, gradually sloping from backshore dike to foreshore edge. Small-grade riprap substrate is exposed throughout marsh, indicating moderate erosion of top soil. Textile is exposed along foreshore edge, likely also due to erosion. Small localized sand bars are forming along backshore.

### Impacts & Stressors

Minor grazing of *Carex* spp.. Evidence of erosion along foreshore (exposed textile) and within target habitat (exposed riprap substrate, low vegetative cover). Invasive and exotic plants total >50% of vegetation, but are not responsible for failure in native plant establishment.

### Wildlife Sightings/Evidence

Great Blue Heron (blue-listed, SARA-listed) observed in marsh.

### Adjacent Land Use

Built adjacent to Sapperton Landing Regional Park (N,W). Public walking trail and viewing platforms on top of dike (N,W). Marsh located on NW bank of heavily-used region of Fraser River.

### Threatened Plant Species (Provincial/Federal)

One threatened species was sampled in target habitat: *Eleocharis parvula* (blue-listed), totaling a mean % cover of 0.1 +/- 0.1.

### Invasive Species

Three invasive species were sampled in target habitat: *Lythrum salicaria*, *Phalaris arundinacea*, and *Iris pseudacorus*, totaling a mean % cover of 6.5 +/- 6.0.



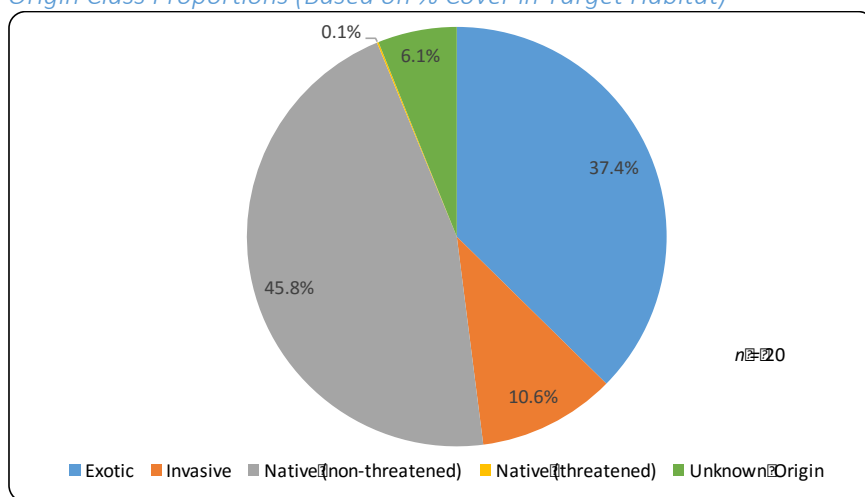
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI(95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	739.0	100	37.1 +/- 11.4*	6.4 +/- 4.7	1.63	20	Mid to high marsh (target habitat). *Note: rock and bare ground were combined for '% Unvegetated Ground' field, as bare rock was primary substrate.

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	jointed rush	<i>Juncus articulatus</i>	N	1	16.3	5.8	20	40.0
1	tall fescue	<i>Schedonorus arundinacea</i>	E	3	6.9	3.5	20	12.0

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established(% of area goal)</b>	100.0	140.5*	Good	Combined target habitats of 13-013-A and 13-012-B comprise 141% of the original habitat compensation goal at 2503 sqm. Reason for ~700 sqm surplus of marsh is uncertain, but likely due to boundary uncertainty, not marsh expansion.
<b>2. Proportion/Relative % Cover Native Species</b>	59.2	45.9	Fair	Relative % cover of native species was lower than combined average of nearby reference marshes REF-11-001 and REF-12-001. Despite acceptable proportion of native species, overall marsh vegetation is poorly established, with a total % cover of ~60%. Low vegetative cover and low % cover of native species greatly limits value of created habitat.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Bare Ground	4	Plant bare ground with appropriate native species.	Site is only 60% vegetated, and vegetation is only 46% native. Aggressively plant unvegetated substrate with native species to reduce risk of invasive plant encroachment, increase marsh productivity, and increase habitat value.
Invasive Species	1	Remove patches of existing invasive species.	Invasive species are not well-established, only comprising 11% of all marsh vegetation. Eradicate all invasive species before they can establish. All species may be removed manually.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Bare Ground/Vegetation	3	Monitor establishment of vegetation in marsh, identifying potential stressors and forming mitigation solutions.	Cause of extensive bare ground unknown. Even if bare ground is planted (see Mitigation section), site should be monitored to ensure that vegetation is establishing. Investigate benefits of a higher foreshore berm and/or log boom structure if erosion appears to be limiting agent.



## Site# 13-012-B CPR# 9606F058

---

### Background

Site constructed in compensation for riparian, intertidal marsh, and intertidal mudflat habitat disturbed during construction of Skytrain Millennium Line along the Fraser River. Intertidal marsh channel and benches were created and surrounding upslope habitat was planted with riparian vegetation. Habitat was constructed in 2000 and planted in 2001. Habitat compensation goal = 1781 sqm marsh, 5260 sqm riparian habitat.

### Description

The site is a crescent-shaped 1765 sqm marsh channel, which connects to the Fraser through northern and southern entrances. The marsh is surrounded by a riprap slope on every side, with young riparian vegetation above. Surrounding riparian habitat was part of the riparian component of the project (see riparian file). A public trail surrounds the site, and a pedestrian bridge crosses over both north and south entrances. Both bridges have lattice debris barriers extending from ground height to walkway (~3 m). Lattice excludes large woody debris and garbage, and likely reduces drainage and flushing of marsh. Marsh channel is relatively narrow for much of its length (<7 m). As a result, much of the channel is shaded by maturing riparian trees and shrubs. Southern boundary is delineated by a riprap berm, located just west of southern bridge. Northern boundary is delineated by a riprap berm located just east of bridge along the Fraser foreshore.

100% of the site is comprised of typical mid to high marsh vegetation (Community 1), dominated by invasive *Phalaris arundinacea*, exotic *Myosotis scorpioides*, and exotic *Agrostis capillaris*. The channel contains several areas of bare ground, which may be attributed to poor drainage, shading of encroaching riparian vegetation, or mobile log debris. A ~50 sqm wood debris accumulation zone was observed in the southern end of the site. Debris is lifted and relocated at high tide, but marsh vegetation is clearly impacted by periodic grounding of this debris. Several stands of vigorous *Carex obnupta* are present, however invasive and exotic plants account for ~61% of vegetation and are likely displacing native communities throughout the marsh.

### Morphological Features

Crescent-shaped marsh channel, connected to main arm of Fraser via north and south entrances. Several areas of bare ground throughout marsh channel, likely due to poor drainage, long inundation, shading, or wood debris grounding. A single American Beaver channel traverses through marsh from north to south entrance. Bridge lattice at both entrances likely reduces marsh flushing and drainage.

### Impacts & Stressors

Shading by riparian vegetation is reducing vegetative cover of some areas. Invasive and exotic species account for ~61% of vegetation, and are displacing native communities throughout the marsh. Exotic *Myosotis scorpioides* and *Agrostis capillaris* are acting aggressively at this site (>15% cover in >10% of plots (Oregon Department of State Lands, 2009)<sup>1</sup>.

<sup>1</sup>Oregon Department of State Lands. (2009). Routine Monitoring Guidance for Vegetation. Retrieved from [http://www.oregon.gov/dsl/PERMITS/docs/dsl\\_routine\\_monitoring\\_guidance.pdf](http://www.oregon.gov/dsl/PERMITS/docs/dsl_routine_monitoring_guidance.pdf)

### Wildlife Sightings/Evidence

American Beaver channel traverses through marsh from south to north entrance.

### Adjacent Land Use

Built within Sapperton Landing Regional Park. Public walking trail and bridges surround site. Site connected to heavily-used region of Fraser River.

*Threatened Plant Species (Provincial/Federal)*

One threatened plant species was sampled in target habitat: *Juncus oxymeris* (blue-listed), totaling a mean % cover of 1.0 +/- 1.8.

*Invasive Species*

Four invasive species were sampled in target habitat: *Rubus armeniacus*, *Lythrum salicaria*, *Phalaris arundinacea*, and *Iris pseudacorus*, totaling a mean % cover of 21.8 +/- 9.1. *Phalaris arundinacea* was most abundant, with a mean % cover of 13.7 +/- 6.7.

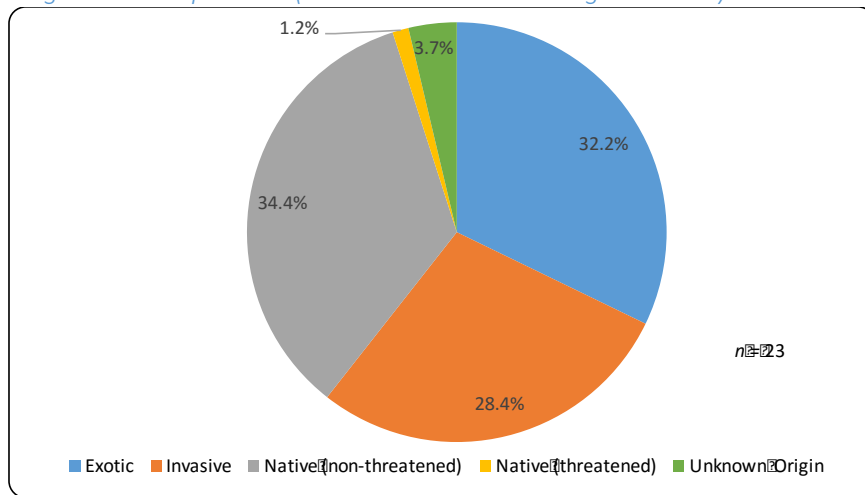
*Community Descriptions*

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	1764.7	100	21.4+/- 10.5	None	2.0	23	Mid to high marsh (target habitat)

*Dominant Species*

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	reed canarygrass	<i>Phalaris arundinacea</i>	I	2	13.7	6.7	23	34.8
1	European forget-me-not	<i>Myosotis scorpioides</i>	E	2	14.3	11.5	23	23.7
1	colonial bentgrass	<i>Agrostis capillaris</i>	E	3	7.7	6.8	23	12.8

*Origin Class Proportions (Based on % Cover in Target Habitat)*



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established(% of area goal)</b>	100.0	100.0*	Good	Combined target habitats of 13-013-A and 13-012-B comprise >100% of the original habitat compensation goal at 2503 sqm. Reason for ~700 sqm surplus of marsh is uncertain, but likely due to boundary uncertainty, not marsh expansion.
<b>2. Proportion/Relative % Cover Native Species</b>	59.2	35.7	Poor	Relative % cover of native species was significantly lower than combined average of nearby reference habitats REF-11-001 and REF-12-001, mostly due to dominance of non-native <i>Phalaris arundinacea</i> , <i>Myosotis scorpioides</i> and <i>Agrostis capillaris</i> .

### Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Bare Ground	4	Plant bare ground with appropriate native species.	Site is 21% unvegetated. Aggressively plant unvegetated areas with appropriate species (e.g. slough sedge) to reduce risk of invasive and exotic species encroachment and increase site productivity.
Invasive Species	3	Remove patches of poorly-established invasive species. Mitigate impacts of reed canarygrass.	Priority should be given to eradicate invasive species that are poorly established ( <i>Lythrum salicaria</i> , <i>Iris pseudacorus</i> , <i>Rubus armeniacus</i> ). <i>Phalaris arundinacea</i> should be mitigated through aggressive planting of native marsh species (e.g. slough sedge), and removal of poorly-established patches.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Wood Debris	2	Monitor accumulation of small wood debris at south end of site.	A ~50 sqm small wood debris accumulation zone is located at south end of site. Monitor long-term to ensure it is not increasing. Remove wood if it begins to significantly impact marsh.





## Site# 14-004

### CPR# 8702-0015

---

#### Background

A 50 x 20 m marsh bench with riprap foreshore, built in compensation for loss of mudflat (2500 sqm) habitat due to inshore installation of four dry dock sections. Mudflat was also affected by dredging, rail bed, and other construction activities. Marsh built in 1986 and planted in 1992. Habitat compensation goal = 1000 sqm marsh habitat.

#### Description

The site is a 1098 sqm rectangular marsh bench (approximately 20 x 50 m), backed by a riprap dike with mature riparian vegetation above. The marsh protrudes from the surrounding shoreline, exposing 3 sides to the Fraser River, all of which are armoured by a steep riprap berm. A small wetted depression runs along the backshore of the site, parallel to the backshore riprap dike. An evaluation of historic photos indicates that the majority of the marsh has gained elevation due to sediment aggradation. As a result, the hydrology of most of the marsh is too high to limit expansion of *Phalaris arundinacea* and encroaching woody riparian species (*Salix* spp., *Cornus stolonifera*, *Rubus armeniacus*). Aggradation has not occurred in the northeast corner of the site, where river erosion appears to limit sediment deposition and vegetation establishment. A similar, smaller vegetated mudflat is located along the western boundary of the marsh. In both areas, the vegetated mudflat is delineated from the aggraded marsh by steep cut banks 0.2 to 1 m in height. A log boom structure borders the entire foreshore. Easternmost log does not fully protect NE foreshore due to faulty design or damage, and appears to frequently ground within marsh at low tide (see photos).

89% of the site is comprised of typical mid to high marsh vegetation (Community 1), dominated by invasive *Phalaris arundinacea*. Patchy vegetated mudflats account for the remaining 11% of site area, sparsely vegetated by exotic *Callitriche stagnalis*, native *Equisetum fluviatile*, native *Crassula aquatica* and seedling native *Carex obnupta*. Invasive plants are greatly impacting marsh biodiversity, currently comprising 82% of marsh vegetation in target habitat. Several unique native plant species are present (e.g. *Juncus oxymeris*, *Carex utriculata*) but are not in high abundance due to displacement. Elevation of target habitat has raised due to aggradation, and marsh will likely continue to be colonized by *P. arundinacea* and riparian shrubs unless mitigated.

#### Morphological Features

A wetted depression runs parallel to backshore dike, supporting noticeably more hydrophytes (i.e. *Typha latifolia*). Vegetated mudflats occur in NE and W boundaries of marsh, and appear to be at original elevation of project. Remaining marsh has lifted in elevation due to sediment aggradation. Aggraded areas can be clearly delineated from vegetated mudflats by presence of cut banks, from 0.2 to 1 m in height.

#### Impacts & Stressors

Northeast foreshore appears to be eroded by wave and current erosion due to improper placement of east log boom. Invasive species account for 82% of marsh vegetation, and are clearly displacing native plant species.

#### Wildlife Sightings/Evidence

Great Blue Heron (blue-listed, SARA-listed) observed in and around site. A mid-sized mammal, likely a Mustelid, was seen running through backshore marsh vegetation. Patches of backshore vegetation grazed and flattened, likely by a mammal species.

#### Adjacent Land Use

Sand and gravel depot (SE). Mill and lumber yard (S, SW). Site located along southern bank of heavily-used region of Fraser.

### Threatened Plant Species (Provincial/Federal)

One threatened plant species was incidentally observed but not sampled: *Juncus oxymeris* (blue-listed).

### Invasive Species

Two invasive species were sampled in target habitat: *Phalaris arundinacea*, and *Iris pseudacorus*, totaling a mean % cover of 44.5 +/- 11.7. *Lythrum salicaria* and *Rubus armeniacus* were incidentally observed in the marsh, but were not sampled.

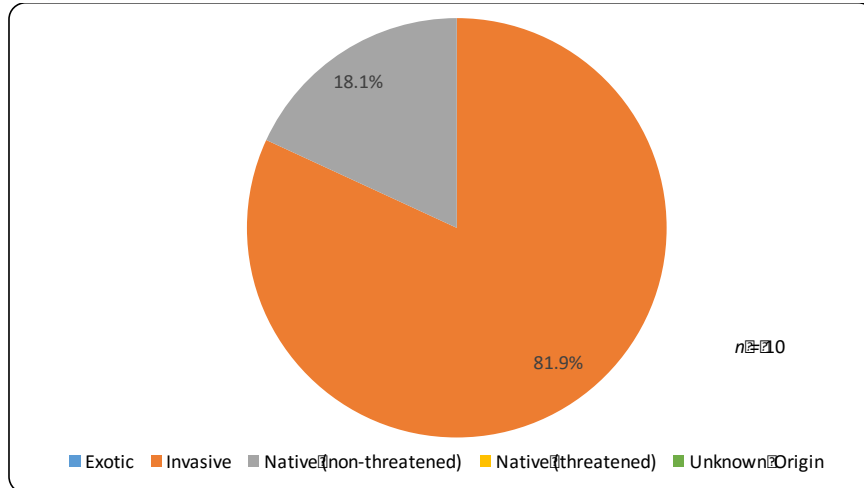
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	981.0	89.4	52.1 +/- 14.2	2.5 +/- 4.9	1.91	10	Mid to high marsh (target habitat)
2	116.8	10.6	98.2 +/- 1.2	None	1.00	3	Vegetated mudflat

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	reed canarygrass	<i>Phalaris arundinacea</i>	I	2	40.0	10.7	10	90.3
2	pond water-starwort	<i>Callitriche stagnalis</i>	E	1	0.3	0.3	3	21.1
2	swamp horsetail	<i>Equisetum fluviatile</i>	N	1	0.3	0.3	3	21.1
2	pigmyweed	<i>Crassula aquatica</i>	N	1	0.3	0.3	3	21.1
2	slough sedge	<i>Carex obnupta</i>	N	1	0.3	0.3	3	21.1

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
1. Proportion of Target Habitat Established(% of area goal)	100.0	98.1	Good	The target habitat comprises 98% of the original habitat compensation goal at 981 sqm.
2. Proportion/Relative % Cover Native Species	59.2	18.1	Poor	Relative % cover of native species was significantly lower than combined average of nearby reference sites REF-11-001 and REF-12-001. Low proportion of native species likely reflects displacement by <i>Phalaris arundinacea</i> and <i>Iris pseudacorus</i> .

### Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	5	Remove patches of <i>Lythrum salicaria</i> and <i>Iris pseudacorus</i> . Mitigate displacement by <i>Phalaris arundinacea</i> .	Eradicate less-established <i>Iris pseudacorus</i> and <i>Lythrum salicaria</i> while treatment is manageable. Both species are sparse enough that manual removal is possible. <i>Phalaris arundinacea</i> is not easily addressed without first addressing high site elevation.
Erosion	4	Adjust current log boom structure along east boundary. Plant eastern foreshore with soil-binding species.	Eastern foreshore appears to be heavily impacted by wave and current erosion. Evaluation of aerial imagery indicates that east log boom has been in need of adjustment for several years, as it does not protect NE corner and grounds in E marsh at low tide. Rest of the log boom appears to be functioning well. Bare ground along eastern and western foreshore may also be planted with erosion-reducing species (e.g. <i>Juncus balticus</i> , <i>Carex obnupta</i> ).
Bare Ground	3	Plant bare ground with appropriate native species.	Some backshore bare ground is natural result of shading from riparian trees to south. Other areas, particularly along foreshore, may be planted with appropriate species to reduce risk of invasive species encroachment and increase marsh productivity (see Erosion).
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Erosion of foreshore	2	Monitor erosion of eastern foreshore to determine changes in vegetated mudflat size.	Use photo monitoring or detailed mapping to identify whether vegetated mudflats along eastern and western foreshores are expanding or diminishing. May be a precursor to erosion mitigation actions.
Aggradation of backshore	3	Monitor changes to target habitat elevation and plant community over time.	Monitor encroachment of woody riparian species, and abundance of non-obligate marsh species (e.g. reed canarygrass) in target habitat. Use detailed elevation mapping to acquire baseline data that may be used to monitor changes in elevation over time.



## Site# 15-001-B

CPR# 9205-0051, 9205-0059

---

### Background

Compensation for habitat disturbed due to dredging of trench and placement of backfill in foreshore marsh. Impacted marsh area was 61 m wide. Much of the vegetation was salvaged from the site and replanted successfully once works were completed. Restoration was achieved by natural recovery, by seeding with *Phalaris arundinacea* and *Carex* spp., planting trees and shrubs, and by using cultured sprigs as needed. Site disturbed in 1992 and planted in 1993. DFO indicated in 1990s that they were satisfied with restoration efforts, however further riparian planting was required. Additional riparian planting was completed 1996/1997. Habitat compensation goal = 80 sqm marsh habitat.

North and South boundaries of compensation site were impossible to delineate, as marsh characteristics resembled that of surrounding habitat. Boundaries were estimated using marine pipeline signage, located ~60 m apart at north and south foreshore. Sampling focused on capturing representative vegetation along marsh gradient of approximate compensation area. Planting of riparian trees and shrubs was mentioned in site record, yet no riparian habitat was included in original habitat compensation goals. Because of this, no riparian sampling was conducted at this site, but backshore riparian community appeared to be well-established with few invasives present.

Site 15-001-A is also included in this project, and is located on the opposite bank of the Pitt River. This site was visited but not sampled because (1) riparian habitat was in use by illegal campers (2), marsh bench was very small, as marsh was located on outer bend of river and (3) description and photos from BIEAP-FREMP database only allowed us to confirm location of 15-001-B. Although not sampled, our field observations indicated that 15-001-A was functioning well.

