Bridge River Power Development Water Use Plan

Carpenter Reservoir Drawdown Zone Re-Vegetation Program

Implementation Year 1

Reference: BRGWORKS-1

Period: 2014

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Executive Summary

2014 was the phase 1 of the BRGWORKS-1 five year re-vegetation project on Carpenter Reservoir drawdown zone. Four terrain types and 5 elevation bands were planted with 1X1m test plots with one of 7 native forb species. In total 7652 plugs were planted and 1521 cottonwood (*Populus balsamifera ssp trichocarpa*) and willow (*Salix sp*.) live stake cuttings were installed. Plugs were planted out by hand, cuttings were planted using a combination of hand planting in areas as well as employing an excavator to dig 1.5-2m deep trenches for cuttings. All planting sites were monitored for site conditions, vegetation cover and wildlife sign prior to planting. Plots were monitored for survival 3 months post planting. Following the objectives of Phase 1 from the TOR (BC Hydro 2014), Based on the predicted water pool levels for Carpenter Reservoir in 2014 planting locations were chosen to test species, microsites, and elevations on four types of terrain which were categorized as having the highest potential for successful revegetation within the targeted re-vegetation zone. These terrain types included: steep beach, shallow beach, the Gun Creek fan, and a south shore alluvial fan. Research was carried out to establish the best technique for monitoring dust storm frequency at the project target site. A programmable weather station with data collection and a digital camera was assembled and ordered for installation. A public survey was compiled and surveys were distributed and assembled online to gather feedback from local residents on their perceptions and use of the area. The survey data will be used to provide information to assess potential shifts in aesthetic perception and recreational use of the Reservoir and in particular the WORKS-1 project area. Wildlife sign at each planting site was recorded; evidence of mule deer (*Odocoileus hemionus*) presence was the most frequently recorded observation. We communicated with Bridge Seton WUP project managers running aquatic studies that overlapped the WORKS-1 Revegetation Zone. We requested that their studies consider potential effects the WORKS-1 revegetation effort may have on the aquatic habitat.

Table 1 BRGWORKS 1 STATUS 2014

OBJECTIVES, MANAGEMENT QUESTIONS and HYPOTHESES after 2014			
Study Objectives	**Management Questions**	**Management Hypotheses**	**Year 2014 (Status)**
1To design and implement a reservoir planting program for the Western end of Carpenter Lake focusing on the area between Tyaughton Lake Road Junction and the Gun Creek Fan.	H1 Will the planting of vegetation in the drawdown area mitigate the effects of dust storms resulting from reservoir drawdown particularly in the western end of the reservoir near the Town of Gold Bridge?	1 The planting of vegetation in the drawdown area does not mitigate the effects of dust storms resulting from reservoir drawdowns particularly in the western end of the reservoir near the Town of Gold Bridge.	Initial observations indicate dust is generated from areas of fine sands located along the river channel banks at low pool times of year March –June. This area will be targeted in future for dust mitigation trials. Closer monitoring to come with weather station installation in 2016
2 To focus on the planting of appropriate species of vegetation this is done using information gained in the BRGMON 2 program.1	H2 Will the planting of vegetation in the drawdown area increase the aesthetic quality and recreational opportunities in the western end of the reservoir? 1	2 The planting of vegetation in the drawdown area does not increase the aesthetic quality and recreational opportunities in the western end of the reservoir.1	Public survey conducted to assess perceptions of reservoir aesthetic and recreational use of region pre planting. Also included questions regarding wildlife and dust storm
To conduct evaluations of the program to assess the degree to which the planting program helps to establish natural re-colonization of the area from Tyaughton Lake Road Junction to Gun Creek Fan (This will be covered under the BRGMON2 program)2	H3- Will the planting of vegetation enhance the quality of riparian habitats to increase their potential to support wildlife populations and provide localized improvements in the quality and productivity of aquatic habitats in the reservoirs? 2	3- The planting of vegetation in the drawdown area does not enhance the quality of riparian habitats to increase their potential to support wildlife populations and provide localized improvements in the quality and productivity of aquatic habitats in the reservoirs. --2	Wildlife observations recorded at sites of re-vegetation as part of baseline data collection.
To conduct evaluations of the program in order to assess the degree to which the planting program helps enhance the quality of riparian habitats, increases their potential to support wildlife populations, and provide localized improvements in the quality and productivity of aquatic habitats in the reservoir.---	H4 Will planting of vegetation provide localized improvements in the quality and productivity of aquatic habitats in the reservoir ----	The planting of vegetation in the drawdown area does not enhance the quality and productivity of aquatic habitats in Carpenter Reservoir.	In communication with BRGMON 4 (Carpenter Reservoir and Middle Bridge River Fish) and BRGMON 10 Carpenter Reservoir Productivity Model, Study programs to include consideration of WORKS 1 Revegetation region in their studies.

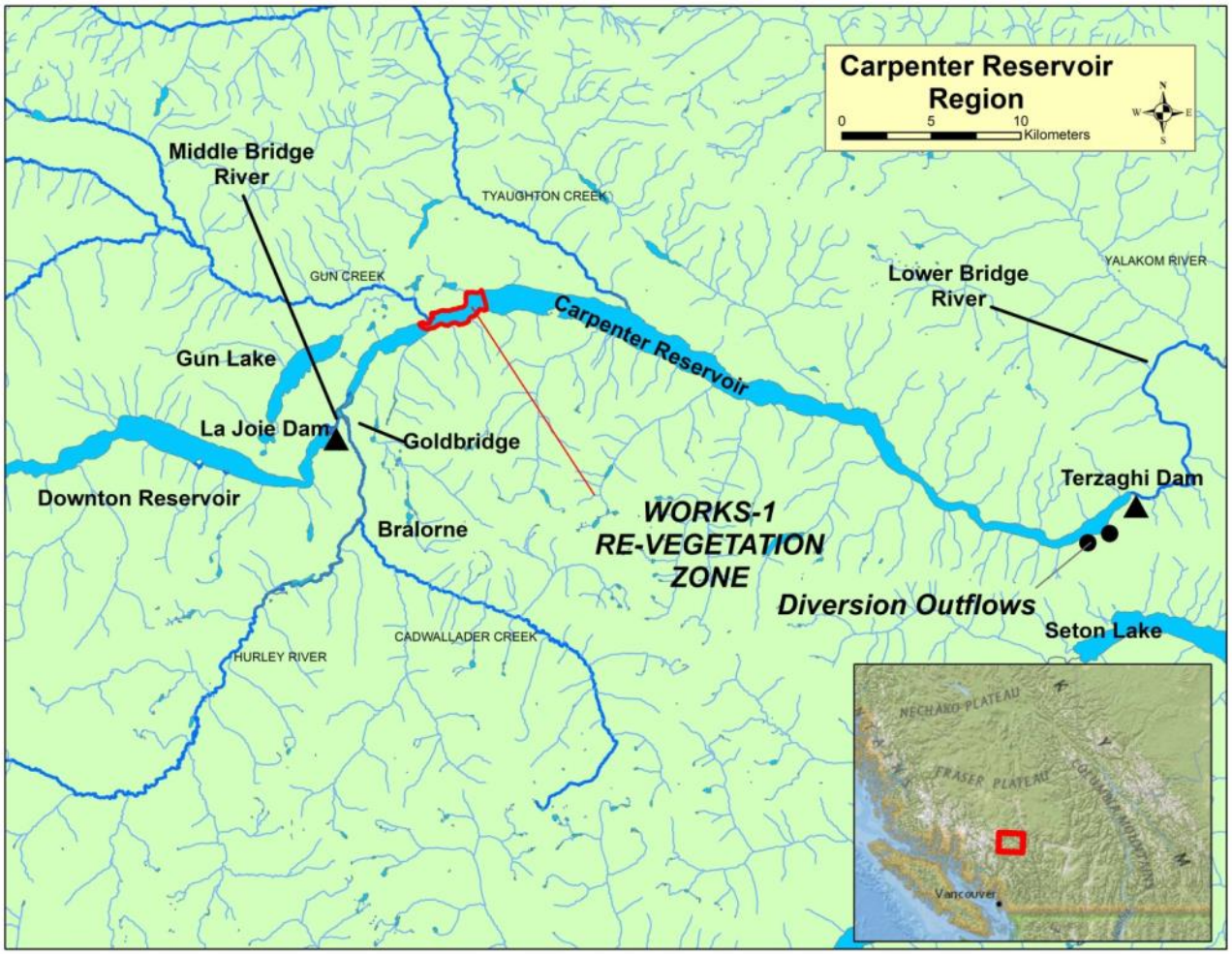


Figure 1 Carpenter Reservoir Region and geographic location in the province. 292 ha targeted re-vegetation region of the Carpenter Reservoir WORKS-1 Re-vegetation Project.