### Description

The sampled site is a 2486 sqm low-gradient marsh, integrated into natural bench habitat on the east bank of the Pitt River. Characteristics of marsh resemble that of surrounding shoreline, making true compensation site boundaries difficult to accurately delineate. Marsh is backed by a thick riparian forest, much of which was likely planted as part of this project. Foreshore is an unarmoured, low-gradient mudflat. Marsh backshore appears to be poorly drained, evident in monoculture of *Comarum palustre*, and extensive accumulation of log debris. Several small drainage channels flow from backshore to Pitt River. No log booms were present at time of survey, but imagery indicates that log booms protect foreshore periodically.

The site contains 3 distinct vegetation communities, each located at different elevations along marsh gradient. Community 1 (mid to high marsh) is the highest of the communities, represents 74% of the site, and is dominated by invasive *Phalaris arundinacea*, and native *Comarum palustre*. Community 2 (transitional marsh) accounts for 15% of site area, and is dominated by native *Eleocharis palustris* and native *Equisetum fluviatile*. Community 3 (vegetated mudflat) is the lowest of the communities, represents 11% of the site, and is dominated by low-marsh hydrophytes such as exotic *Callitriche stagnalis*, native *Sagittaria cuneata*, *Gratiola ebracteata* and *Limosella aquatica*. Moderate log debris along the backshore is reducing marsh productivity through grounding and smothering of marsh vegetation. Invasive species account for ~42% of target habitat vegetation and are likely displacing several native species.

### Morphological Features

Marsh backshore appears to be poorly drained, evident in monoculture of *Comarum palustre*, and extensive accumulation of log debris. Many logs appear to have been in marsh for several years, as many are now nurse logs to herbaceous and woody vegetation. Several small drainage channels flow from backshore to Pitt River. Community 1 (mid to high marsh) is separated from other downslope communities by a small cut bank, ~0.1 - 0.3 m in height.

### Impacts & Stressors

Log debris has accumulated along the backshore of the marsh, accounting for 14.6 +/- 12.6 % of target habitat area. Invasive plants are not a concern in Communities 2 and 3, but invasive species account for ~42% of target habitat vegetation and are likely displacing several native species.

### Wildlife Sightings/Evidence

Great Blue Heron tracks (blue-listed, SARA-listed) in mudflat. Canada Geese seen on nearby mudflat. Common Merganser (2) in water adjacent to site. Belted Kingfisher perched near site on river piling. Garter Snake observed in target habitat.

### Adjacent Land Use

Mature riparian vegetation (E). Trans Canada trail east of riparian forest. Site located on east bank of Pitt River, frequently used by tugs and recreational boaters.

### Threatened Plant Species (Provincial/Federal)

No threatened plant species were observed in Community 1 (target habitat). Two threatened species were sampled in community 2: *Juncus oxymyris* (blue-listed), and *Eleocharis parvula* (blue-listed), totaling a mean % cover of 4.6 +/- 4.6. *Eleocharis palustris* was also observed in Community 3, totaling a mean % cover of 2.1 +/- 1.6.

### Invasive Species

Three invasive species were observed in target habitat: *Lythrum salicaria*, *Phalaris arundinacea* and *Iris pseudacorus*, totaling a mean % cover of 32.0 +/- 20.6. Dominance of *P. arundinacea* is typical of natural and created mid-elevation marshes in region.

### Community Descriptions

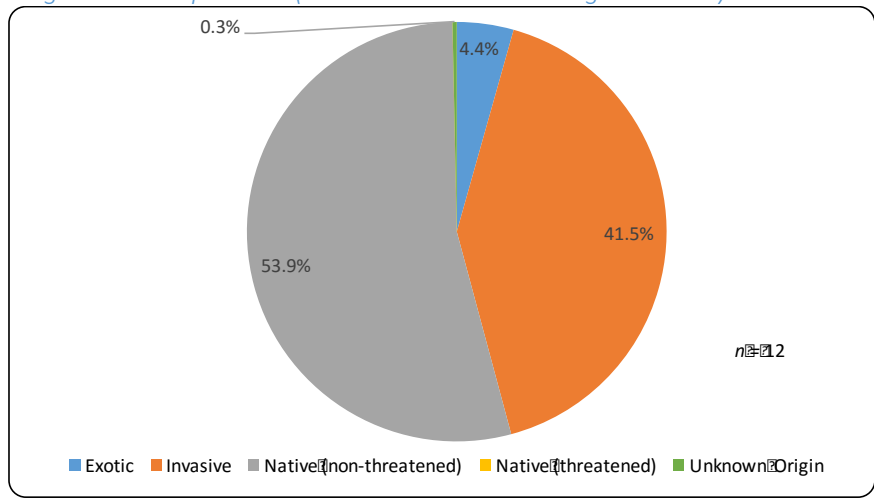
Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	1836.0	73.9	9.8 +/- 6.4	14.6 +/- 12.6	1.66	12	Mid to high marsh (target habitat)
2	369.7	14.9	54.9 +/- 9.5	0	1.05	7	Transitional marsh (between target habitat and vegetated mudflat)
3	280.3	11.3	57.6 +/- 22.8	0	1.01	7	Vegetated mudflat

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	reed canarygrass	<i>Phalaris arundinacea</i>	I	2	29.7	19.5	12	56.8
1	marsh cinquefoil	<i>Comarum palustre</i>	N	1	24.9	22.1	12	23.9
2	common spike-rush	<i>Eleocharis palustris</i>	N	1	27.0	6.9	7	69.1
2	swamp horsetail	<i>Equisetum fluviatile</i>	N	1	5.9	3.7	7	15.2
3	pond water-starwort	<i>Callitriche stagnalis</i>	E	1	9.1	13.4	7	30.7
3	arum-leaved arrowhead	<i>Sagittaria cuneata</i>	N	1	6.9	5.9	7	16.6
3	water mudwort	<i>Limosella aquatica</i>	N	1	5.1	3.1	7	14.8
3	bractless hedge-hyssop	<i>Gratiola ebracteata</i>	N	1	4.6	6.8	7	11.1



Origin Class Proportions (Based on % Cover in Target Habitat)



Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established(% of area goal)</b>	100.0	100.0	Good	The sampled target habitat comprises >100% of original compensation goal at 2486 sqm of 80 sqm compensated. Site was indistinguishable from surrounding marsh foreshore, so sampling effort focused on adequately describing marsh gradient in approximate area of works (thus, the large area). Compensation actions appear to have re-created pre-disturbance habitat adequately, despite the uncertainty of sampling boundaries.
<b>2. Proportion/Relative % Cover Native Species</b>	59.2	53.9	Good	Relative % cover of native species in target habitat is slightly lower than combined average of nearby reference sites REF-11-001 and REF-12-001. Native species are likely being displaced by invasive <i>Phalaris arundinacea</i> . Site record indicates that <i>P. arundinacea</i> was seeded at time of compensation, likely due to lack of information at time regarding species' origin. Vegetation was reduced along the backshore due to extensive log debris accumulation.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	3	Remove patches of <i>Lythrum salicaria</i> and <i>Iris pseudacorus</i> .	Eradicate less-established <i>Iris pseudacorus</i> and <i>Lythrum salicaria</i> while treatment is manageable. Both species are sparse enough that manual removal is possible. <i>Phalaris arundinacea</i> is not easily addressed at this site, as it is prevalent throughout this region of the Pitt River.
Log Debris	2	Remove backshore log debris and replace with native plants.	Backshore log debris currently accounts for ~15% of site area. Remove log debris and replant area with native vegetation to prevent encroachment of invasive species, and increase site productivity.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Log Debris	3	Monitor size of log debris accumulation zone to determine changes over time.	Log debris zone many fluctuate seasonally. Use photo monitoring and/or detailed mapping to monitor whether log debris increases or decreases over time. May be a precursor to mitigation actions.



## Site# 15-003-A

### CPR# 0705F024

---

#### Background

Compensation for habitat lost in creation of new Pitt River Bridge. Construction actions lead to the loss of 579 sqm subtidal, 4302 sqm unvegetated intertidal, and 4925 sqm riparian fish habitat. Overall compensation project aimed to compensate through creation of 2700 sqm subtidal, 3529 sqm unvegetated intertidal, and 7085 sqm riparian fish habitat. Compensation actions were completed in 2010, and site was monitored by Hatfield and Golder till 2015 (see Monitoring descriptions below). Habitat compensation goal (at this site specifically) = 482 sqm marsh habitat.

A 2011 monitoring report by Hatfield indicated that littoral habitat required additional planting. Habitat was then re-planted in 2011. Follow-up monitoring by Hatfield (2012) indicated that site did not conform to original design specifications. Report noted that *Phalaris arundinacea* had established and that native planting survivorship was ~70%. Hatfield recommended planting of 200 *Carex lyngbyei* and 200 *Carex obnupta* in lower intertidal, and 50 *Lonicera involucrata* and 50 *Cornus stolonifera* along backshore. Golder (2013) noted that recommended plantings were completed. Lower intertidal was still unvegetated, but Golder claimed that this resembled areas up and downstream of site. Golder also noted evidence of anthropogenic disturbance (e.g. footprints, dog prints) in area. Survivorship of native vegetation was estimated to exceed 90% and no remedial actions were recommended. In 2014, Golder noted that anthropogenic disturbance was continuing in site, and claimed that survivorship of native *Carex* spp. and *Juncus* spp. was strong. *Phalaris arundinacea* tussocks were observed in low marsh, but Golder claimed that this was consistent with surrounding shoreline.

#### Description

The site is 620 sqm marsh, built in line with surrounding shoreline. Site is bordered by the Pitt River bridge to the southwest, with a shaded and sparsely vegetated riparian bench underneath it (see riparian file). Northeast shoreline consists of mature riparian vegetation, with a healthy marsh community and mudflat along the foreshore. 15-001-A is approximately 40 m northeast. Backshore is bordered by a hill, which was planted as part of the riparian component of the project. Foreshore of marsh is sparsely vegetated slope of exposed cobble and mud substrate.

69% of the site is comprised of typical mid to high marsh vegetation (Community 1), dominated by invasive *Phalaris arundinacea* and exotic grasses. Exotic grasses were likely seeded as part of compensation actions to reduce soil erosion. A vegetated mud/gravel bar accounts for remaining 31% of area, and sparse vegetation is dominated by *P. arundinacea*, native *Juncus articulatus* and exotic *Echinochloa crus-galli*. Log debris accounts for 31.9 +/- 18.4% of target habitat area, and is likely impacting site productivity due to grounding and smothering of vegetation. Anthropogenic impacts (e.g. compaction, garbage) were first noted in 2013 (see Site Background) and continue to threaten marsh health. Invasive species account for 36% of marsh vegetation in target habitat, and *P. arundinacea* is likely limiting establishment of planted native species.

#### Morphological Features

A sloped unvegetated intertidal mud/gravel bar borders the site foreshore (Community 2). Marsh backshore (Community 1), is a typical mid-elevation marsh.

#### Impacts & Stressors

Significant grazing on native *Carex* spp. and *Juncus* spp., most prominent in foreshore Community 2. Soil compaction from dog walkers and fishers, who access site via unsanctioned trail from Poco Trail. Log debris represents about 32% of backshore marsh (Community 1). Invasive and exotic species are dominant in both communities, representing 91% of vegetation in Community 1 and 66% of vegetation in Community 2.

#### Wildlife Sightings/Evidence

Raccoon and Great Blue Heron (blue-listed, SARA-listed) prints in vegetated mudflat.

*Adjacent Land Use*

Belfast Street and highway infrastructure (W). Public Traboulay PoCo Trail along upslope (W/NW). Site is attached to riparian compensation projects under and SW of Pitt River Bridge. Mature riparian forest and marsh shoreline to NE.

*Threatened Plant Species (Provincial/Federal)*

None.

*Invasive Species*

Three invasive species were sampled in target habitat: *Rubus armeniacus*, *Lythrum salicaria*, and *Phalaris arundinacea*, totaling a mean % cover of 23.2 +/- 12.8.

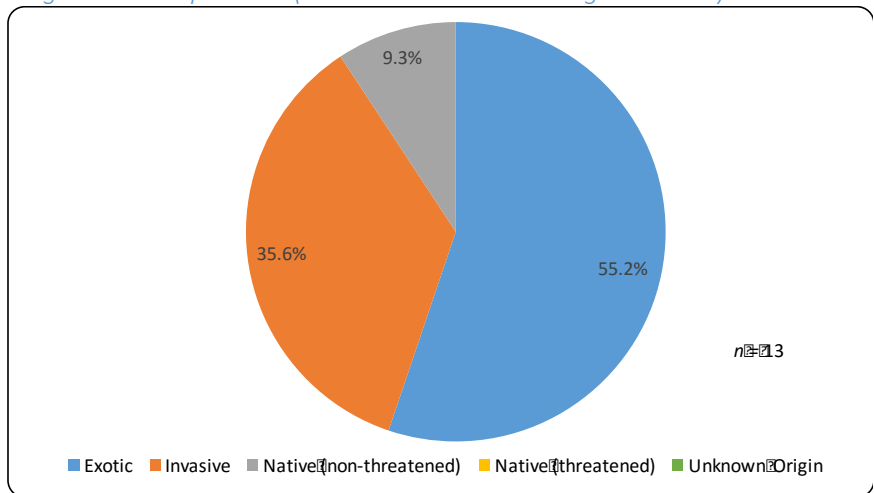
*Community Descriptions*

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	427.8	69.0	3.2 +/- 3.2	31.9 +/- 18.4	2.40	13	Mid to high marsh (target habitat)
2	192.4	31.0	96.8 +/- 5.3	None	1.81	5	Vegetated mudflat

*Dominant Species*

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	reed canarygrass	<i>Phalaris arundinacea</i>	I	2	28.5	17.0	13	40.5
1	exotic turf grasses	n/a	E	n/a	22.2	12.7	13	47.2
2	reed canarygrass	<i>Phalaris arundinacea</i>	I	2	1.0	1.5	5	37.0
2	jointed rush	<i>Juncus articulatus</i>	N	1	0.9	1.5	5	33.3
2	large barnyard-grass	<i>Echinochloa crus-galli</i>	E	3	1.0	2.0	5	18.5

*Origin Class Proportions (Based on % Cover in Target Habitat)*



Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
1. Proportion of Target Habitat Established(% of area goal)	100.0	88.0	Good	The target habitat comprises 88% of the original habitat compensation goal at 427.80 sqm.
2. Proportion/Relative % Cover Native Species	59.2	9.3	Poor	Relative % cover of native species was significantly lower than combined average of nearby reference marshes REF-11-001 and REF-12-001, and of nearby compensation habitats. Native plantings appear to be surviving ( <i>Carex</i> spp. and <i>Juncus</i> spp. occurred in 69% of target habitat plots), their mean % cover is insignificant (5.3 +/- 5.1), likely an indicator of (1) recency of plantings (2) displacement by <i>Phalaris arundinacea</i> and (3) other stressors, such as grazing and soil compaction.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Log Debris	4	Remove backshore log debris and replace with appropriate native species.	Log debris accounts for 31.9 +/- 18.4% of target habitat area. Log debris reduces marsh productivity through grounding and smothering of native species. Consider removal of some log debris, and replanting of native species in new habitat.
Anthropogenic Impacts	3	Exclude marsh from public access, or concentrate foot traffic to prescribed areas.	Establishment of foreshore vegetation likely limited by anthropogenic damage. Evidence of soil compaction and foot traffic throughout foreshore. Dog walkers and fishermen observed using foreshore for all site visits. A well-established illegal camp is located ~50 m NE of site. Garbage littered throughout. Consider fencing or signage.
Bare Ground	2	Plant foreshore bare ground with appropriate native species.	Should only be completed if anthropogenic impacts reduced. Plant unvegetated substrate along foreshore to increase site productivity and habitat value.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
None			





Site# 15-003-B

CPR# 0705F024

---

### Background

Compensation for habitat lost in creation of new Pitt River Bridge. Construction actions lead to the loss of 579 sqm subtidal, 4302 sqm unvegetated intertidal, and 4925 sqm riparian fish habitat. Overall, project aimed to compensate through creation of 2700 sqm subtidal, 3529 sqm unvegetated intertidal, and 7085 sqm riparian fish habitat. Compensation actions were completed in 2010, and site was monitored by Hatfield (2011-2012) and Golder (2013-2014) till 2015 (see monitoring descriptions below). Habitat compensation goal (at this site specifically) = 3590 sqm marsh habitat.

#### Marshes north and south of bridge:

Hatfield (April 2011) noted that marsh was not planted to prescription and required supplemental actions. Observations determined ~80% survival rate of plantings; however, there was a significant shortage of intertidal littoral habitat planted, as specified in the DFO authorization. Recommended supplemental works included further planting of bulrush along the left intertidal bank of the Pitt River and removal of all invasive *Rubus armeniacus* at the toe of the southern slope to protect planted stock. Supplemental actions were completed later in 2011. A 2012 site visit noted up to 75% mortality of 2011 plantings. *Lythrum salicaria* and *Phalaris arundinacea* had become established in areas, while native species colonization was marginal. Because of this, Hatfield recommended in-fill planting of 200 *Carex lyngbyei*, 200 *Carex obnupta* and 200 *Juncus balticus* within the intertidal littoral zones of both marshes. Planting of 50 *Lonicera involucrata* and 50 *Cornus stolonifera* (two gallon) was also recommended in both marshes to help prevent further establishment of *P. arundinacea*. A 2013 monitoring report by Golder indicated that survivorship of plantings was high and total cover of native vegetation was estimated at 60%, still falling short of DFO requirements. The report also noted that *P. arundinacea* was well-established throughout the marshes, and *L. salicaria* was observed sporadically. No supplemental plantings recommended in 2012 had been carried out by 2013. Golder re-affirmed the need for supplemental plantings and recommended management of *L. salicaria*. The 2014 site visit by Golder noted strong survivorship of native vegetation (90%), with evidence of natural colonization of native marsh species including *Mentha arvensis*, *Galium trifidum* and *Cicuta douglasii*. Recommended *Carex* spp. and *Juncus* spp. plantings had been completed and were healthy. No further remedial actions were recommended.

#### Marsh below bridge:

Hatfield (April 2011) noted that marsh was not planted to prescription and required supplemental actions. Observations determined ~80% survival rate of plantings; however, there was a significant shortage of intertidal littoral habitat planted, as specified in the DFO authorization. Recommended supplemental works included intertidal littoral re-planting of bulrush. Recommendations for this site also included the removal of all invasive *Rubus armeniacus* at the toe of the southern slope to protect the planted stock. Site was re-planted later in 2011. A 2012 site inspection noted significant mortality of planted areas, with survivorship estimated to be 10%. Because of this, Hatfield (2012) recommended that 200 *Carex obnupta* and 200 *Typha latifolia* be in-fill planted to achieve adequate density and cover within marsh. Monitoring in 2013 by Golder observed that no recommended plantings had been carried out, with exotic *Persicaria maculosa* as the dominant ground cover, and native emergent plants (*Carex obnupta*, *Eleocharis* spp.) occurring only sporadically. Golder re-affirmed Hatfield's 2012 planting recommendations. A 2014 site inspection noted slow incremental establishment of clumped native vegetation. *Carex* spp. and *Juncus* spp. plantings were carried out as prescribed. Survivorship of native vegetation was estimated to exceed 90%, in compliance with the DFO Authorization. No further remedial actions were recommended.



### Description

The site is an embayed 3831 sqm marsh, located along the eastern shore of the Pitt River below and around the Pitt River Bridge. Marsh is backed by a small riprap slope, with extensive riparian plantings above (see riparian file). Foreshore north of bridge is unarmoured, smoothly transitioning to mudflat and subtidal along a low gradient. Southern marsh is also unarmoured, but transitions into subtidal via a small cut bank (~0.2-0.5 m). Marsh below bridge is separated from Pitt River due to armoured bridge abutment along foreshore. As a result, marsh below bridge is more saturated, with unvegetated areas of standing water throughout. Site is bordered by natural shoreline to northeast and southwest. Trans Canada Trail runs parallel to the marsh along dike to the east.

95% of the site is comprised of typical mid to high marsh vegetation (Community 1) in varying levels of establishment. Dominant species include invasive *Phalaris arundinacea*, native *Carex obnupta* and exotic *Lotus corniculatus*. A vegetated mudflat accounts for remaining 5% of site area, with sparse vegetation most dominated by blue-listed *Eleocharis parvula*. Invasive and exotic species account for > 50% of marsh vegetation, likely an indicator that (1) recent native plantings are yet to establish and (2) non-native plants are colonizing aggressively, displacing native species. The entire site (particularly areas of bare ground under bridge and north of bridge), continues to be threatened by the advancement of non-native species while native plantings establish.