Introduction

2014 was the first year of implementation of the BRGWORKS-1 five year re-vegetation project on Carpenter Reservoir drawdown zone. The objectives of the BRGWORKS-1 project are to identify appropriate species of vegetation and effective methods for re-vegetation and promotion of natural re-colonization in the drawdown zone area of Carpenter Reservoir. The targeted drawdown zone area lies between Tyaughton Lake Road Junction and the Gun Creek Fan (Figure 1). This initial year of field work was designed to carry out trial plantings within the targeted WORKS-1 re-vegetation area as dictated by the Terms of Reference and accepted proposal for the project (BC Hydro, 2014). The initial year focused efforts on planting test plots and was influenced by;

1. Timing constraints imposed by the official project approval date of June 24th 2014
2. Predicted reservoir inundation level and rate.

Based on the real and predicted parameters for 2014, test plots were targeted for drawdown zone elevations between 644m and 649m within the targeted revegetation zone

Scope and Management Questions

The scope of the WORKS program as identified by the Bridge River Water Use Plan Consultative Committee is as follows:

1) To design and implement a reservoir planting program for the western end of Carpenter Lake, focusing on the area between Tyaughton Lake Road Junction and the Gun Creek Fan.
2) To focus on the planting of appropriate species of vegetation (This will be done using information gained in the BRGMON-2 program. A supportive argument must be made on the choice of species).
3) To conduct evaluations of the program to assess the degree to which the planting program helps to establish natural re-colonization of the area from Tyaughton lake Road Junction to Gun Creek Fan (This will be covered by the BRGMON 2 program).
4) To conduct evaluations of the program in order to assess the degree to which the planting program helps enhance the quality of riparian habitats, increase their potential to support wildlife populations, and provide localized improvements in the quality and productivity of aquatic habitats in the reservoir

BACKGROUND

Terzaghi dam construction was completed in 1960, enlarging the former Mission Dam and forming Carpenter Reservoir. Based on the Water Comptrollers order Sections 87 and 88, Carpenter Reservoir's targeted operating levels are above the minimum level of 606.55 masl and 648 masl at high pool for the end of August. The 648m target for full pool leaves a 3.08m buffer zone to provide water holding space to prevent the need to spill water through Terzaghi and into the Lower Bridge River. The buffer zone was implemented into the Carpenter water management strategy after a major spill event down the Lower Bridge River in the 1990's that caused damage to fish habitat and lead to a lawsuit against BC Hydro by Department of Fisheries and Oceans.

The intention of BRGWORKS-1 is to fulfill the *Order* issued by the Comptroller of Water Rights on 30 March 2011. The *Order* states that BC Hydro shall implement a short term re-vegetation program to mitigate the effects of dust storms, increase the aesthetic quality, enhance the quality of riparian habitats, and provide localized improvements in the quality and productivity of aquatic habitats in areas affected by the drafting of Carpenter Lake Reservoir (as stated in Schedule A). The 292 ha area of focus lies at the western end of Carpenter Reservoir from the Gun Creek Fan to the Tyaughton Road, Hwy 40 junction (Figure 2).

243 ha of the target region is terrestrial when the reservoir is drawn down below the 636m elevation. The zones to be re-vegetated span elevations from 636m in the reservoir to the

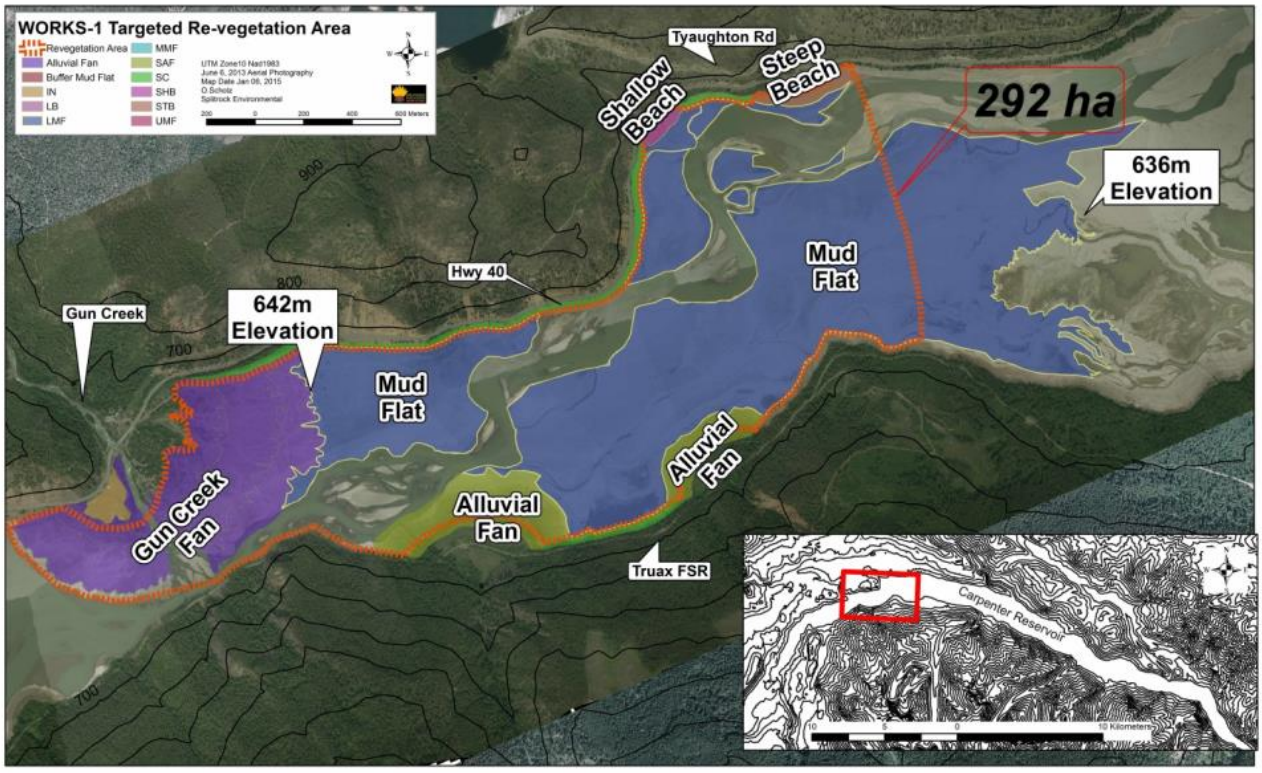


Figure 2 . 292 ha targeted re-vegetation region of the Carpenter Reservoir WORKS-1 Re-vegetation Project.

upper buffer zone between 648 and 651m. The 5 year project's intent is to vegetate to mitigate dust storms, increase aesthetic quality and enhance the quality of riparian habitats and the quality and productivity of localized aquatic habitats. By planting and seeding into areas of the reservoir the intention is to promote the natural recruitment of native plant species through planting and seeding areas thereby speeding up natural succession. An early evaluation of planting success was conducted in late summer after plantings had been completed.