### Morphological Features

A vegetated mudflat (Community 2) occurs along low-gradient foreshore of northern marsh. Southern marsh foreshore is less gradual, with a small cut bank (~0.2-0.5 m) separating marsh from unvegetated mudflat below. Marsh below bridge is separated from Pitt River due to armoured bridge abutment along foreshore. North and south marshes are relatively well-drained, gradually sloping to foreshore edge. Habitat below bridge is poorly drained due to abutment, which blocks direct contact with Pitt River. As a result, marsh below bridge is more saturated, with small areas of standing water throughout.

### Impacts & Stressors

Minor log debris. Some evidence of anthropogenic use of land (e.g. dog tracks and boot prints in marsh), though no significant impacts observed. Non-native plants account for 53% of marsh vegetation, and are likely displacing poorly-established native plantings.

### Wildlife Sightings/Evidence

Coyote observed nearby and scat found on site. Raccoon and Great Blue Heron (blue-listed, SARA-listed) tracks in vegetated mudflat.

### Adjacent Land Use

Marsh located below and around Pitt River Bridge. Creosote log storage upslope of site to south. Trans Canada Trail parallels site at top of dike. Marsh is located on east bank of Pitt River, frequently used by tugs and recreational boaters.

### Threatened Plant Species (Provincial/Federal)

Three threatened plant species were sampled in target habitat: *Lilaea scilloides* (blue-listed), *Juncus oxymeris* (blue-listed), and *Eleocharis parvula* (blue-listed), totaling a mean % cover of 0.8 +/- 0.4. *Eleocharis parvula* was also sampled in Community 2, with a total mean % cover of 8.3 +/- 10.8.

### Invasive Species

Three invasive species were sampled in target habitat: *Lythrum salicaria*, *Phalaris arundinacea* and *Iris pseudacorus*, totaling a mean % cover of 16.6 +/- 6.4.

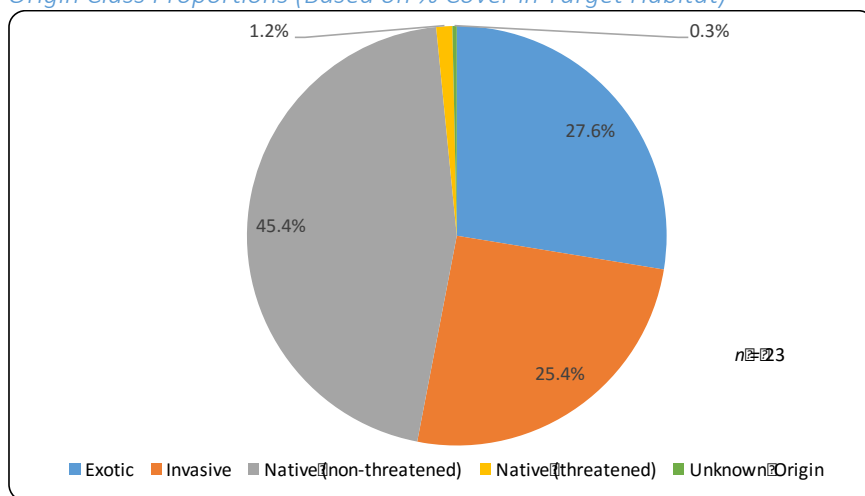
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	% Unvegetated Ground, CI (95%)	% Log Debris, CI (95%)	Wetland Indicator Status	n	Description
1	3632.4	94.8	30.2 +/- 12.6	5.4 +/- 5.8	1.83	23	Mid to high marsh (target habitat)
2	199.0	5.2	87.0 +/- 11.7	None	1.06	10	Vegetated mudflat

### Dominant Species

Community	Common Name	Scientific Name	Origin (N/T/E/I)	Wetland Indicator Status	Mean Absolute % Cover	CI (95%)	n	Relative Dominance (%)
1	reed canarygrass	<i>Phalaris arundinacea</i>	I	2	15.3	6.2	23	39.5
1	slough sedge	<i>Carex obnupta</i>	N	1	12.9	9.1	23	23.9
1	bird's-foot trefoil	<i>Lotus corniculatus</i>	E	3	10.7	7.9	23	16.8
2	small spike-rush	<i>Eleocharis parvula</i>	T	1	8.3	10.8	10	78.2

### Origin Class Proportions (Based on % Cover in Target Habitat)



### Compensation Success

Criterion	Target Percent	Actual Percent	Success	Description
<b>1. Proportion of Target Habitat Established(% of area goal)</b>	100.0	88.0	Good	The target habitat comprises 88% of the original habitat compensation goal at 3632 sqm. Missing 12% can likely be attributed to boundary mapping inaccuracy.
<b>2. Proportion/Relative % Cover Native Species</b>	59.2	46.6	Fair	Relative % cover of native species was below combined average of nearby reference marshes REF-11-001 and REF-12-001. The total vegetation cover for the target habitat was 64% and the proportion of native species was 47%. Low cover of native species is likely the result of (1) recentness of marsh plantings (< 5 years) and (2) displacement by invasive <i>Phalaris arundinacea</i> . Marsh success is not likely to improve without mitigation of invasive species.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	3	Remove patches of poorly-established invasive species. Mitigate impacts of <i>Phalaris arundinacea</i> .	Priority should be given to eradicate invasive species that are poorly established ( <i>Lythrum salicaria</i> , <i>Iris pseudacorus</i> ). <i>Phalaris arundinacea</i> will require more intensive actions to mitigate.
Bare Ground	4	Plant bare ground with appropriate native species.	Marsh directly beneath bridge is heavily shaded and less vegetated. Consider in-fill planting with shade-tolerant marsh species (e.g. <i>Carex obnupta</i> ) to reduce risk of invasive species encroachment, and increase marsh productivity.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Anthropogenic Impacts	2	Monitor impacts unsanctioned actions in habitat.	Proximity of marsh to public environment and easy access via Trans Canada trail put site at risk of anthropogenic impacts. An active unsanctioned camp was observed 10 m upslope of marsh, under Pitt River Bridge. 15-003-A, located directly across the river, is heavily stressed by recreational users. Monitor site to ensure these impacts are not occurring over time.



## Appendix VIII – Riparian Compensation Site Descriptions



Figure 2. Locations of FREMP riparian compensation habitats, surveyed July-October 2015. Large scale map features (e.g. precise locations, site boundaries) can be viewed on the FREMP-BIEAP Atlas online, under the 2015 Field Data map layer: [http://www.cmnbc.ca/atlas\\_gallery/fremp-bieap-habitat-atlas](http://www.cmnbc.ca/atlas_gallery/fremp-bieap-habitat-atlas).

Site# 01-008  
CPR# 0112F080

---

### Background

Intertidal mudflat habitat (4083 sqm) and subtidal riverbed (3124 sqm) was disturbed due to sediment and groundwater remediation works. Compensation habitat created in 2002 and planted in 2003. Habitat compensation goal = 996 sqm riparian, 2161 sqm intertidal marsh, 562 sqm intertidal mudflat, and 199 sqm subtidal riverbed habitat.

### Description

Habitat consists of a linear strip of vegetation (approximately 135 m X 8 m) created along the top of a riprap dike. Upland edge is bordered by light industrial infrastructure (shipping lot, railway, buildings), and foreshore edge is bordered by riprap slope with compensation marsh below (see marsh file). The riparian understory is primarily comprised of *Rosa nutkana* (estimated 50% cover), *Holodiscus discolor* (estimated 15% cover), and *Cornus stolonifera* (estimated 15% cover). Overstory vegetation is still in early seral stages (no tree exceeds 4 m height), consisting of 13 *Acer macrophyllum* and 3 *Alnus rubra*. Invasive *Rubus* spp. are present, but currently cover only an estimated 8% of habitat.

### Morphological Features

Site located along top of riprap dike slope. Upland access from industrial site is limited by concrete retaining wall blocks, which border much of upland edge.

### Impacts & Stressors

Habitat appears to be functioning well. Invasive *Rubus* spp. are present, covering approximately 8% of site, but are yet to displace native vegetation.

### Wildlife Sightings/Evidence

None.

### Adjacent Land Use

Light industrial facilities with railway line, asphalt lot, and warehouse building (NW). Compensation marsh along Fraser River North Arm (SE).

### Threatened Plant Species (Provincial/Federal)

None.

### Invasive Species

Two invasive species were observed in riparian habitat: *Rubus armeniacus* and *Rubus laciniatus*, with approximately 8% cover combined.

### Community Descriptions

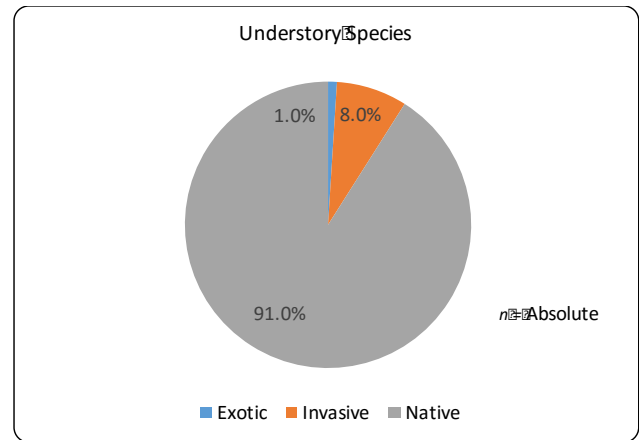
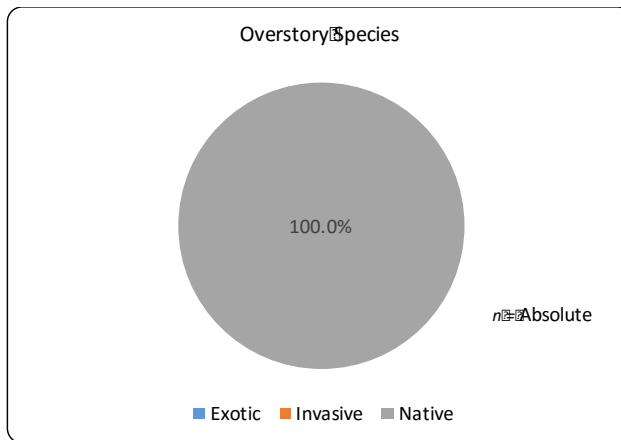
Community	Area (m <sup>2</sup> )	% of Total Area	<i>n</i>	Description
1	1044.7	100	Absolute	Linear riparian habitat constructed above riprap slope.



### Dominant Species

Community	Strata	Common Name	Scientific Name	Origin (N/T/E/I)	Stems /ha	Estimated Absolute % Cover	CI (95%)	n
1	overstory	bigleaf maple	<i>Acer macrophyllum</i>	N	2600	-	-	Absolute
1	overstory	red alder	<i>Alnus rubra</i>	N	600	-	-	Absolute
1	understory	Nootka rose	<i>Rosa nutkana</i>	N	-	50.0	-	Absolute
1	understory	oceanspray	<i>Holodiscus discolor</i>	N	-	15.0	-	Absolute
1	understory	red-osier dogwood	<i>Cornus stolonifera</i>	N	-	15.0	-	Absolute

### Origin Class Proportions (Based on % Cover)



### Compensation Assessment

Criterion	Target Percent	Actual Percent	Current Status	Predicted Trajectory
<b>1. Overstory: % Native Stems/ha</b>	100.0	100.0	Native <i>Acer macrophyllum</i> and <i>Alnus rubra</i> are planted at relatively high densities. Despite drought year, trees appeared vigorous. All trees are still <4 m height.	Some tree mortality should be expected over time due to natural succession. Current density is high enough to allow for some natural mortality.
<b>2. Understory: Relative Percent Cover Native Species</b>	100.0	91.2	Native shrubs are well established and likely resilient to invasive species encroachment, representing 91% of understory vegetation.	Invasive <i>Rubus</i> spp. may threaten habitat, but will likely be limited by density of well-established native species.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive species	4	Control invasive species	<i>Rubus armeniacus</i> (approximately 6% cover) and <i>Rubus laciniatus</i> (approximately 2% cover) are present. Riparian habitats are susceptible to blackberry invasions. Current invasion is small and therefore would be easy to control at this stage.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
None			



Site# 02-006

CPR# 9604-0029

---

### Background

121 sqm (38 sqm of existing riparian compensation and 83 sqm of existing riparian) were disturbed in 1997 to complete seismic upgrade works to the BC Gas Pipeline at BC Gas Fraser Gate Station. Restoration was to be completed at the top of the riprap slope by planting riparian species. Compensation habitat goal = 138 sqm riparian habitat.

### Description

Habitat consists of a linear strip of riparian vegetation located along the top of a riprap dike. The site is bordered by a public pathway and Riverfront Park (north), unvegetated riparian habitat (east), mature riparian vegetation (west) and the Fraser River North Arm (south). Site is well-integrated into similar riparian vegetation to the west. Riparian vegetation at edge of habitat is managed (pruned) to prevent growth into Riverfront Park lawn to the north. The site has an early-seral overstory, containing two *Populus balsamifera* (5 m and 8 m height respectively). Habitat is dominated by understory species (>100% cover) consisting of *Cornus stolonifera* (approx. 60% cover), and invasive *Rubus armeniacus* (approx. 40% cover). Site is threatened by continued advancement of well-established *R. armeniacus*.

### Morphological Features

Flat riparian strip above steep riprap slope. It is questionable whether the site is truly 'riparian' as habitat is well-elevated above high water mark and well-separated from intertidal habitat.

### Impacts & Stressors

*Rubus armeniacus* currently covers approximately 40% of site area, and is likely displacing planted native species.

### Wildlife Sightings/Evidence

Many songbirds in habitat (e.g. Song Sparrows).

### Adjacent Land Use

Riverfront Park with public trails (N, E). Similar riparian vegetation along top of dike (W), Fraser River North Arm (S).

### Threatened Plant Species (Provincial/Federal)

None.

### Invasive Species

One invasive species was observed in riparian habitat: *Rubus armeniacus*, with approximately 40% cover.

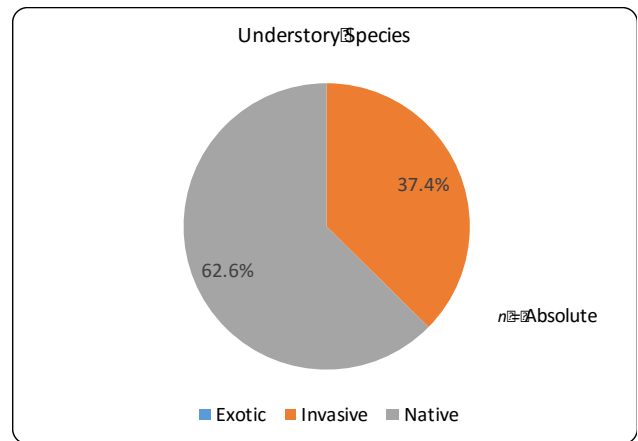
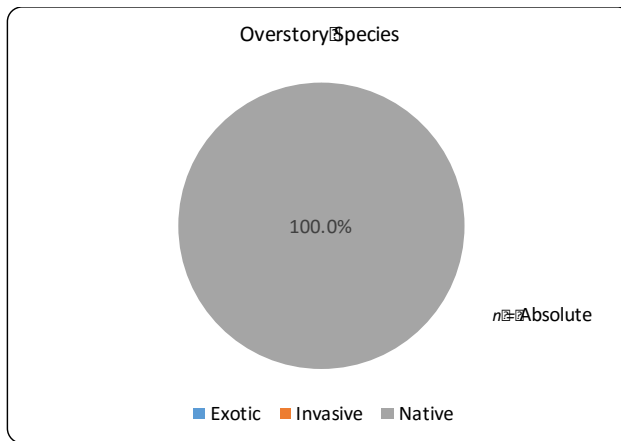
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	n	Description
1	200.0	100.0	Absolute	Patch of riparian vegetation along top of steep riprap dike.

### Dominant Species

Community	Strata	Common Name	Scientific Name	Origin (N/T/E/I)	Stems/ha	Estimated Absolute % Cover	CI (95%)	n
1	overstory	black cottonwood	<i>Populus balsamifera</i>	N	400	-	-	Absolute
1	understory	red-osier dogwood	<i>Cornus stolonifera</i>	N	-	60	-	Absolute
1	understory	Himalayan blackberry	<i>Rubus armeniacus</i>	I	-	40	-	Absolute

### Origin Class Proportions (Based on % Cover)



### Compensation Assessment

Criterion	Target Percent	Actual Percent	Current Status	Predicted Trajectory
<b>1. Overstory: % Native Stems/ha</b>	100.0	100.0	Despite presence of only two trees, stem density of overstory species is similar to reference habitats in region. Tree are still in early seral stage, with canopy still poorly developed.	<i>Populus balsamifera</i> are likely to rapidly grow, however low stem density leaves little room for mortality in healthy trajectory of habitat.
<b>2. Understory: Relative Percent Cover Native Species</b>	100.0	62.6	<i>Rubus armeniacus</i> currently covers approximately 40% of site area, with mature canes growing on top of tall native shrubs.	<i>Rubus armeniacus</i> is somewhat limited by park maintenance crews, but cane-like growth habit of plant appears to allow it to smother mature riparian shrubs. Native vegetation may be increasingly displaced by <i>R. armeniacus</i> over time.

*Recommendations*

<b>Mitigation</b>			
<b>Impact</b>	<b>Priority Rank (1 Low - 5 High)</b>	<b>Action Required</b>	<b>Comments</b>
Invasive Species	4	Control invasive species	<i>Rubus armeniacus</i> accounts for approximately 40% of understory vegetation. If not controlled it could displace native shrubs.
Lack of Overstory	2	Plant overstory species	Only two <i>Populus balsamifera</i> are present. Increase habitat heterogeneity by planting more riparian tree species.
<b>Monitoring</b>			
<b>Impact</b>	<b>Priority Rank (1 Low - 5 High)</b>	<b>Action Required</b>	<b>Comments</b>
None			



Site# 02-007-A

CPR# 8901-003

---

### Background

1085 sqm of intertidal mudflat, 1720 sqm of marsh, and 175 sqm of riparian habitat were impacted as a result of shoreline works. Compensation habitats (3) were created and planted in 1993. Total habitat compensation goal of three compensation habitats (02-007-A,B,C) = 3984 sqm marsh and 175 linear m or sqm riparian habitat.

### Description

Riparian vegetation was integrated into dike through installation metal “pots” mid-way down riprap slope. Approximately 35 containers (approximately 1 m X 1 m) were placed along 101 linear meters of dike, bordering the backshore of an embayed compensation marsh backshore. There were 7 trees present in containers including 3 *Alnus rubra*, 1 *Populus balsamifera* and 1 *Betula pendula*. The most abundant understory species was *Cornus stolonifera*, with 29% absolute cover, followed by *Salix sitchensis* and *Symphoricarpos albus*, with approximately 17% absolute cover each. *Rubus armeniacus* is abundant in riprap and is beginning to invade native plantings.

### Morphological Features

Riparian vegetation is planted in 35 x 1 sqm containers within riprap slope. Pots likely have little water-holding capacity, as they occur on a slope and are isolated from surrounding soils.

### Impacts & Stressors

*Rubus armeniacus* is abundant in nearby riprap and is beginning to invade plantings. Vegetation is likely stunted in pots due to harsh growing conditions from light/heat reflection off riprap, poor water-holding capacity of pots, and lack of overstory.

### Wildlife Sightings/Evidence

None.

### Adjacent Land Use

Residential condos and townhouses (N). Paved BC Parkway multi-use trail at top of dike.

### Threatened Plant Species (Provincial/Federal)

None.

### Invasive Species

Two invasive species were observed in riparian habitat: *Rubus armeniacus* and *Rubus laciniatus*, with approximately 8% cover combined.

### Community Descriptions

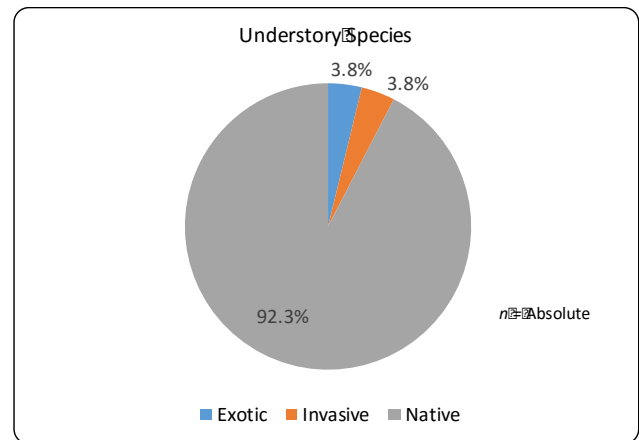
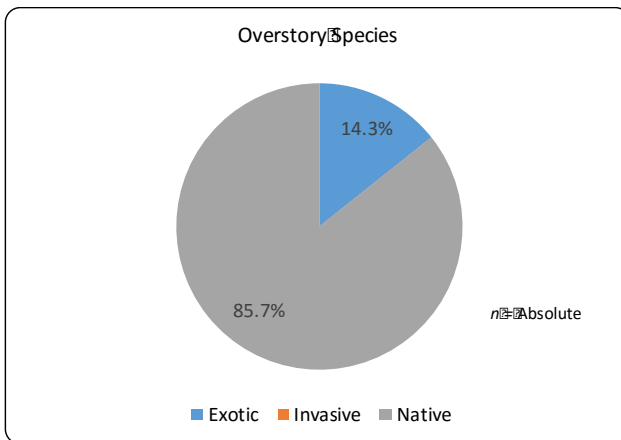
Community	Area (m <sup>2</sup> )	% of Total Area	n	Description
1	36.0	100	Absolute	Vegetated metal “pots” integrated into riprap slope.



### Dominant Species

Community	Strata	Common Name	Scientific Name	Origin (N/T/E/I)	Stems /ha	Estimated Absolute % Cover	CI (95%)	n
1	overstory	red alder	<i>Alnus rubra</i>	N	1429	-	-	Absolute
1	overstory	black cottonwood	<i>Populus balsamifera</i>	N	286	-	-	Absolute
1	overstory	Nootka rose	<i>Betula pendula</i>	E	286	-	-	Absolute
1	understory	red-osier dogwood	<i>Cornus stolonifera</i>	N	-	29.0	-	Absolute
1	understory	Sitka willow	<i>Salix sitchensis</i>	N	-	17.0	-	Absolute
	understory	snowberry	<i>Symphoricarpos albus</i>	N	-	17.0	-	Absolute

### Origin Class Proportions (Based on % Cover)



### Compensation Assessment

Criterion	Target Percent	Actual Percent	Current Status	Predicted Trajectory
<b>1. Overstory: % Native Stems/ha</b>	100.0	85.7	Mix of native and exotic trees have been planted/colonized soil media. At present none exceed 13 m height.	All tree species present are relatively durable, but it is questionable whether metal pots will be able to support trees long-term, as trees will likely outgrow pot size.
<b>2. Understory: Relative Percent Cover Native Species</b>	100.0	92.3%	Native species represent 92% of vegetation. Invasive <i>Rubus armeniacus</i> and exotic <i>Rosa rugosa</i> are present, but are not presently displacing vegetation. Native shrubs are not well-established, and appear to be struggling in harsh dike growing conditions.	Invasive <i>Rubus armeniacus</i> . may threaten habitat may threaten to invade and displace weak native species over time.

*Recommendations*

<b>Mitigation</b>			
<b>Impact</b>	<b>Priority Rank (1 Low - 5 High)</b>	<b>Action Required</b>	<b>Comments</b>
Invasive species	3	Control invasive species	Remove <i>Rubus armeniacus</i> from in and around habitat while still manageable. Native plantings are poorly-established and incapable of resisting invasion.
<b>Monitoring</b>			
<b>Impact</b>	<b>Priority Rank (1 Low - 5 High)</b>	<b>Action Required</b>	<b>Comments</b>
Tree health	1	Monitor tree health long-term	It is questionable whether metal containers can support mature riparian trees. Monitor tree health over time and consider alternative planting methods if unsuccessful.



Site# 04-001  
CPR# 8801-0005

---

### Background

Site was built in compensation for loss of intertidal mudflats (2284 sqm) due to creation of a compensation marsh. Kistritz (1995) noted that riparian vegetation had been damaged by people, horses and vehicles and also questioned whether conditions along backshore were wet enough to support a true riparian community. Upon casual site visit in January 2016, riparian vegetation had been severely pruned since time of 2015 survey (perhaps to improve view for neighbouring golf course). Due to time of impact, these impacts are not reflected in 2015 results. Compensation habitat goal = 3461 sqm marsh habitat 105 sqm riparian habitat.

### Description

Habitat consists of a linear strip of riparian vegetation constructed at the top of a riprap slope. Site is placed between foreshore riprap slope with compensation marsh below (see marsh file) and a public walking path, which runs parallel to Point Grey Golf and Country Club. Riparian vegetation is functioning well and has likely expanded habitat, overhanging the compensation marsh, riprap dike, and trail edge in several places. Overstory contains six *Alnus rubra* (max height 6 m), and three exotic *Acer campestre* (max height 6 m). The understory vegetation is dense and layered, dominated by *Symphoricarpos albus* (approx. 70% cover), *Cornus stolonifera* (approx. 30% cover), tree-like *Salix sitchensis* (approx. 27% cover), and *Rosa nutkana* (approx. 13% cover). Some invasive *Rubus armeniacus* is present but currently only occupies approximately 1% of site area. Invasive *Polygonum cuspidatum* is present and mown on the opposite side of adjacent public trail, threatening to advance into habitat over time.

### Morphological Features

Habitat was constructed between riprap slope and the adjacent public walking trail. It is questionable whether the site is truly 'riparian,' as habitat is well-elevated above high water mark and well-separated from intertidal habitat.

### Impacts & Stressors

Some *Rubus armeniacus* is present but currently occupies approximately 1% of site area. *Polygonum cuspidatum* is present and is being mown on the opposite side of adjacent public trail, threatening to advance into the site over time. Recent pruning in January 2016 has impacted and reduced riparian vegetation, but impacts were not recorded in 2015 survey data.

### Wildlife Sightings/Evidence

None.

### Adjacent Land Use

Gravel walking trail and Point Grey Golf and Country Club (N). Compensation marsh and Fraser River South Arm (S).

### Threatened Plant Species (Provincial/Federal)

None.

### Invasive Species

One invasive species was observed in riparian habitat: *Rubus armeniacus*, with approximately 1% cover. *Polygonum cuspidatum* is found in nearby habitat on opposite side of public walking trail.

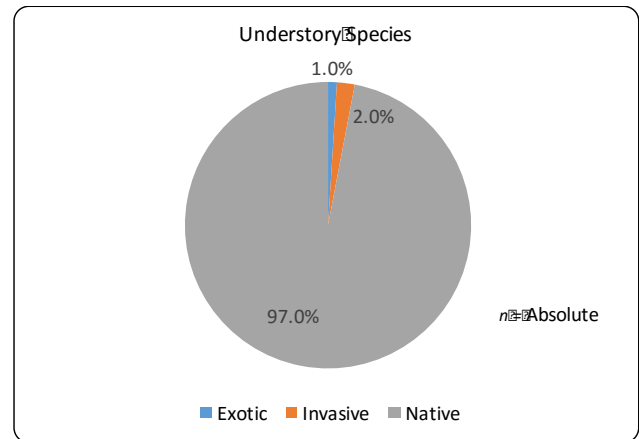
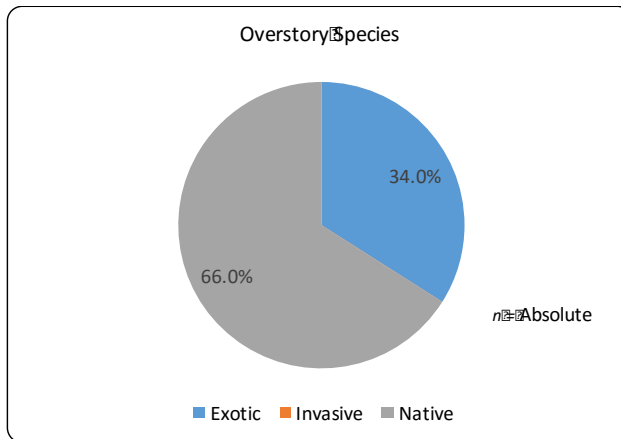
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	n	Description
1	617.9	100	Absolute	Strip of riparian vegetation constructed between top of riprap slope and public walking trail. Contains both trees and shrubs.

### Dominant Species

Community	Strata	Common Name	Scientific Name	Origin (N/T/E/I)	Stems/ha	Estimated Absolute % Cover	CI (95%)	n
1	overstory	red alder	<i>Alnus rubra</i>	N	800	-	-	Absolute
1	overstory	field maple	<i>Acer campestre</i>	E	600	-	-	Absolute
1	understory	snowberry	<i>Symphoricarpos albus</i>	N	-	70.0	-	Absolute
1	understory	red-osier dogwood	<i>Cornus stolonifera</i>	N	-	30.0	-	Absolute
1	understory	Sitka willow	<i>Salix sitchensis</i>	N	-	27.0	-	Absolute
1	understory	Nootka rose	<i>Rosa nutkana</i>	N	-	13.0	-	Absolute

### Origin Class Proportions (Based on % Cover)



### Compensation Assessment

Criterion	Target Percent	Actual Percent	Current Status	Predicted Trajectory
<b>1. Overstory: % Native Stems/ha</b>	100.0	57.1	Overstory species are still in early seral stages (all < 6 m height). Weedy exotic <i>Acer campestre</i> is present (43% of overstory stems), and is known to seed aggressively in upland habitats. Stem density of trees is comparable to similar reference habitats in region.	Exotic <i>Acer campestre</i> may aggressively seed in and around riparian habitat. Fast-growing <i>Alnus rubra</i> are likely to provide a healthy canopy layer over time.
<b>2. Understory: Relative Percent Cover Native Species</b>	100.0	97.3	Understory plantings are well-established and appear resilient to invasion by <i>Rubus armeniacus</i> .	Although resilient to invasion by <i>Rubus armeniacus</i> , vegetation may be slowly displaced over time.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive and exotic species	3	Control invasive and exotic species	<i>Rubus armeniacus</i> is present but only covers approx. 1% of site area. <i>Polygonum cuspidatum</i> is present and is being mown on the opposite side of public trail. Weedy <i>Acer campestre</i> is known to invade upland habitats, and may need to be controlled if displacing native species (see monitoring).
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Exotic overstory species	1	Monitor behaviour of <i>Acer campestre</i>	<i>Acer campestre</i> is capable of aggressively colonizing upland habitats. Monitor seedlings and stem density over time to ensure native species are not being displaced/replaced.



Site# 04-005

CPR# 0504F023

---

### Background

Compensation for loss of 125 sqm intertidal marsh, 90 sqm riparian, 2700 sqm unvegetated intertidal mudflat and 2300 sqm subtidal mudflat. Riparian habitat design used "Eco pockets", which were placed within foreshore riprap slope. Site was created in 2006, and planted in 2007. Habitat compensation goal = 2000 sqm subtidal, 1300 sqm unvegetated intertidal mudflat, 325 sqm marsh and 3600 linear m or sqm riparian habitat.

### Description

Vegetation was integrated within riprap slope in 36 x 1 sqm planting "Eco pockets", spread over 408.1 m of linear foreshore length. Pockets are lined with landscape fabric, presumably to hold soil media. The Legacy FREMP records indicate that 3600 sqm of riparian habitat was created; however, this survey found only 36 x 1 sqm pockets. Reason for this discrepancy is uncertain, but we suggest that 3600 sqm may be a typing error and the true number may be 36 sqm or 360 linear meters.

Overall, riprap slope is sparsely covered by riparian vegetation with only 36 x 1 sqm pockets over 408.1 m length. Some "Eco pockets" are non-functional, due to damaged and exposed fabric and/or no vegetation present. The majority of the pockets are planted with *Symphoricarpos albus* (estimated 82% cover), followed by *Ribes sanguineum* (estimated 27% cover). Understory species appear stressed, likely due to difficult growing conditions. No overstory species were present.

### Morphological Features

"Eco pockets" of soil media integrated into foreshore riprap slope.

### Impacts & Stressors

Some "Eco pockets" are damaged and/or unvegetated.

### Wildlife Sightings/Evidence

None.

### Adjacent Land Use

Residential development (N). Fraser River North Arm (S).

### Threatened Plant Species (Provincial/Federal)

None.

### Invasive Species

None.

### Community Descriptions

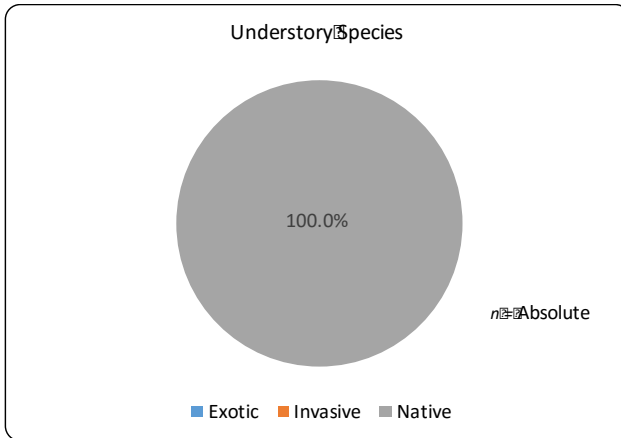
Community	Area (m <sup>2</sup> )	% of Total Area	n	Description
1	36.0	100.0	Absolute	Plantings integrated into riprap slope via 36 x 1 sqm "Eco Pockets" of soil media.



### Dominant Species

Community	Strata	Common Name	Scientific Name	Origin (N/T/E/I)	Stems/ha	Estimated Absolute % Cover	CI (95%)	n
1	understory	snowberry	<i>Symphoricarpos albus</i>	N	-	82.0	-	Absolute
1	understory	red-flowering currant	<i>Ribes sanguineum</i>	N	-	27.0	-	Absolute

### Origin Class Proportions (Based on % Cover)



### Compensation Assessment

Criterion	Target Percent	Actual Percent	Current Status	Predicted Trajectory
<b>1. Overstory: % Native Stems/ha</b>	100.0	n/a	No overstory species are present in "Eco pockets".	"Eco pockets" are unlikely to be successfully colonized by overstory species. Managers may remove any successful colonizers, as tree roots may threaten dike integrity long-term.
<b>2. Understory: Relative Percent Cover Native Species</b>	100.0	100.0	No invasive species are present, but "Eco pockets" are poorly vegetated in general. Some "Eco pockets" are entirely unvegetated soil media.	Some shrubs may continue to survive in "Eco pockets", however growing conditions seem harsh for many species – likely due to heat reflection from riprap, water deficiency in soil media, and lack of overstory cover. Best case scenario is approximately 36 x 1 sqm pockets of healthy vegetation.

### Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Unvegetated "Eco pockets"	4	Plant unvegetated "Eco pockets" with sun and drought-tolerant shrubs.	Several "Eco pockets" are unvegetated or sparsely-vegetated. Re-plant with appropriate native species. Planting should include at least 1 growing season of watering.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
None			



Site# 05-003  
CPR# 9810F085

---

### Background

Creation of habitat in compensation for disturbance of 274 sqm riparian, 134 sqm marsh and 319 sqm intertidal mudflat habitat from construction of Airport Connector crossing. Project included creation of riparian habitat above riprap dike and withdrawal of 294 sqm habitat from the Fraser Habitat Bank. Riparian habitat was created and planted in 2000. Compensation habitat goal = 274 sqm riparian habitat.

Determining site boundaries was difficult for sampling, as riparian vegetation is continuous along shoreline and accuracy of the legacy FREMP-BIEAP Atlas polygon was questionable. The site was determined to be 350.1 sqm by drawing a polygon based on (1) the furthestmost extent of the riparian vegetation along the foreshore and upland boundaries, and (2) our GPS position in relation to the BIEAP-FREMP Atlas polygon. Due to the inaccuracy of the boundary delineation methods the area sampled (350.1 sqm) may not be entirely accurate.

### Description

Riparian plantings located above a steep riprap slope (approx. 35-40 degrees) bordering the north shore of the Fraser River Middle Arm. Plantings occur at least 3 m above high water. BIEAP-FREMP polygons indicate that site borders Compensation Site 05-004 to north. The habitat contained only two trees (*Acer macrophyllum*, *Populus balsamifera*) and was densely vegetated by mature understory vegetation. The understory was primarily comprised of *Rubus armeniacus*, accounting for approximately 58% of the total cover, followed by *Cornus stolonifera* with approximately 29% total cover. Invasive *R. armeniacus* is currently displacing native species, and threatens to further degrade site over time.

### Morphological Features

Riparian vegetation located on gently-sloped ground above steep riprap slope (35 - 40 degrees). Vegetation occurs approximately 3 m above high water mark.

### Impacts & Stressors

Invasive *Rubus armeniacus* is the most dominant species present, and is likely displacing native species and limiting natural succession processes.

### Wildlife Sightings/Evidence

None.

### Adjacent Land Use

There are a variety of roads, trails, and grass fields around the site (N,W). Directly adjacent and bordering the site to the west is an informal trail. Site is elevated above nearby Fraser River Middle Arm (SE). Compensation site 05-004 immediately north.

### Threatened Plant Species (Provincial/Federal)

None.

### Invasive Species

Two invasive species were observed in riparian habitat: *Rubus armeniacus* and *Cytisus scoparius*, with approximately 58% total cover (<1% *C. scoparius*).

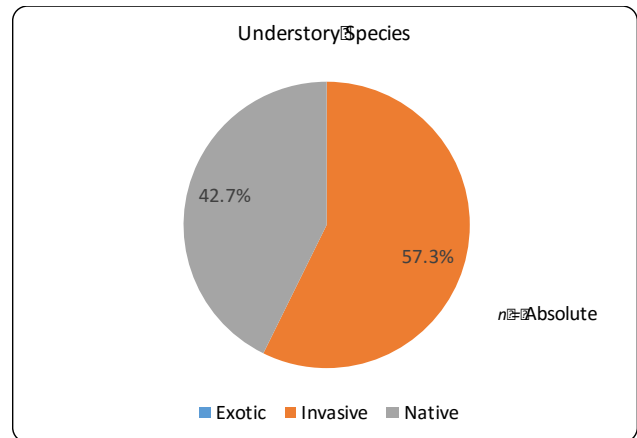
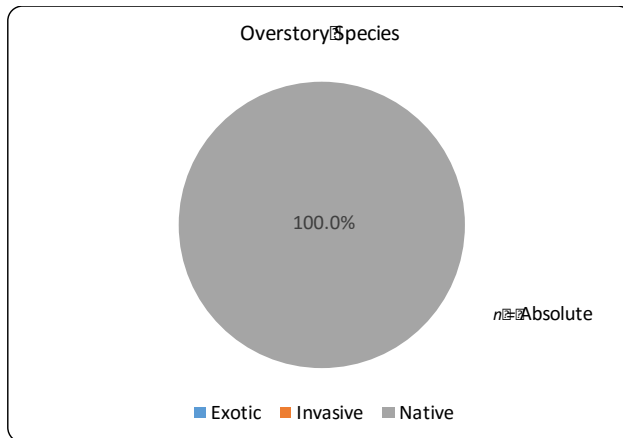
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	n	Description
1	350.1	100.0	Absolute	Riparian shrubs and a few trees on upslope habitat above riprap dike.

### Dominant Species

Community	Strata	Common Name	Scientific Name	Origin (N/T/E/I)	Stems/ha	Estimated Absolute % Cover	CI (95%)	n
1	overstory	bigleaf maple	<i>Acer macrophyllum</i>	N	200	-	-	Absolute
1	overstory	black cottonwood	<i>Populus balsamifera</i>	N	200	-	-	Absolute
1	understory	Himalayan blackberry	<i>Rubus armeniacus</i>	I	-	58.0	-	Absolute
1	understory	red-osier dogwood	<i>Cornus stolonifera</i>	N	-	29.0	-	Absolute

### Origin Class Proportions (Based on % Cover)



### Compensation Assessment

Criterion	Target Percent	Actual Percent	Current Status	Predicted Trajectory
<b>1. Overstory: % Native Stems/ha</b>	100.0	100.0	Tree stem density is comparable to reference habitats in region, however early seral stage of trees limits their ability to provide overstory habitat.	Trees appear healthy (despite stress of dry summer) and are likely to persist. Shading of habitat may reduce <i>Rubus armeniacus</i> , but current stem density will likely not make a significant impact.
<b>2. Understory: Relative Percent Cover Native Species</b>	100.0	43.3	Though this site has > 100% understory cover,, it is heavily dominated by <i>Rubus armeniacus</i> , with approximately 58% total cover.	Invasive <i>Rubus armeniacus</i> is likely to further displace native understory species over time. Habitat may increase in size due to expansion of shrubs along foreshore riprap slope, which appears to be already occurring.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	4	Remove <i>Rubus armeniacus</i> and replace with appropriate native species	<i>Rubus armeniacus</i> is currently the most abundant species. Remove, and replace with native riparian shrubs. Treatment of nearby infestations is also recommended if possible, to reduce risk of immediate re-colonization.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
None			



Site# 05-004

CPR# n/a

---

### Background

Riparian habitat (624 sqm) was disturbed as a result of dyke upgrade works. In compensation, the dike was set back in to create an area at the top of the river bank for the planting of riparian vegetation. Site was created and planted in 1999. Habitat compensation goal = 624 sqm riparian habitat.

Determining site boundaries was difficult for sampling, as riparian vegetation is continuous along shoreline and accuracy of the legacy FREMP-BIEAP Atlas polygon was questionable. The site was determined to be 963.2 sqm by drawing a polygon based on (1) the furthestmost extent of the riparian vegetation along the foreshore and upland boundaries, and (2) our GPS position in relation to the BIEAP-FREMP Atlas polygon. Due to the inaccuracy of the boundary delineation methods the area sampled (963.2 sqm) may not be entirely accurate.