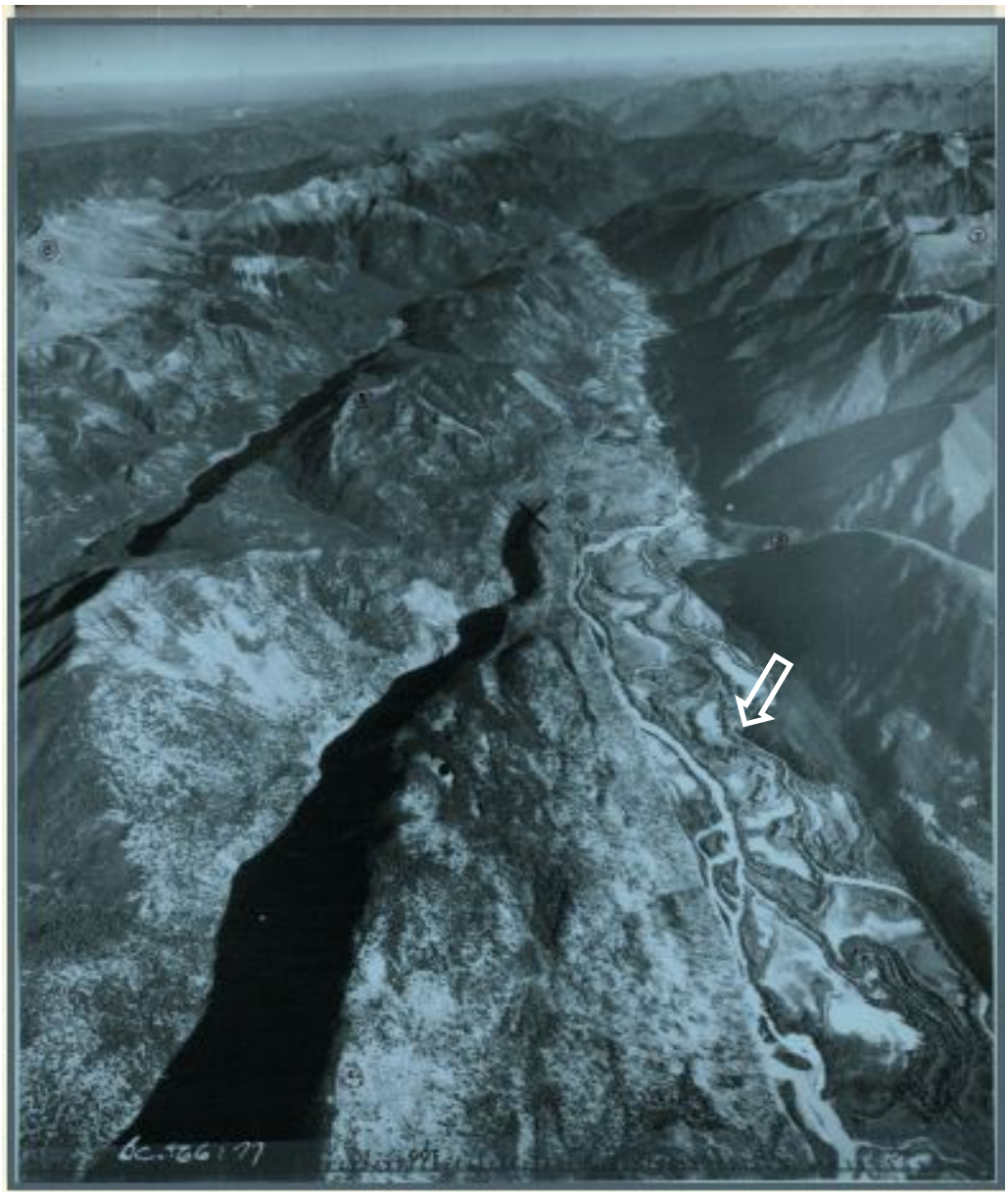
In addition to field trials the first year of the WORKS project included a review of other reservoir drawdown zone re-vegetation projects in British Columbia including the Arrow Lakes and Kinbasket systems.

Region

Carpenter Reservoir is located approximately 280km north-east of Vancouver British Columbia on the eastern edge of the Coast Range Mountains (Figure 1). The Upper Bridge River is formed largely from melt water off the Bridge Glacier in the Coast Mountains. The Upper Bridge flows into Downton Reservoir, through La Joie Dam into the Middle Bridge and into Carpenter Reservoir where the bulk of the water is diverted through Mission Mountain into Seton Lake, a portion of water is passed through Terzaghi Dam and down the Lower Bridge River into the Fraser River (Figure 1). Carpenter Reservoir captures the flow of several other large rivers namely the Hurley River, Tyaughton Creek and Gun Creek as well as numerous smaller snowmelt fed creeks that enter the reservoir across its 75km span. Carpenter Reservoir water

Figure 3 Historical air photo of Bridge River valley looking south east with Tyaughton Creek entering the Bridge River valley at the center of the frame. Marshall Creek The entire valley bottom in the image is now low mud flat habitat at low water see Fig 4.

levels, under normal operations are regulated between its licenced maximum and minimum levels of 651.08m and 606.55m through discharge of water via Terzaghi Dam into the Lower Bridge River and by diversion through penstocks to the Bridge generating plants on Seton Lake.