### Description

Riparian plantings located above a steep riprap slope (approx. 35-40 degrees) bordering the north shore of the Fraser River Middle Arm. Plantings occur at least 3 m above high water. BIEAP-FREMP polygons indicate that site borders Compensation Site 05-003 to south. The site did not contain any trees, and was densely covered by well-established understory vegetation. The understory was primarily comprised of *Rubus armeniacus*, accounting for approximately 62% of the total cover, followed by *Rosa nutkana*, with approximately 21% cover and *Symphoricarpos albus*, with approximately 12% cover. Invasive *R. armeniacus* is currently displacing native species, and threatens to further degrade site over time.

### Morphological Features

Riparian vegetation located on gently-sloped ground, above riprap slope of 35 - 40 degrees. Vegetation occurs approximately 3 m above high water mark.

### Impacts & Stressors

Invasive *Rubus armeniacus* is dominating the site with approximately 62% cover and is likely displacing native plantings.

### Wildlife Sightings/Evidence

None.

### Adjacent Land Use

There is a variety of roads, trails, and grass fields around the site (N,W). Directly adjacent and bordering the site to the west is an informal trail. Site is elevated above nearby Fraser River Middle Arm (SE). Compensation site 05-003 immediately south.

### Threatened Plant Species (Provincial/Federal)

None.

### Invasive Species

One invasive species was observed in habitat: *Rubus armeniacus*, with approximately 62% total cover.



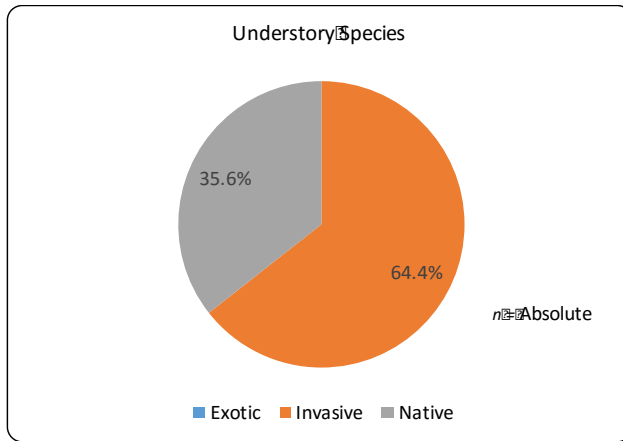
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	n	Description
1	963.2	100.0	Absolute	Riparian vegetation growing above, and slightly overhanging foreshore riprap slope.

### Dominant Species

Community	Strata	Common Name	Scientific Name	Origin (N/T/E/I)	Stems/ha	Estimated Absolute % Cover	CI (95%)	n
1	understory	Himalayan blackberry	<i>Rubus armeniacus</i>	I	-	61.9	-	Absolute
1	understory	Nootka rose	<i>Rosa nutkana</i>	N	-	20.8	-	Absolute
1	understory	snowberry	<i>Symphoricarpos albus</i>	N	-	11.8	-	Absolute

### Origin Class Proportions (Based on % Cover)



### Compensation Assessment

Criterion	Target Percent	Actual Percent	Current Status	Predicted Trajectory
<b>1. Overstory: % Native Stems/ha</b>	100.0	n/a	No overstory species are present in habitat. Little opportunity for natural colonization due to density of understory vegetation, particularly <i>Rubus armeniacus</i> .	Overstory species are likely to remain absent unless mitigation actions occur. Currently there is no vacant habitat for colonization/planting to occur.
<b>2. Understory: Relative Percent Cover Native Species</b>	100.0	39.5	Though this site has >100% understory cover, it is heavily dominated by <i>Rubus armeniacus</i> , with approximately 62% total cover.	Invasive <i>Rubus armeniacus</i> is likely to further displace native understory species over time. Habitat may increase in size due to expansion of shrubs along foreshore riprap slope, which appears to be already occurring.

### Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive species	3	Control <i>Rubus armeniacus</i>	<i>Rubus armeniacus</i> is dominating the site with 62% total cover. Control actions are recommended. Treatment of nearby infestations is also recommended if possible, to reduce risk of immediate re-colonization.
No overstory species	2	Plant trees	Currently there are only no trees within this site. Adding some trees (approximately 100 - 200 stems/ha) is recommended.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
None			



Site# 09-013  
CPR# 9502-0019

---

### Background

Creation of subtidal, intertidal marsh, and riparian habitat to compensate for disturbance within the Captain's Cove Marina Ltd. marina facility. A sub/intertidal marsh bench was constructed in 1997, with riparian plantings on top of riprap slope. There was no compensation for subtidal habitat lost. Habitat compensation goal =23790 subtidal, 2780 marsh, and 325 sqm riparian habitat.

### Description

Riparian habitat is series of vegetated "pockets" spaced approximately 10 m apart within a 105 x 3.5 m strip of riprap dike (Image 09-013 (8)). Habitat pockets are 3 m in diameter, and lined with textile to contain soil media. Riparian understory vegetation is primarily composed of *Rosa nutkana* and *Cornus stolonifera*. Overstory riparian tree species are present, but are yet to exceed 6 m in height. Invasive *Rubus armeniacus* represents approximately 12% of all riparian vegetation, and threatens to expand within riprap slope. Portions of riparian vegetation were disturbed by 2015 construction and should be monitored to ensure damages are compensated.

### Morphological Features

Riprap dyke with 3 m diameter habitat "pockets" integrated into slope. Pockets are spaced ~ 10 m apart and lined with textile to contain soil media.

### Impacts & Stressors

Invasive *Rubus armeniacus* represents approximately 12% of all riparian vegetation and threatens to increase abundance. Recent construction activities have damaged and destroyed 5-10 habitat pockets.

### Wildlife Sightings/Evidence

None.

### Adjacent Land Use

Millennium trail runs along top of dike (S). New residential development under construction immediately south of site. Compensation marsh lies at base of dike (N).

### Threatened Plant Species (Provincial/Federal)

None.

### Invasive Species

One invasive species was sampled in habitat: *Rubus armeniacus*, with approximately 6.5% total cover.

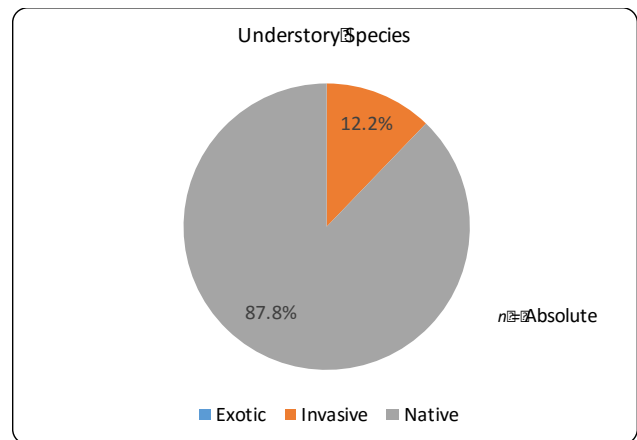
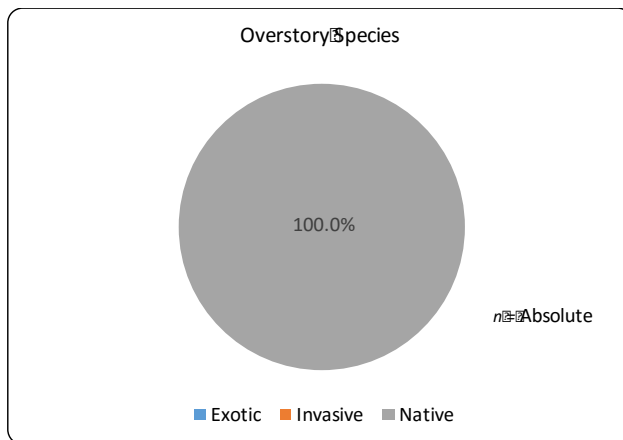
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	n	Description
1	368	100	Absolute	Riparian plantings along riprap dyke. Habitat area was difficult to measure, as (1) riparian plantings appeared to continue westward towards marina office and (2) pocket plantings were discontinuous along dyke. We agreed that area requirements were likely met, attributing uncertainty to lack of site information.

### Dominant Species

Community	Strata	Common Name	Scientific Name	Origin (N/T/E/I)	Stems/ha	Estimated Absolute % Cover	CI (95%)	n
1	overstory	black cottonwood	<i>Populus balsamifera</i>	N	544.0	-	-	Absolute
1	overstory	red alder	<i>Alnus rubra</i>	N	217.6	-	-	Absolute
1	overstory	paper birch	<i>Betula papyrifera</i>	N	108.8	-	-	Absolute
1	understory	Nootka rose	<i>Rosa nutkana</i>	N	-	21.5	-	Absolute
1	understory	red-osier dogwood	<i>Cornus stolonifera</i>	N	-	17.1	-	Absolute

### Origin Class Proportions (Based on % Cover)



### Compensation Assessment

Criterion	Target Percent	Actual Percent	Current Status	Predicted Trajectory
<b>1. Overstory: % Native Stems/ha</b>	100.0	100	Tree density is consistent with compensation and natural habitats in the region, with approximately 870 stems/ha. Most trees were $\leq 3$ m in height, and no trees exceeded 6 m. Many trees had been cut to reduce height.	Tree density is likely to remain consistent or slowly decrease, with little opportunity for further tree colonization in habitat 'pockets'. Trees will remain $< 6$ m if pruning continues. No threat of invasive/exotic tree invasion identified.
<b>2. Understory: Relative Percent Cover Native Species</b>	100.0	87.8	Total understory vegetation cover was 39% and the proportion of native species was 88%. Vegetation cover was low due to planting design, where large gaps of unvegetated rip rap occurs between habitat "pockets".	Vegetation in habitat pockets is likely to further expand over time, but will never form a continuous vegetative strip, as with natural habitats. Extensive vegetation along dyke slope is considered a threat to dike integrity long-term.

*Recommendations*

<b>Mitigation</b>			
<b>Impact</b>	<b>Priority Rank (1 Low - 5 High)</b>	<b>Action Required</b>	<b>Comments</b>
Invasive Species	4	Remove all patches of establishing <i>Rubus armeniacus</i> .	<i>Rubus armeniacus</i> covers approximately 7% of site. Blackberry is yet to establish and should be treated while still manageable.
<b>Monitoring</b>			
<b>Impact</b>	<b>Priority Rank (1 Low - 5 High)</b>	<b>Action Required</b>	<b>Comments</b>
Construction impacts	3	Revisit site once construction is completed to ensure damaged riparian vegetation is compensated.	Several "pockets" were damaged or destroyed by construction activities (see photo). Revisit to ensure adequate compensation is completed.



Site# 09-015  
CPR# n/a

---

### Background

Intertidal mudflat (2200 sqm) was disturbed as a result of bank stabilization works on the south shore of Deas Slough. Compensation actions included the creation of intertidal marsh (900 sqm), creation of riparian habitat (50 sqm), and enhancement of riparian habitat (120 sqm). Actions completed in 2000. Sample area exceeds that of project goals, due to uncertainty of project boundaries. As a result, sample efforts focused on habitat representative of general compensation area. Compensation habitat goal = 900 sqm marsh and 170 sqm or linear meters riparian habitat.

### Description

The site is a linear strip of riparian vegetation located along dyke of Deas Slough. Site is backed by Millennium trail at top of dike to south. Created marsh is located along immediate foreshore (see marsh file). Enhanced riparian habitat differs from created riparian habitat in both vegetative age and soil structure. Enhanced area is located in northeast of site, with riparian vegetation growing in unarmoured substrate. Created habitat spans most of created marsh (~125 m length), with plantings located along toe of riprap dyke. Enhanced habitat contains several mature *Populus balsamifera*, up to 40 m in height. Created habitat contains *P. balsamifera* and *Alnus rubra*, but none exceed 4 m. Understory shrubs, primarily composed of *Rosa nutkana*, *Malus fusca* and *Cornus stolonifera* exceed 100% cover in enhanced habitat. Vegetation accounts for 28% of created habitat area, and no shrubs are considered dominant at this stage in establishment. Common shrubs in created habitat include *R. nutkana*, *C. stolonifera* and *Rubus spectabilis*. Erosion appears to be undercutting toe of slope in enhanced area, which may lead to minor bank collapse over time (see photo). Invasive species are not prevalent in either habitats, but *Rubus armeniacus* and *Rubus laciniatus* are abundant at the top of dike, and risk encroaching into site over time.

### Morphological Features

Speculated enhancement area is an unarmoured riparian slope bordering compensation marsh below. Riparian slope is eroding at toe, with several undercut banks that may collapse over time. Created habitat consists of riparian plantings at lower regions of linear rip rap dyke.

### Impacts & Stressors

Invasive species only account for ~2.3% of marsh vegetation, but upslope region of dike is heavily invaded by *Rubus armeniacus* and *Rubus laciniatus*, threatening to encroach over time. Formation of cut banks in NE corner of site threaten to collapse slope over time.

### Wildlife Sightings/Evidence

Song Sparrow, Pacific-Slope Flycatcher, Rufus Hummingbird and Downy Woodpecker in riparian vegetation.

### Adjacent Land Use

Millennium trail at top of dike above site (S). Farm land on opposite side of Millennium Trail (S). Deas Slough (N) is well-used by recreational boaters and rowers.

### Threatened Plant Species (Provincial/Federal)

None.



### Invasive Species

No invasive species were observed in enhanced habitat. Two invasive species were observed in created habitat: *Rubus armeniacus* and *Rubus laciniatus*, with approximately 1.5% total cover. *Phalaris arundinacea* and *Iris pseudacorus* were observed incidentally, but were not sampled.

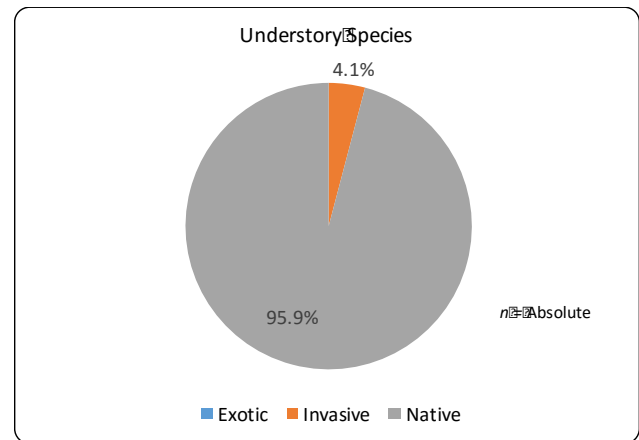
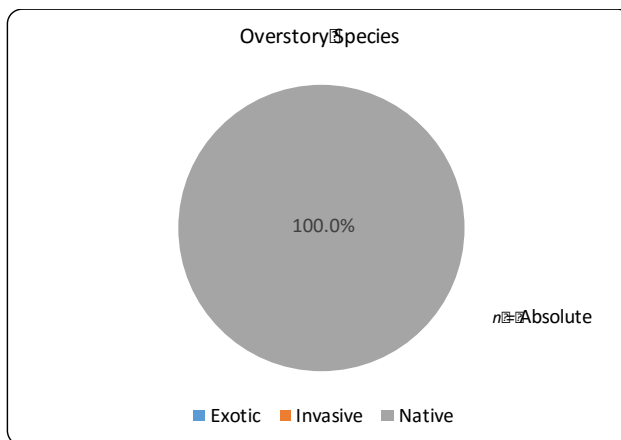
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	n	Description
1	212.49	23.7	Absolute	Enhanced riparian habitat. The site exceeds the area requirements for riparian compensation habitat at 898 sqm. Habitat borders were difficult to delineate, as (1) site information was limited and (2) riparian vegetation was difficult to differentiate from surrounding habitats. We sampled what we believed was representative of compensation actions.
2	685.08	76.3	Absolute	Created riparian habitat. See above.

### Dominant Species

Community	Strata	Common Name	Scientific Name	Origin (N/T/E/I)	Stems/ha	Estimated Absolute % Cover	CI (95%)	n
1	overstory	black cottonwood	<i>Populus balsamifera</i>	N	200.9	-	-	Absolute
1	understory	Nootka rose	<i>Rosa nutkana</i>	N	-	55.7	-	Absolute
1	understory	Pacific crab apple	<i>Malus fusca</i>	N	-	24.8	-	Absolute
1	understory	red-osier dogwood	<i>Cornus stolonifera</i>	N	-	14.3	-	Absolute

### Origin Class Proportions (Based on weighted & combined % cover of created and enhanced habitats)

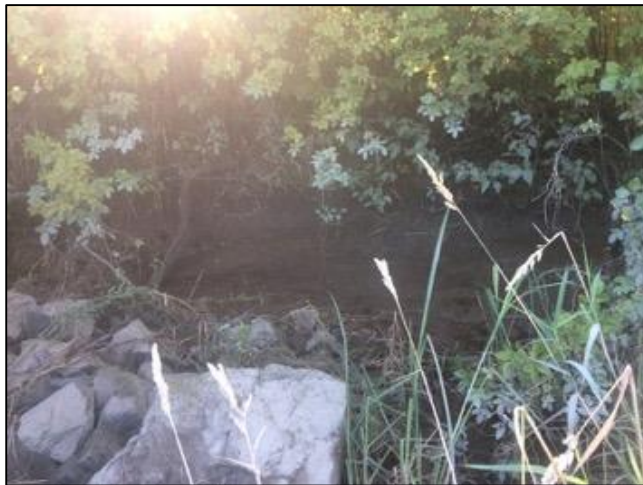


### Compensation Assessment

Criterion	Target Percent	Actual Percent	Current Status	Predicted Trajectory
<b>1. Overstory: % Native Stems/ha</b>	100.0	100	Mature <i>Populus balsamifera</i> (20 m) occur in enhanced habitat. Created habitat is shrub-dominated, with only occasional <i>Alnus rubra</i> and <i>P. balsamifera</i> saplings, all <4 m height. Enhanced habitat has normal tree density (200 stems/ha), while restored habitat is below riparian norm (45 stems/ha).	Tree density is not likely to increase in immediate future, as habitat is well-covered by <i>Phalaris arundinacea</i> , and understory shrub species. Existing trees are not being pruned, and are likely to increase in size over time.
<b>2. Understory: Relative Percent Cover Native Species</b>	100.0	95.9	Combined understory vegetation cover for both habitats was 72% and the proportion of native species 96%. Vegetative cover was significantly higher in enhanced habitat (106%) than created habitat (28%), reflecting the presence of mature, remnant plants in enhanced area.	Lack of invasives and high survival of planted riparian shrubs indicate habitat is on trajectory for long-term success. <i>Rubus armeniacus</i> is abundant at top of dike, but appears to be managed with occasional mowing.

### Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	3	Remove all patches of invasive <i>Rubus</i> spp.. Consider removal of upslope invasives.	Invasive <i>Rubus</i> spp. covers approximately 3% of site and should be treated while still unestablished. Depending on available resources, removal of upslope <i>Rubus</i> spp. should be considered, as it threatens to advance into site over time.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Erosion	3	Monitor erosion of riparian slope in NE corner of site.	Monitor condition of undercut riparian banks at northeast end of site to ensure long-term stability of upslope habitat. Determine whether bank condition is stable or worsening (e.g. photo monitoring).



Site# 10-002-B  
CPR# n/a

---

### Background

Creation of two marsh lagoons (10-002-A and 10-002-B) in compensation for bank stabilization work for Richmond Landfill site. Sites were completed in 1979, apparently in violation of DFO, as they were (1) built in red-coded habitat and (2) well-removed from the impact site. Mean surface elevation of compensation bench was noted to be higher than original marsh of site. Site was built smaller than specifications.

Large tires were installed as debris barriers at all site inflows/outflows. A past report indicated that the debris barriers needed to be improved, but there is no indication that such actions took place. Combined habitat compensation goal of 10-002-A and 10-002-B = 10000 sqm marsh habitat. No riparian habitat was included in goals, indicating site may have formed naturally due to high site elevation.

### Description

Site is a 637 sqm riparian island located within a 3611 sqm compensation marsh lagoon. Marsh lagoon was completed in 1979, and it is likely that riparian habitat slowly formed due to aggradation of river sediments and colonization of woody vegetation. Woody vegetation appears to be younger than 35 years. Habitat is bordered by a large log accumulation zone to northeast and northwest, with a marsh lagoon to the south. Riparian overstory is dominated by *Populus balsamifera* and *Alnus rubra*, varying in heights from 6 - 13 m. Several *A. rubra* and *P. balsamifera* snags are present in riparian forest. Understory is dominated by large *Salix sitchensis* and *Salix lucida*. Shrub community is mature and well-established, with several plants exceeding 4 m in height. Habitat is well-vegetated and 98% of sampled vegetation was native. Invasive species are sparse both in and around habitat, but threaten to encroach over time.

### Morphological Features

Site is a slightly elevated riparian mound within a compensation marsh lagoon. Riparian vegetation appears to be inundated during extreme events.

### Impacts & Stressors

Invasive Himalayan blackberry (*Rubus armeniacus*) represents approximately 2% of riparian vegetation and may threaten to expand over time.

### Wildlife Sightings/Evidence

Common Yellowthroat in riparian vegetation.