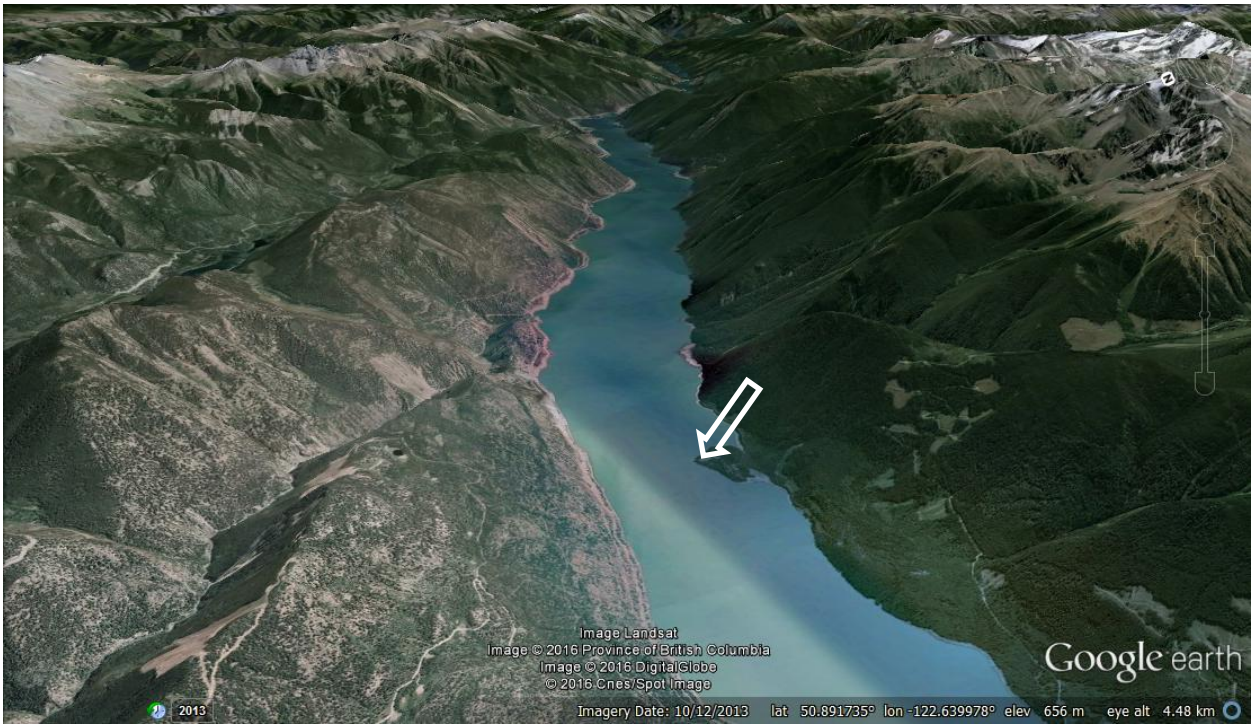


Figure 4 A Google Earth replication of the area of capture in the Historical image in Figure 3, arrow marks point of peninsula in both images.

Figure 5 Typical site on the Lower mud flats in 2014 near the Gun Creek Fan, note old stumps, silt substrate and dust.

Terzaghi dam was constructed in 1948, prior to flooding the area inundated under the

waters of Carpenter Reservoir was a complex mosaic of riparian habitats as described by George A. Wood in 1949; "the river flows sinuously within a mile-wide flood plain of oxbow lakes, marshes and cut-offs" (G.A. Wood, 1949) (Figure 3). The mudflats complex at the west end of the Reservoir between the Gun Creek Fan and the town of Goldbridge are remaining sections of the Middle Bridge River with vestiges of the original vegetation complex. The vast majority of the 75km long reservoir bottom has been converted to mud flats where fine silts and sands accumulate when inundated under reservoir pooling (Figure 4). The surrounding sloping edges of the reservoir are defined largely by their upslope geomorphology and interactions with the reservoir, In the WORKS 1 target area these include steep beach (STB), shallow beach (SHB), steep alluvial fans (SAF) formed by tributary streams, The Gun Creek Fan east and west (GCFE, GCFW) side as well as steep colluvium (SC) and low mud flats (LMF).