### Adjacent Land Use

Site is relatively isolated. Land NW of site is currently undeveloped and used to store mounds of river sand. Developed warehouses to the NE. Lagoon is connected to South Arm of the Fraser River.

### Threatened Plant Species (Provincial/Federal)

None.

### Invasive Species

One invasive species was sampled in habitat: *Rubus armeniacus*, with a total % cover of 1.3 +/- 2.1, representing 2.1% of sampled vegetation.

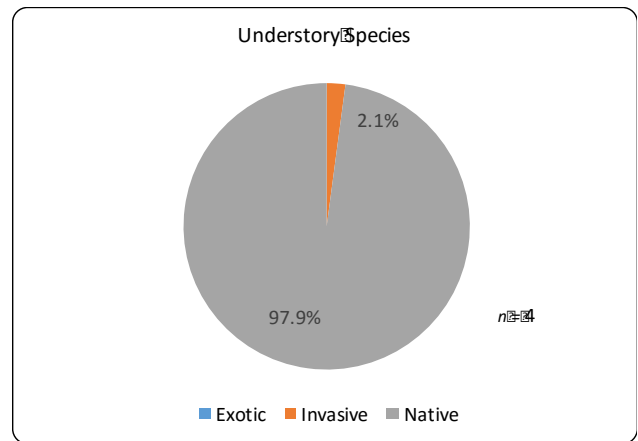
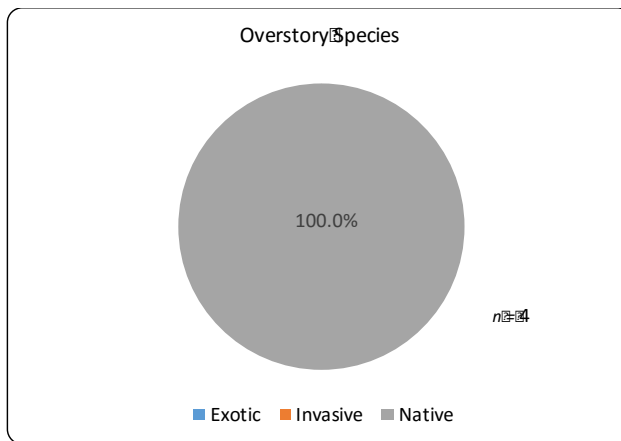
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	n	Description
1	637.0	100	4	Riparian habitat was not included in original compensation goals of this site. Site is ~35 years old, and it is likely that riparian habitat has formed through natural aggradation and colonization. Age of vegetation is consistent with this theory. Regardless of riparian island, site still exceeds marsh creation requirements.

### Dominant Species

Community	Strata	Common Name	Scientific Name	Origin (N/T/E/I)	Stems/ha	Mean % Cover	CI (95%)	n
1	overstory	black cottonwood	<i>Populus balsamifera</i>	N	350.0	-	289.9	4
1	overstory	red alder	<i>Alnus rubra</i>	N	300.0	-	294.0	4
1	understory	Sitka willow	<i>Salix sitchensis</i>	N	-	19.8	5.4	4
1	understory	shining willow	<i>Salix lucida</i>	N	-	18.5	21.6	4

### Origin Class Proportions (Based on % Cover)



### Compensation Assessment

Criterion	Target Percent	Actual Percent	Current Status	Predicted Trajectory
<b>1. Overstory: % Native Stems/ha</b>	100.0	100	Stem density is comparable to nearby natural and created riparian habitats at 650 stems/ha. Trees are not yet mature, ranging from 7-13 m height.	Stem density is likely to decrease over time, as several mature trees appear stressed or recently-deceased. Likely the result of successional thinning, and non-ideal hydric conditions.
<b>2. Understory: Relative Percent Cover Native Species</b>	100.0	97.9	Total understory vegetation cover was 57% and the proportion of native species was 98%.	Shrubs are already mature and well-spaced. Little change is expected to occur over time.

### Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	3	Remove all patches of establishing <i>Rubus armeniacus</i> .	<i>Rubus armeniacus</i> covers approximately 1% of habitat and should be removed while still manageable.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
None			





Site# 10-004  
CPR# 9401-0014

---

### Background

Loss of habitat due to dredging resulted in the creation of an intertidal marsh bench and planting of upslope riparian habitat. Habitats were created in 1996, and both marsh and riparian habitats were planted in April/May 1997. Riparian habitat was to be primarily planted with *Populus balsamifera*. Monitoring was scheduled to occur annually from 1997-2002. Habitat compensation goal = 1525 sqm marsh, 30 m/sqm riparian habitat.

### Description

Site is a linear strip of riparian plantings (approximately 60 m x 2 m) located at top of riprap dyke. Habitat is located between a Seaspan terminal to south and a compensation marsh downslope to north. Riparian vegetation is primarily overstory, dominated by *Populus balsamifera*, with infrequent *Alnus rubra* and exotic *Pinus sylvestris*. Several *P. balsamifera* have now exceeded 10 m height. Majority of site is absent of any shrub (82%), and instead vegetated by exotic grasses and forbs. Native understory shrubs are sparse and poorly established, only representing 8.5% of habitat area. Invasive *Rubus armeniacus* represents 10% of habitat area and 54% of understory vegetation. Together, the high % of unoccupied habitat and the presence of established *R. armeniacus* put this site at risk of invasive species encroachment long-term. Mitigation through native plantings and *R. armeniacus* removal is paramount to long-term success.

### Morphological Features

Site is a flat planting area located above riprap dyke. Dike slopes downwards to compensation marsh below.

### Impacts & Stressors

Required *Populus balsamifera* plantings are well-established, with no visible threats present. *Rubus armeniacus* accounts for 10% of site area. Understory habitat is largely unoccupied, and *R. armeniacus* threatens to colonize it over time.

### Wildlife Sightings/Evidence

None.

### Adjacent Land Use

Seaspan terminal (S, E). Compensation marsh directly downslope (N).

### Threatened Plant Species (Provincial/Federal)

None.

### Invasive Species

One invasive species was observed in habitat: *Rubus armeniacus*, with approximately 10% of total cover, representing about 54% of understory vegetation.

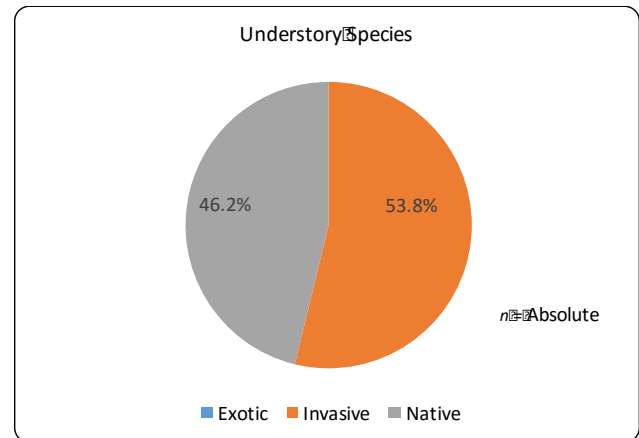
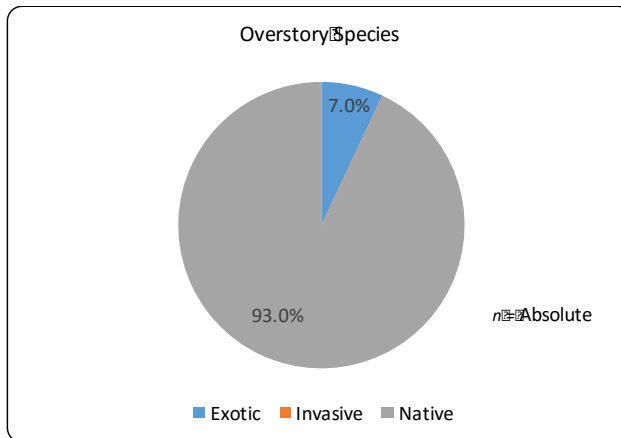
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	n	Description
1	141.5	100	Absolute	The site exceeds the area requirements for riparian habitat compensation habitat at 142 sqm. This was likely due to our inclusion of riparian vegetation that was not in compensation actions (e.g. <i>Salix</i> growing in riprap slope).

### Dominant Species

Community	Strata	Common Name	Scientific Name	Origin (N/T/E/I)	Stems/ha	Estimated Absolute % Cover	CI (95%)	n
1	overstory	black cottonwood	<i>Populus balsamifera</i>	N	2474.5	-	-	Absolute
1	overstory	red alder	<i>Alnus rubra</i>	N	353.5	-	-	Absolute
1	overstory	Scot's pine	<i>Pinus sylvestris</i>	E	212.1	-	-	Absolute
1	overstory	paper birch	<i>Betula papyrifera</i>	N	141.4	-	-	Absolute

### Origin Class Proportions (Based on % Cover)



### Compensation Assessment

Criterion	Target Percent	Actual Percent	Current Status	Predicted Trajectory
<b>1. Overstory: % Native Stems/ha</b>	100.0	93.0	Overstory is mostly native, with exception to exotic <i>Pinus sylvestris</i> , which is not interfering with habitat function. <i>Populus balsamifera</i> required at project outset have successfully established.	<i>Populus</i> are planted at a high density. Mortality will likely thin trees over time. Overstory is will continue to mature.
<b>2. Understory: Relative Percent Cover Native Species</b>	100.0	46.2	There is no indication that understory species were included in riparian plantings, as total understory species only cover 18% of site. Native shrubs are infrequent (46% of shrub cover), and invasive Himalayan blackberry is most prolific of understory species.	Site is not likely to be colonized by native shrubs. Unless actions are taken, habitat will likely either remain vacant in understory or will be colonized by <i>Rubus armeniacus</i> .

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	4	Remove existing <i>Rubus armeniacus</i> .	<i>Rubus armeniacus</i> currently accounts for 54% of understory vegetation, and 10% of site area. Much of understory habitat is unoccupied and is therefore under threat of <i>R. armeniacus</i> encroachment. Eliminate while still manageable.
Unplanted understory	4	Plant unvegetated understory with native riparian shrubs.	Planting of riparian shrubs was likely not a part of original works. Planting should be performed to (1) increase resilience of site to invasive plant encroachment long-term and (2) increase site productivity and habitat value.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
None			



Site# 10-006  
CPR# 0309F059

---

### *Background*

Site created in compensation for impacts to 600 sqm of riparian and 31 sqm intertidal marsh. Compensation actions included creation of riparian habitat by planting riparian vegetation at the top of bank and creation of a marsh bench. This project was originally submitted in 1997 under CPR No. 9708F073 but subsequently cancelled. The project was reactivated in 2003 under CPR No. 0309F059. Marsh bench was not sampled, as its location could not be verified in 2015. Habitat compensation goal = 250 sqm marsh, 420 sqm riparian habitat.

### *Description*

Site is a linear bench of riparian plantings (approximately 6 m x 120 m) located between a condo development and pedestrian walking trail to west and a riprap dike to east. Site substrate is fine grade riprap, likely with soil media beneath. No overstory vegetation is present. Understory vegetation is dominated by invasive *Rubus armeniacus*, which accounts for 90% of total vegetation and 75% of total riparian area. Original riparian plantings included at least 7 native species, as well as 2 exotic roses (*Rosa rugosa*, *Rosa canina*). Invasive blackberry is the greatest limiter to establishment of plantings, and will likely continue to decrease native plant diversity and abundance over time. Yard waste is being routinely dumped in localized areas of site, smothering native vegetation and potentially introducing exotic and/or invasive species to habitat.

### *Morphological Features*

Flat bench located at top of riprap dike. Riparian plantings placed in riprap, likely with soil media below.

### *Impacts & Stressors*

Invasive *Rubus armeniacus* currently represents 90% of riparian vegetation and is likely limiting establishment of native species. Yard waste is being continually dumped in localized areas of site, smothering native vegetation and potentially introducing exotic and/or invasive species.

### *Wildlife Sightings/Evidence*

None.

### *Adjacent Land Use*

Condo developments (N,W). Public walking trail runs parallel to site along west boundary. Site located on north bank of heavily-used South Arm of Fraser River.

### *Threatened Plant Species (Provincial/Federal)*

None.

### *Invasive Species*

One invasive species was observed in habitat: *Rubus armeniacus*, with approximately 75% total cover, representing 90% of riparian vegetation.

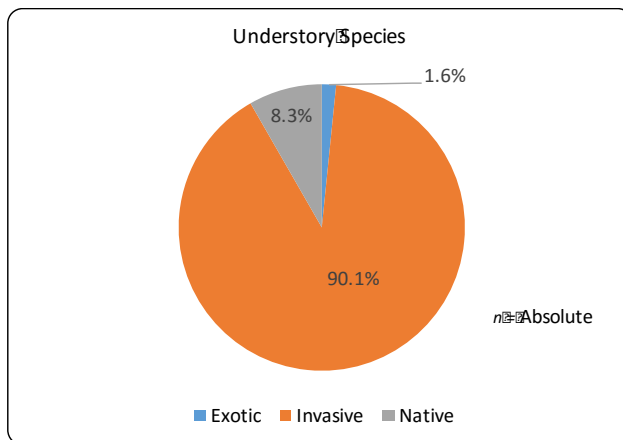
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	n	Description
1	728.0	100	Absolute	Riparian plantings at top of riprap dike. The site exceeds the area requirements for riparian habitat compensation habitat at 728 sqm. This was likely due to expansion of riparian vegetation from original site boundaries (i.e. downslope or overhanging rip rap dyke).

### Dominant Species

Community	Strata	Common Name	Scientific Name	Origin (N/T/E/I)	Stems/ha	Estimated Absolute % Cover	CI (95%)	n
1	understory	Himalayan blackberry	<i>Rubus armeniacus</i>	I	-	75.0	-	Absolute

### Origin Class Proportions (Based on % Cover)



### Compensation Assessment

Criterion	Target Percent	Actual Percent	Current Status	Predicted Trajectory
1. Overstory: % Native Stems/ha	100.0	n/a	No overstory species were observed.	Site will remain without overstory species unless natural colonization or planting actions occur.
2. Understory: Relative Percent Cover Native Species	100.0	8.3	Understory vegetation cover was 83% and the proportion of native species was 8%. Plantings were identified, but poor rocky substrate and displacement by <i>Rubus armeniacus</i> is hindering their establishment.	Without treatment of <i>R. armeniacus</i> , site is likely to be entirely overrun within next few years. Understory native species cover is expected to decline.

### Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	5	Remove existing <i>Rubus armeniacus</i> and replant habitat with native riparian shrubs.	<i>Rubus armeniacus</i> currently accounts for 75% of riparian vegetation and is displacing native plantings. Remove all <i>R. armeniacus</i> and monitor over multiple years to ensure effective removal. Plant treated areas with riparian species to (1) increase site resilience to invasive species and (2) increase habitat productivity and value.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Yard Waste Dumping	1	Monitor dumping of yard waste in riparian vegetation. If problem persists, discuss with strata and/or local government.	Several yard waste dumping areas occur in habitat, including both old and recent plant material. Monitor over time, and if problem persists consider involving strata and/or local government.





Site# 11-007  
CPR# 8611-0076

---

### Background

Compensation for impacts to river shoreline habitat in 1990. Impacts included pulling back of shoreline (hand dug around mature trees), resulting in loss of riparian vegetation. Site was replanted in 1991 with riparian vegetation to restore damaged habitat. Area of restoration was essentially terrestrial, as it was well above high water level. Habitat compensation goal = 270 sqm or linear m riparian habitat (likely the latter).

At time of survey, it was not known that some riparian compensation projects were recorded in linear meters. Because of this, there was a large discrepancy in sample area (>3000 sqm) and habitat compensation goal (270 m/sqm), which at the time of survey had been assumed to be sqm. Due to this confusion two vegetation communities were sampled, though we now suspect that Community 1 was the true compensation habitat.

### Description

Site is a planted strip of riparian vegetation located between an industrial park to south and edge of Annacis Channel to north. Two vegetation communities were identified for sampling due to boundary uncertainties at time of survey (see Background). Community 1 is located along top of dike. Overstory vegetation of Community 1 is dominated by mature *Populus balsamifera* and (*Alnus rubra*, which were present at time of original disturbance. Understory vegetation contains native species, but is dominated by invasive *Rubus armeniacus*. Community 2 is located slightly above Community 1, consisting of trees and occasional shrubs planted within manicured lawn next to a nearby industrial building. These trees and shrubs appear to be planted at time of compensation. Community 2 overstory is dominated by exotic *Liriodendron tulipifera* and native *A. rubra*. No established understory species are present in Community 2, as habitat is primarily mown. Primary stressor of Community 1 is invasive *R. armeniacus*, which constitutes 86% of understory vegetation, and is likely displacing original native plantings.

### Morphological Features

Community 1 is located along moderately-graded dyke. Some small grade riprap located at interface of Community 1 and 2 at top of slope, but is not visible throughout. Community 2 is a flat lawn surface located at top of dike next to building.

### Impacts & Stressors

Invasive species cover 83% of area in Community 1, likely displacing planted native species and limiting ability of native species to colonize. Illegal yard waste is being repeatedly dumped at east boundary of site (grass clippings, leaf litter), smothering native vegetation.

### Wildlife Sightings/Evidence

Coyote scat. Black-capped Chickadees in vegetation.

### Adjacent Land Use

Industrial park (S). Habitat located along south bank of Annacis Channel, frequently used by tugs and other mid-sized ships (N).

### Threatened Plant Species (Provincial/Federal)

None.

### Invasive Species

Two invasive species were sampled in Community 1: *Rubus armeniacus* and *Ilex aquifolium*, totaling a mean % cover of 83.2 +/- 12.3 (*R. armeniacus* = 83.0 +/- 12.2).

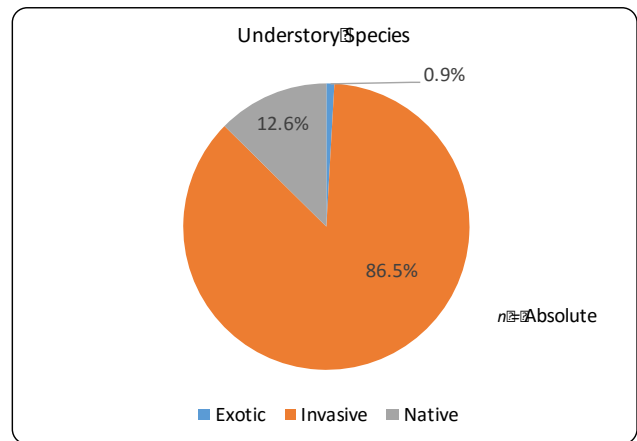
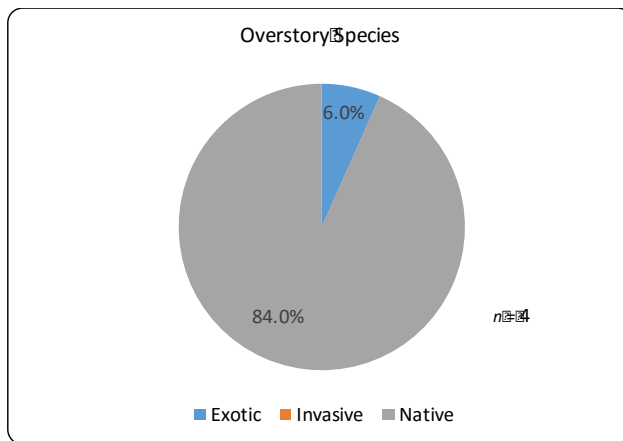
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	n	Description
1	1470.0	44.9	10	Riparian vegetation near top of dike slope. Mature trees present, likely preserved at time of disturbance.
2	1800.0	55.1	Absolute	Sparse trees and shrubs planted in mown lawn above dike.

### Dominant Species

Community	Strata	Common Name	Scientific Name	Origin (N/T/E/I)	Stems/ha	Mean/Absolute % Cover	CI (95%)	n
1	overstory	black cottonwood	<i>Populus balsamifera</i>	N	260.0	-	155.2	10
1	overstory	red alder	<i>Alnus rubra</i>	N	340.0	-	175.8	10
2	overstory	tulip tree	<i>Liriodendron tulipifera</i>	E	100.0	-	-	Absolute
1	understory	Himalayan blackberry	<i>Rubus armeniacus</i>	I	-	83.0	12.2	10

### Origin Class Proportions (Based on % Cover in Community 1)



### Compensation Assessment

Criterion	Target Percent	Actual Percent	Current Status	Predicted Trajectory
1. Overstory: % Native Stems/ha	100.0	84.0	Overstory vegetation of target habitat is well-established, including <i>Populus balsamifera</i> up to 30 m height.	<i>Alnus rubra</i> and <i>Populus balsamifera</i> are likely to continue maturing, with successional thinning over time.
2. Understory: Relative Percent Cover Native Species	100.0	12.6	Understory vegetation covers 96% of target habitat, 13% of which is native. <i>Rubus armeniacus</i> covers 83% of habitat.	Invasive <i>Rubus armeniacus</i> is likely to continue advancing in habitat. Other invasives, <i>Ilex aquifolium</i> and nearby <i>Clematis vitalba</i> may increase in abundance.

## Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	4	Remove <i>Rubus armeniacus</i> and <i>Ilex aquifolium</i> and replace with native riparian vegetation.	Invasive species currently account for 87% of all riparian vegetation. Target sparse <i>Ilex aquifolium</i> plants while still manageable. <i>Rubus armeniacus</i> is prolific, but should be addressed to increase habitat diversity and productivity. Removal of <i>R. armeniacus</i> would leave understory largely unvegetated. Replant all treated areas with appropriate native species to increase site resistance to future invasive colonization.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Illegal Yard Waste Dumping	1	Monitor yard waste dumping at east boundary over time. Discuss issue with property manager if necessary.	Yard waste is being dumped at east boundary of site, smothering riparian vegetation in small area. Landscapers of industrial lot are likely responsible. Monitor dumping area over time, and discuss issue with property owner if impact continues.



Site# 11-013  
CPR# 0404F036

---

**Background**

Compensation for loss of riparian habitat, intertidal marsh and intertidal mudflat. Works completed in 2004. During 2015 site visit, landowner stated that marsh was built in compensation for residential development, and that only appropriate native species were planted. Habitat compensation goal = 1050 sqm marsh, 200 linear m/sqm riparian habitats.

**Description**

Site is an approximately 160 m linear bench of riparian vegetation located at top of dyke. Habitat is bordered by a public trail and condo development to north, and rip rap dyke with compensation marsh to south. Plantings are healthy, but are yet to fully establish in habitat due to age (~10 years). All overstory species were <4 m height. Overstory species included exotic *Prunus cerasifera*, native *Tsuga heterophylla* and native *Betula papyrifera*. Understory vegetation covers 63% of habitat, and is dominated by native *Rosa nutkana*, native *Lonicera involucrata*, and native *Cornus stolonifera*. Several exotic tree and shrub species were included in plantings, constituting about 9% of understory vegetation. *Rubus armeniacus* was the only invasive species observed, only accounting for about 0.6% of all understory vegetation. Barring the addition of new stressors, site appears to be on trajectory to long-term success.

**Morphological Features**

Most of site is flat, however some plants were placed downslope where gradient increases.

**Impacts & Stressors**

Invasive *Rubus armeniacus* presently occupies 0.4% of site at present, and will likely advance over time.

**Wildlife Sightings/Evidence**

None.

**Adjacent Land Use**

~10-year-old condo development directly upland from marsh. Marina on river directly in front of marsh.

**Threatened Plant Species (Provincial/Federal)**

None.

**Invasive Species**

One invasive species was observed in habitat: *Rubus armeniacus*, with approximately 0.4% total cover, representing about 0.6% of riparian vegetation.

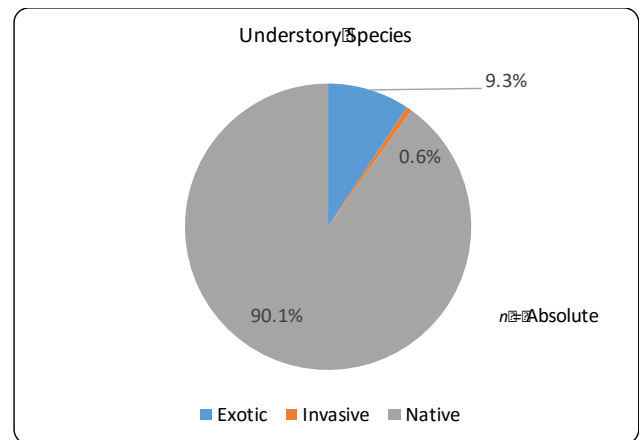
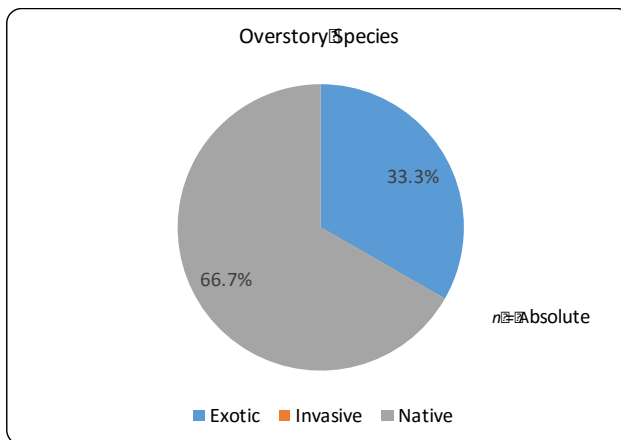
**Community Descriptions**

Community	Area (m <sup>2</sup> )	% of Total Area	n	Description
1	382.4	100	Absolute	Riparian plantings along top of dike, adjacent to walking trail and residential development.

### Dominant Species

Community	Strata	Common Name	Scientific Name	Origin (N/T/E/I)	Stems/ha	Estimated Absolute % Cover	CI (95%)	n
1	overstory	purple leaf plum	<i>Prunus cerasifera</i>	E	255.2	-	-	Absolute
1	overstory	western hemlock	<i>Tsuga heterophylla</i>	N	199.8	-	-	Absolute
1	overstory	paper birch	<i>Betula papyrifera</i>	N	199.8	-	-	Absolute
1	understory	Nootka rose	<i>Rosa nutkana</i>	N	-	23.6	-	Absolute
1	understory	black twinberry	<i>Lonicera involucrata</i>	N	-	13.9	-	Absolute
1	understory	red-osier dogwood	<i>Cornus stolonifera</i>	N	-	12.4	-	Absolute

### Origin Class Proportions (Based on % Cover)



### Compensation Success

Criterion	Target Percent	Actual Percent	Current Status	Predicted Trajectory
<b>1. Overstory: % Native Stems/ha</b>	100.0	66.7	Overstory species are still immature ( $\leq 4$ m) but appear healthy. Tree density of site is comparable to nearby natural and created habitats. Exotic species, <i>Prunus cerasifera</i> , is an ornamental, non-weedy species.	Trees have been planted between river and residential development. Residents may demand trees be reduced in height over time.
<b>2. Understory: Relative Percent Cover Native Species</b>	100.0	90.1	The total vegetation cover for the riparian habitat was 63% and the proportion of native species was 90%.	Vegetation cover is likely to increase over time, as plantings are dense and still establishing. Shrub height may be limited by future trimming/sheering.

### Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	4	Remove sparse patches of <i>Rubus armeniacus</i> .	<i>Rubus armeniacus</i> only occupies 0.4% of site and represents about 0.6% of vegetation. Eradicate all blackberry before plants can fully establish.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
None			



Site# 13-005

CPR# 9506-049

---

### *Background*

Riparian habitat planted in compensation for shoreline protection and development works. Site planted in 1997. Habitat compensation goal = 1530 sqm marsh, 7136 riparian habitat.

### *Description*

The site is a narrow strip of vegetation located alongside 1.5 km of public walking trail. Majority of site is placed between this public walking trail and top of riprap dyke, with exceptions in the southwest and north, where site instead borders pockets of mature riparian vegetation (see photos). Planted areas vary from 1-7 m in width. Exotic and native overstory species have been planted throughout site, but not at significant densities. Understory plantings are diverse (5 exotic and 15 native species), and are most dominated by native *Symphoricarpos albus*. Invasive species are not currently impacting site, but threaten to encroach from nearby infested habitats (e.g. remnant riparian forests, riprap slope) over time. Vegetation along much of site are being impacted by maintenance staff, who appear are hedging shrubs at 1.5 m height to maintain River sightlines.

### *Morphological Features*

Narrow strip of vegetation at top of riprap bank or along pockets of mature riparian forest. Habitat is flat, located above steep rip rap slope below.

### *Impacts & Stressors*

Invasive species are barely established in site, occupying about 0.7% of total area. Invasive species are more abundant in surrounding habitats (e.g. riprap dyke, remnant riparian forests) and may threaten to encroach in time. Nearly all shrubs are hedged to 1.5 m height to maintain Fraser River sightlines for public. As a result, vegetation is unable to provide same services as in non-manicured habitats.

### *Wildlife Sightings/Evidence*

Significant song bird activity in vegetation, including American Robin, Black-capped Chickadee, Song Sparrow, Dark-eyed Junco and Bushtit.

### *Adjacent Land Use*

Majority of site is located between riprap dyke and a public walking trail. Nearby land has been recently developed or is undergoing development. Remnant riparian forests are located adjacent to SW and N regions of site.

### *Threatened Plant Species (Provincial/Federal)*

None.

### *Invasive Species*

Two invasive species were sampled in habitat: *Buddleja davidii* and *Rubus armeniacus*, totaling a mean % cover of 0.9 +/- 0.7. *Cytisus scoparius* was observed in site incidentally, but was not sampled.

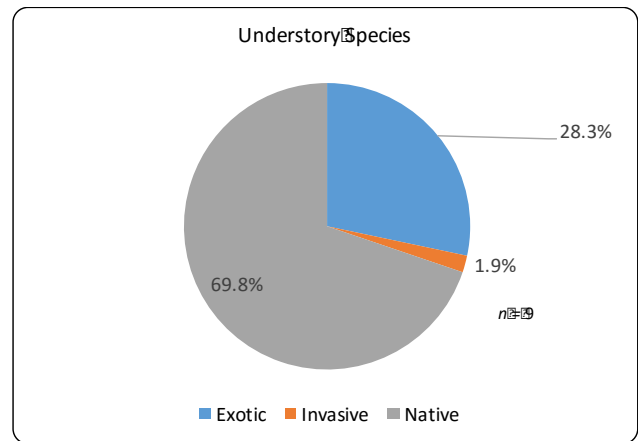
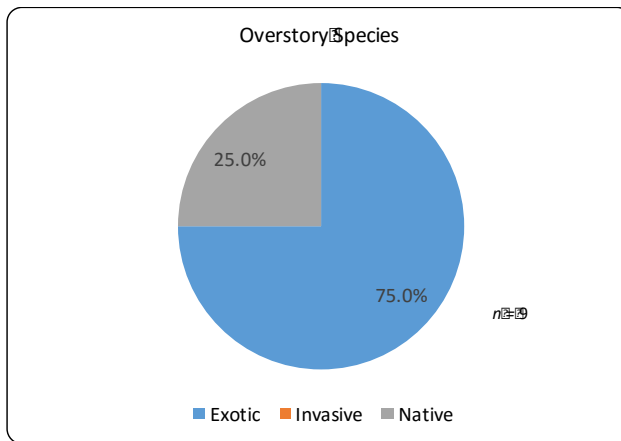
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	n	Description
1	7250.0	100	9	Plantings along public trail. Primarily at top of riprap dyke. The site exceeds the area requirements for riparian compensation at 7250 sqm. Area may not be precise, as (1) area calculations were made using measured length and a field-estimated mean width of total site and (2) accuracy of BIEAP-FREMP Atlas polygon is uncertain.

### Dominant Species

Community	Strata	Common Name	Scientific Name	Origin (N/T/E/I)	Stems/ha	Mean % Cover	CI (95%)	n
1	understory	snowberry	<i>Symphoricarpos albus</i>	N	-	20.7	19.5	9

### Origin Class Proportions (Based on % Cover)



### Compensation Assessment

Criterion	Target Percent	Actual Percent	Current Status	Predicted Trajectory
<b>1. Overstory: % Native Stems/ha</b>	100.0	75.0	Overstory species are still establishing, ranging from 1 -5 m height. Many exotic species were planted in favour of native species, including weedy <i>Sorbus aucuparia</i> , ornamental <i>Picea abies</i> and ornamental <i>Cercis canadensis</i> .	Trees are likely to be well-maintained by staff. Some risk of height-reducing pruning, as trees are located between residences and river.
<b>2. Understory: Relative Percent Cover Native Species</b>	100.0	69.8	The total vegetation cover for the riparian habitat was 78% and the proportion of native species was 70%. Most non-native vegetation was exotic, not invasive.	Invasive species such as <i>Rubus armeniacus</i> are unlikely to further colonize, as maintenance crews are likely to remove. Hedging of shrubs will continue to limit height of understory species.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Hedging	3	Discuss alternatives to current hedging of shrubs with maintenance staff.	Hedging is likely required in some areas to appease public. Collaborate with City of New Westminster to reduce impacts by designating "no trim zones".
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	3	Monitor encroachment of invasive species from surrounding habitats.	<i>Rubus armeniacus</i> only represents 0.9% of total site area. Site is at risk of encroachment from surrounding infested habitats. Monitor site long-term to ensure invasives remain unestablished.



## Site# 13-010

CPR# 9805F035

---

### Background

Creation of bench for planting of riparian and intertidal marsh vegetation. Constructed in compensation for riparian habitat and intertidal marsh habitat disturbed as a result of upgrade works to Front Street. Site completed in 1998. Alleged total marsh gain = 175 sqm marsh, 210 sqm riparian habitat.

### Description

Site is a rectangular (6 x 75 m) riparian bench constrained between a railway retaining wall (upslope) and rip rap dike (downslope). Nearly one third of site is situated above compensation marsh (see marsh file). Remainder of riparian habitat borders unrestored riprap shoreline. No overstory species were present, other than a single *Alnus rubra* that appears to have naturally colonized. Planted understory species are well-established, expanding beyond site boundaries, and now overhang riprap slope below. Understory vegetation is dominated by native *Physocarpus capitatus*, native *Lonicera involucrata* and invasive *Rubus armeniacus*. *Rubus armeniacus* currently occupies about 15% of site area and is displacing native vegetation in localized areas. Although not present in compensation area, site is at risk of encroachment by invasive *Clematis vitalba*, which is prolific in nearby habitats.

### Morphological Features

Flat riparian bench placed between cement retaining wall (upslope) and riprap dyke (downslope).

### Impacts & Stressors

Invasive *Rubus armeniacus* occupies about 15% of site area, and represents 14% of vegetation. Native vegetation is well-established, and there is only minor indication of native plant displacement by invasive blackberry.

### Wildlife Sightings/Evidence

Spotted Towhee and Song Sparrow in vegetation.

### Adjacent Land Use

Railway and Front Street (W). Compensation marsh along foreshore with several barges moored in river (E).

### Threatened Plant Species (Provincial/Federal)

None.

### Invasive Species

One invasive species was observed in habitat: *Rubus armeniacus*, with approximately 15% total cover and representing 14% of riparian vegetation.

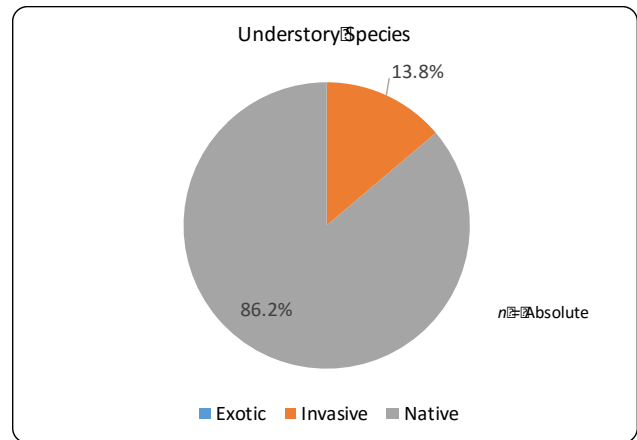
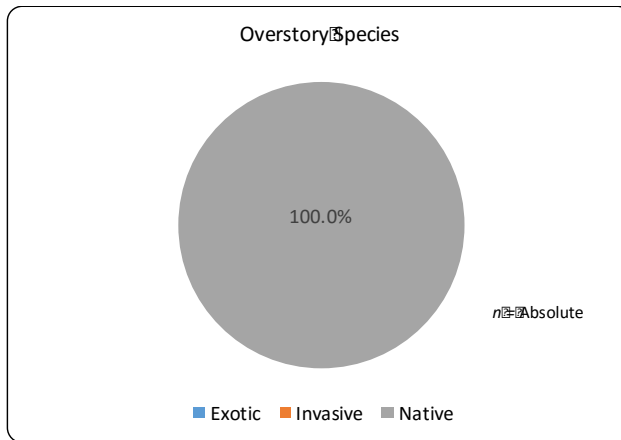
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	<i>n</i>	Description
1	452.2	100	Absolute	Planted bench at top of riprap dike The site exceeds the area requirements for riparian habitat compensation at 452 sqm. Site area has likely expanded due to expansion of planted riparian vegetation over time.

### Dominant Species

Community	Strata	Common Name	Scientific Name	Origin (N/T/E/I)	Stems/ha	Estimated Absolute % Cover	CI (95%)	n
1	understory	Pacific ninebark	<i>Physocarpus capitatus</i>	N	-	65.0	-	Absolute
1	understory	black twinberry	<i>Lonicera involucrata</i>	N	-	22.0	-	Absolute
1	understory	Himalayan blackberry	<i>Rubus armeniacus</i>	I	-	15.0	-	Absolute

### Origin Class Proportions (Based on % Cover)



### Compensation Assessment

Criterion	Target Percent	Actual Percent	Current Status	Predicted Trajectory
1. Overstory: % Native Stems/ha	100.0	100.0	No planted overstory species were observed. A single <i>Alnus rubra</i> has naturally colonized.	Site is likely to remain without significant overstory cover unless planting occurs.
2. Understory: Relative Percent Cover Native Species	100.0	86.2	The total vegetation cover for the site exceeds 100% and the proportion of native species was 86%.	Nearby infestation of <i>Clematis vitalba</i> may indicate threat of future colonization. <i>Rubus armeniacus</i> , although present, is unlikely to overwhelm site, as native vegetation is well-established.

### Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	3	Remove all invasives both in and immediately around site.	<i>Rubus armeniacus</i> currently occupies about 15% of site area, and should be treated while still manageable. Invasive <i>Clematis vitalba</i> occurs in nearby riparian vegetation and threatens to invade. Consider removing nearby invasives to reduce risk of encroachment over time.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
None			







Site# 13-012-B

CPR# 9606F058

---

### Background

Site constructed in compensation for riparian, intertidal marsh, and intertidal mudflat habitat disturbed during construction of Skytrain Millennium Line along the Fraser River. Intertidal marsh channel and benches were created and surrounding upslope habitat was planted with riparian vegetation. Habitat was constructed in 2000 and planted in 2001. Habitat compensation goal = 1781 sqm marsh, 5260 sqm riparian habitat.

### Description

Site consists of upland riparian plantings encircling a compensation marsh channel below (see marsh file). An armoured riprap bank separates marsh channel from upland riparian habitat. Habitat is located in Sapperton Landing Regional Park, and is encircled by a public walking path frequently used by pedestrians. Skytrain Millennium Line traverses west boundary of site. Overstorey species are abundant and well-established, many now approaching 10 m height. *Alnus rubra* is the most dominant tree species, however plantings included several native species such as *Acer macrophyllum*, *Thuja plicata* and *Pseudotsuga menziesii* among others. Understorey vegetation is also well-established, and now covers >100% of area due to high density of plants and overlapping of vegetative strata. Dominant understorey plants include invasive *Rubus armeniacus*, native *Crataegus douglasii*, exotic *Rosa canina*, and native *Malus fusca*. Although site is well-vegetated, *R. armeniacus* represents about 50% of total understorey vegetation, and is likely displacing native plantings. Further displacement will likely occur if it remains untreated.

### Morphological Features

Site gradually slopes from circular public pathway around to marsh channel at center. Riprap bank divides marsh and riparian habitats at base of slope.

### Impacts & Stressors

*Rubus armeniacus* represents 50% of all understorey species, and is displacing native plantings.

### Wildlife Sightings/Evidence

Old American Beaver damage on some mature trees. Nothing recent.

### Adjacent Land Use

Built within Sapperton Landing Regional Park. Public walking trail and bridges surround site.

### Threatened Plant Species (Provincial/Federal)

None.

### Invasive Species

One invasive species was observed in habitat: *Rubus armeniacus*, with approximately 60% total cover, and representing about 50% of total understorey riparian vegetation.

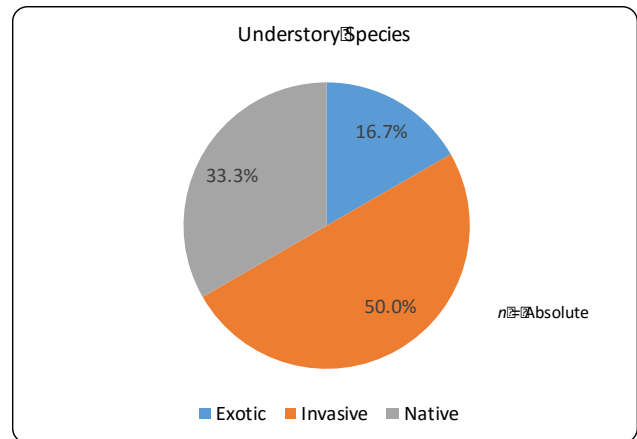
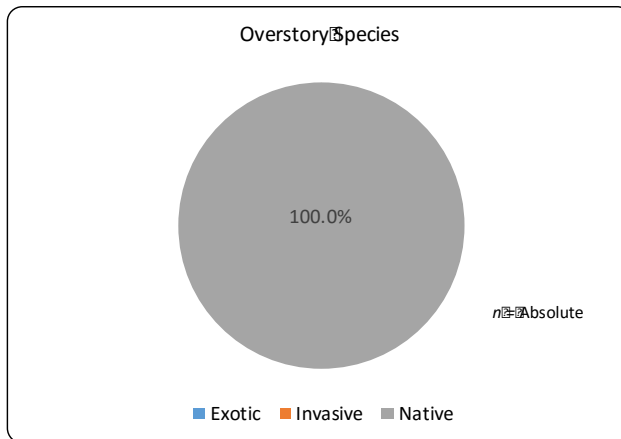
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	n	Description
1	5741.9	100	Absolute	Panted riparian habitat encircling compensation marsh channel below. The site exceeds the area requirements for riparian compensation habitat at 5742 sqm. Excess of ~500 sqm is likely the result of vegetation expansion, particularly in areas where vegetation now overhangs riprap at marsh interface.

### Dominant Species

Community	Strata	Common Name	Scientific Name	Origin (N/T/E/I)	Stems/ha	Estimated Absolute % Cover	CI (95%)	n
1	overstory	red alder	<i>Alnus rubra</i>	N	168.8	-	-	Absolute
1	understory	Himalayan blackberry	<i>Rubus armeniacus</i>	I	-	60.0	-	Absolute
1	understory	black hawthorn	<i>Crataegus douglasii</i>	N	-	25.0	-	Absolute
1	understory	dog rose	<i>Rosa canina</i>	E	-	20.0	-	Absolute
1	understory	Pacific crab apple	<i>Malus fusca</i>	N	-	10.0	-	Absolute

### Origin Class Proportions (Based on % Cover)



### Compensation Assessment

Criterion	Target Percent	Actual Percent	Current Status	Predicted Trajectory
<b>1. Overstory: % Native Stems/ha</b>	100.0	99.2	Overstory plantings were diverse, including 9 native species and 1 exotic species. A mixture of coniferous and deciduous trees was used. At 235 stems/ha, tree density is comparable to nearby natural riparian habitats.	Many trees are tall enough to no longer be threatened by <i>Rubus armeniacus</i> . <i>Alnus rubra</i> density will likely be reduced as trees thin during succession.
<b>2. Understory: Relative Percent Cover Native Species</b>	100.0	33.3	Site was adequately planted but has since been overrun by <i>Rubus armeniacus</i> , which represents 50% of understory vegetation. Exotic <i>Rosa canina</i> was also included in plantings, perhaps as a substitute for <i>Rosa nutkana</i> .	<i>Rubus armeniacus</i> is likely to continue expansion. Establishment of overstory may hinder further expansion of <i>R. armeniacus</i> in localized areas.

*Recommendations*

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Invasive Species	5	Remove or mitigate impacts of <i>Rubus armeniacus</i> .	Himalayan blackberry now comprises 50% of total site vegetation and is displacing original native plantings. Remove manually or chemically to promote long-term establishment of native plantings.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
None			



Site# 15-003-A

CPR# 0705F024

---

### Background

Compensation for habitat lost in creation of new Pitt River Bridge. Construction actions lead to the loss of 579 sqm subtidal, 4302 sqm unvegetated intertidal, and 4925 sqm riparian fish habitat. Overall compensation project aimed to compensate through creation of 2700 sqm subtidal, 3529 sqm unvegetated intertidal, and 7085 sqm riparian fish habitat. Compensation actions were completed in 2010, and site was monitored by Hatfield and Golder till 2015 (see Monitoring descriptions below). Compensation habitat goal (at this site specifically) = 1293 sqm riparian habitat.

A preliminary site visit in 2011 noted that habitats north and south of bridge were not planted to prescription and required supplemental work. Approximately 70% of plantings survived, and soil compaction was noted along upper slope. Recommended supplemental actions included the addition of topsoil, and in-fill planting of *Rosa nutkana* and *Populus balsamifera*. A follow-up site visit in 2011 noted that in-fill plantings had been completed, and natural regeneration of *Alnus rubra* and *P. balsamifera* was occurring. Hatfield (2012) noted 70% survivorship of plantings (significant mortality) and establishment of *Phalaris arundinacea* in site. Similar to 2011, Hatfield recommended the addition of topsoil (400 mm thick) be placed on top of slope, and that additional plantings occur. Species were recommended based on their ability to survive well-drained soils for top of slope (e.g. *Rosa gymnocarpa*, *Amelanchier alnifolia*), and for their ability to shade out *P. arundinacea* at bottom of slope (e.g. *Salix* spp.). Golder (2013) noted that topsoil had been added to site, and prescribed plantings were completed. Survivorship of native plantings was estimated at 90%, with varying degrees of plant health. Invasive species were noted throughout area, and recommended actions included management of *Rubus armeniacus*, hand pulling of weedy species rosettes from bare soil, terraced application, and mechanical control of *P. arundinacea*. Later monitoring by Golder (2014) noted that native plantings were healthy (90% survivorship) but experienced little growth from 2013. Weedy species were likely untreated in 2013, resulting in dense proliferation and cover of non-native and invasive species by 2014. The ISCMV later chemically-treated several weedy species. Recommended follow-up actions for 2015 included removal of exclusion fencing and rebar, assessment of herbicide success, management of weedy species, (including *P. arundinacea*) and optional supplemental planting.

### Description

Site is located on west bank of Pitt River, and includes a planted riparian hillside bisected by the shadow of Pitt River Bridge. Habitat is bordered by Traboulay Poco trail to west and Pitt River to east. Habitats north and south of bridge slope downwards from public trail to intertidal marsh - an elevation difference of approximately 7 m. Vegetation at top of slope indicated drier, less productive conditions than plants further downslope. Soil substrate is predominantly coarse mineral material at top of slope, creating dry nutrient-poor conditions that appear problematic to planting health. Overstory species are dominated by re-colonizing *Alnus rubra* and *Populus balsamifera*. Significant mortality of naturally-established both species was noted in summer 2015, but represented only a fraction of total trees and is likely a natural process of succession. Understory species are yet to establish in any of the site, and plant growth is likely hindered by dry conditions (upslope) and competition by invasive *Phalaris arundinacea* (downslope). Treatment of invasive species appears successful, as woody invasives only represented about 1.6 +/- 1.0% of site area. Several pockets of invasive *Rubus armeniacus* remain untreated directly adjacent to site (e.g. under bridge, southwest boundary) and threaten to encroach over time if not monitored. Site productivity is likely the strongest filter limiting project success, evident in poor growth of plantings at top of slope. Establishment of *A. rubra* and *P. balsamifera* is following natural patterns of succession, but site will be at risk of invasive species until vegetation is well-established.

### Morphological Features

Habitat slopes from top of dyke (adjacent to PoCo trail) down to intertidal. No evidence of erosion along slope. Soil substrate is coarse mineral and well-drained, limiting productivity at top of slope.

### Impacts & Stressors

Invasive species represent 16% of understory vegetation. Anthropogenic impacts include tearing down of exclusion fencing, removal of ISCMV signage, and an unsanctioned access trail in habitat south of bridge, leading to a small memorial.

### Wildlife Sightings/Evidence

Bushtits in riparian vegetation.

### Adjacent Land Use

Belfast Street and Highway infrastructure to west. Public Traboulay PoCo Trail along upslope. Mature riparian forest and marsh shoreline to north.

### Threatened Plant Species (Provincial/Federal)

None.

### Invasive Species

One invasive species was sampled in riparian habitat: *Rubus armeniacus*, totaling a mean % cover of 1.6+/- 1.0 over both communities. *Cytisus scoparius*, *Hypericum perforatum* and *Phalaris arundinacea* were observed incidentally in the habitat.

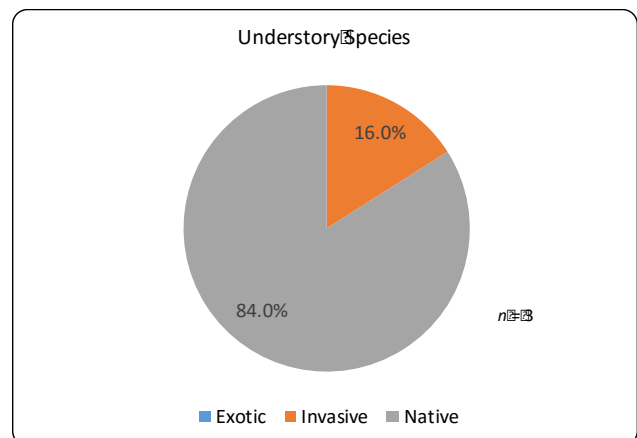
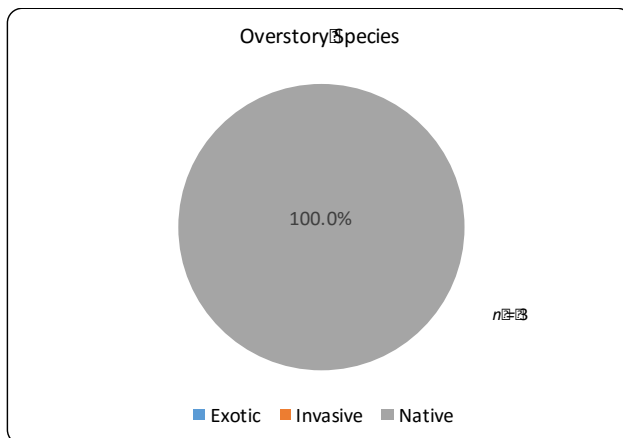
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	n	Description
1	523.0	40.2	3	Riparian hillslope north of Pitt River Bridge
2	770.0	59.2	3	Riparian hillslope south of Pitt River Bridge

### Dominant Species

Community	Strata	Common Name	Scientific Name	Origin (N/T/E/I)	Stems/ha	Mean % Cover	CI (95%)	n
1	overstory	black cottonwood	<i>Populus balsamifera</i>	N	1533.3	-	1589.6	3
1	overstory	red alder	<i>Alnus rubra</i>	N	200.0	-	392.0	3
2	overstory	black cottonwood	<i>Populus balsamifera</i>	N	933.3	-	1829.3	3

### Origin Class Proportions (Based on % Cover - Communities 1 & 2 Combined)



### Compensation Assessment

Criterion	Target Percent	Actual Percent	Current Status	Predicted Trajectory
<b>1. Overstory: % Native Stems/ha</b>	100.0	100.0	Stem density of site far exceeds that of natural riparian conditions at ~1600 stems/ha. <i>Alnus rubra</i> and <i>Populus balsamifera</i> appear to have colonized site naturally.	Over time stem density will decline as natural succession occurs. <i>Alnus rubra</i> and <i>Populus balsamifera</i> mortalities were observed throughout site.
<b>2. Understory: Relative Percent Cover Native Species</b>	100.0	84.0	The total understory vegetation of the site is 8.3% and the proportion of native species is 84%. Low understory cover reflects age of plantings (< 5 years), as well as low productivity of site due moisture and nutrient limitations of soil substrate.	Site was sampled while monitoring was still occurring. Abundance of disturbed, low-nutrient substrate may promote colonization and displacement by invasive species over time. Native plants are likely to survive, but poor conditions will likely hinder their speedy establishment.

### Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Bare Ground/Invasive Species	5	Remove all invasive species, and monitor growth of plantings to ensure adequate density over time.	Native plantings have been slow to establish. As a result, much of habitat is suitable for invasive species colonization. Continue to treat all invasives in site, and begin treating plants adjacent to site (e.g. <i>Rubus armeniacus</i> under bridge & southwest of site). Density existing plantings to increase site resilience.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Anthropogenic Impacts	2	Monitor site to ensure unsanctioned trails and litter are not impacting site.	Site is directly adjacent to well-used PoCo trail. Anthropogenic impacts are insignificant at present time, but site should be monitored to ensure illegal dumping, unsanctioned trails and other impacts are not occurring.





Site# 15-003-B

CPR# 0705F024

---

### Background

Compensation for habitat lost in creation of new Pitt River Bridge. Construction actions lead to the loss of 579 sqm subtidal, 4302 sqm unvegetated intertidal, and 4925 sqm riparian fish habitat. Overall, project aimed to compensate through creation of 2700 sqm subtidal, 3529 sqm unvegetated intertidal, and 7085 sqm riparian fish habitat. Compensation actions were completed in 2010, and site was monitored by Hatfield (2011-2012) and Golder (2013-2014) till 2015 (see monitoring descriptions below). Alleged total riparian habitat gained (at this site specifically) = 8019 sqm.

#### Habitat north of Pitt River bridge:

Preliminary 2011 monitoring indicated that habitat had not been planted to prescription. Supplemental planting of *Populus balsamifera* was recommended in areas of site and was carried out later that year. *Rubus armeniacus* and *Polygonum cuspidatum* were recommended for removal. A 2012 follow-up report by Hatfield indicated that survivorship of plantings was adequate, however more plantings were recommended in some areas to increase density and cover of vegetation. Golder (2013) noted that survivorship of plantings remained high, although plants were growing slowly due to soil compaction and poor drainage. Minor infill plantings were recommended in portions of habitat. Several native graminoid species were observed to have colonized site, as well as invasive *Phalaris arundinacea*, *Cytisus scoparius*, and *Lythrum salicaria*. Golder recommended management of *C. scoparius* and *L. salicaria*. A revisit by Golder in 2014 noted ATV tracks and damage in site. The ISCMV conducted chemical treatment of *R. armeniacus*, *P. arundinacea* and *Cirsium arvense* in 2014, with follow up-treatment scheduled for Spring 2015.

#### Habitat south of Pitt River bridge:

Preliminary 2011 monitoring identified *Polygonum cuspidatum* in habitat, and noted that area had not been planted to prescription. Supplemental planting of *Populus balsamifera* was recommended in areas of site. Additional plantings were carried out later in 2011 and *P. cuspidatum* was removed. 2012 monitoring by Hatfield indicated that riparian plantings were increasing in size with exception to *Acer macrophyllum*, which displayed significant mortality. *Polygonum cuspidatum* was still present, although less abundant, and *Phalaris arundinacea* had established along south margin. To combat mortality of maple and expansion of *P. arundinacea*, additional infill plantings were recommended. Treatment of remaining *P. cuspidatum* was also recommended. Golder (2013) noted that plantings were healthy, and that natural colonization of *P. balsamifera* from nearby seed sources was strong. A follow-up report by Golder (2014) noted that the ISCMV chemically treated several invasive species, including *P. cuspidatum*, *R. armeniacus*, and *C. scoparius*. Monitoring of chemical treatment success was recommended for 2015.

### Description

Site is a large riparian floodplain bisected by shadow of Pitt River bridge. Habitat is bordered by a small riprap slope to the northwest, with compensation marsh below (see marsh file). Remainder of backshore is bordered by steep riprap dyke, with public Trans Canada trail above. Site contains several shallow pools of standing water, likely the result of flat gradient and compacted soil. A combination of native plantings and native tree colonization has resulted in high densities of overstory species both north and south of Pitt River Bridge. Overstory species are dominated by pioneer *Populus balsamifera* and *Alnus rubra*. With the exception of *Spiraea douglasii*, understory species remain sparse and unestablished throughout site. Invasive species only occupy 1.3 +/- 1.5 of site area at present, representing 6% of total vegetation. Low invasive cover likely reflects management efforts of 2011-2015 site monitoring (see site background). Due to soil compaction and poor site drainage, planted vegetation has been slow to establish site. As a result, site is only 20% vegetated, with high risk of invasive species encroachment into habitat over time.

### Morphological Features

Site is flat floodplain located below backshore rip rap dyke. Compacted soil and flatness of site have resulted in shallow pools of standing water throughout.

### Impacts & Stressors

Evidence of anthropogenic use (footprints) throughout site. An active illegal camp is located in habitat below bridge. Soil compaction and poor drainage are limiting growth of plantings.

### Wildlife Sightings/Evidence

Coyote observed nearby and scat found on site.

### Adjacent Land Use

Creosote log storage upslope of site (S). Trans Canada Trail parallels site at top of dike (E). Interfaces intact riparian habitat (NE).

### Threatened Plant Species (Provincial/Federal)

None..

### Invasive Species

Three invasive plants were sampled in habitat: *Cytisus scoparius*), *Rubus armeniacus*, and *Rubus laciniatus*, totaling a mean % cover of 1.3+/-1.5. Sporadic patches of *Phalaris arundinacea* and *Lythrum salicaria* were incidentally observed. Patches of living *Polygonum cuspidatum* are present under bridge.

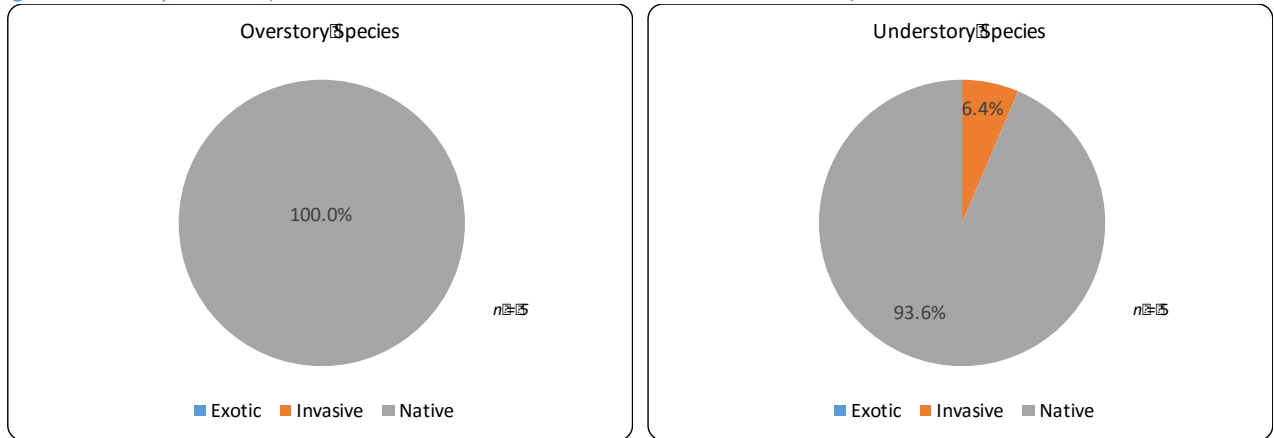
### Community Descriptions

Community	Area (m <sup>2</sup> )	% of Total Area	n	Description
1	4813.0	59.3	5	Constructed riparian floodplain north of bridge.
2	3302.9	40.7	5	Constructed riparian floodplain south of bridge.

### Dominant Species

Community	Strata	Common Name	Scientific Name	Origin (N/T/E/I)	Stems/ha	Mean % Cover	CI (95%)	n
1	overstory	black cottonwood	<i>Populus balsamifera</i>	N	8420.0	-	3513.5	5
1	overstory	red alder	<i>Alnus rubra</i>	N	8420.0	-	7659.8	5
2	overstory	western redcedar	<i>Thuja plicata</i>	N	2120.0	-	3509.6	5
2	overstory	Douglas-fir	<i>Pseudotsuga menziesii</i>	N	1200.0	-	2352.0	5
2	understory	Sitka spruce	<i>Picea sitchensis</i>	N	-	15.6	18.1	5

Origin Class Proportions (Based on % Cover - Communities 1 & 2 combined)



Compensation Assessment

Criterion	Target Percent	Actual Percent	Current Status	Predicted Trajectory
<b>1. Overstory: % Native Stems/ha</b>	100.0	100.0	Stem densities are extremely high, as habitat has been heavily colonized by native <i>Alnus rubra</i> and <i>Populus balsamifera</i> . No non-native overstory species were identified in site.	Stem density will likely decline over time due to successional competition. Likely to become a <i>Populus balsamifera</i> / <i>Alnus rubra</i> dominated floodplain over time, with infrequent conifers growing in understory.
<b>2. Understory: Relative Percent Cover Native Species</b>	100.0	93.6	The total understory vegetation cover of the site is 20% and the proportion of native species is 94%. Low understory cover reflects age of plantings (< 5 years), as well as low productivity of compacted, poorly-drained soil.	Poor soil quality, degree of exposed soil, and abundance of invasives in nearby habitat put site at risk of invasive dominance over time. Difficult to predict current trajectory, as site invasives have been managed till this year. As monitoring actions cease, site is likely to face increased threat of non-native understory species.

Recommendations

Mitigation			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Bare Ground/Invasive Species	5	Remove all invasive species, and monitor growth of plantings to ensure adequate density over time.	Native plantings have been slow to establish. As a result, much of habitat is suitable for invasive species colonization. Continue to treat all invasives until density of native species is adequate to resist encroachment. Continue to treat <i>Polygonum cuspidatum</i> until completely eliminated.
Monitoring			
Impact	Priority Rank (1 Low - 5 High)	Action Required	Comments
Anthropogenic Impacts	2	Monitor site to ensure unsanctioned trails and litter are not impacting site.	Site is directly adjacent to well-used Trans Canada trail. Anthropogenic impacts are insignificant at present time, but site should be monitored to ensure illegal dumping, unsanctioned trails and other impacts are not occurring.