Steep Beach (STB)

The steep beach polygon was located directly south of the Tyaughton Road turnoff. The beach is a fan like formation that sits at the base of a small draw, the draw carries up slope for about 150 vertical metres (Figure 7). The beach area is approximately 3 ha in area approximately .5km long. The slope is between 11° and 13° and it is a concave shaped feature on the north shore coastline. The terrain polygon is flanked by steep colluvium polygons to the east and west. The upland vegetation from the steep beach is a Ponderosa pine (*Pinus ponderosa*) dryland forest that was partially burned in the Tyaughton Lake fire of 2009. The far east end of the beach has young cottonwood trees growing in the upland an indication that there is a sub-surface moisture source. The band of upland vegetation above the beach sits between the beach and Hwy 40, it is narrowest at the east end measuring less than 20m and widens to 60m at the widest point in the center. The beach substrate is dominated by a mosaic of patches of mixed sand, cobbles and gravels. Vegetation cover across the beach inundation zone is sparse with mainly annual species and the occasional patch of horsetail (*Equisetum arvense*). The upper elevations in the buffer zone have encroaching snowbrush (*Ceanothus sp.*), and trembling aspen (*Populous tremuloides*).

Figure 6 Steep Beach polygon upper elevations with a very coarse substrate and an encroaching patch of dogbane *Apocynum* androsaemifolium.

Access to the steep beach site is very good as the beach is within 50 m of the highway. Two gravel roads spaced within 20m of each other heading off highway 40 lead down from the highway to just above the high water mark of the reservoir. One of the roads at the west end stops at a clearing that is used as a camping spot. It is obvious that the beach site is utilized by people for recreation including camping, atv riding, dog walking, and possibly even fishing and swimming. The two roads provided excellent access and staging areas for planting. The easy access also means there is a higher chance of disturbance from other users including atvs. A few atv tracks were observed on the beach.

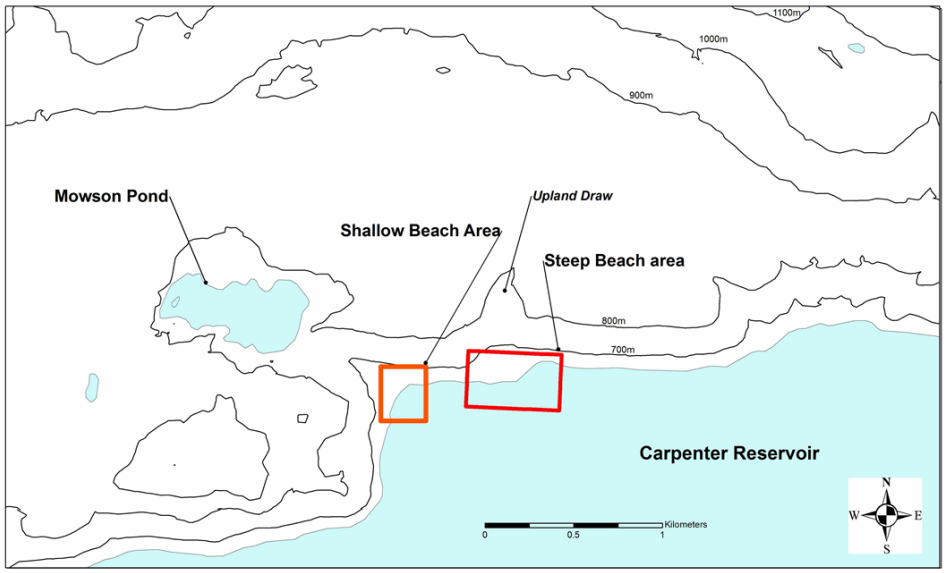


Figure 7 Steep beach and shallow beach areas from a landscape topographic perspective,.

Shallow Beach (SHB)

The shallow beach site is located half a kilometer to the west of the steep beach site. The beach location is in a concave south east facing cove at the base of a steep draw that stretches upslope approximately 200 vertical metres and 700m horizontal distance to Mowson Pond (Figure 7). The terrain type exemplified by the gently sloped shallow beach is fairly unique from what was seen of the Carpenter Reservoir shoreline landscape. The slope of the beach is

Figure 8 Trembling aspen encroaching into the drawdown zone on the Shallow Beach site.

relatively low being between 5° and 6° with a mixed fine sand and coarser gravel-cobble substrate. The upland ecosystem was recently burned and has regenerated into young seral growth stage with predominantly deciduous tree and shrub cover dominated by black cottonwood (*Populous balsamifera*). To the west on the shallow beach is a notable stand of

trembling aspen (*Populus tremuloides*) (Figure 8). The aspen was observed to be suckering down into the drawdown zone of the shallow beach. The natural tendency of the poplars to spread via aggressive suckering may be an advantageous quality to exploit in the upper drawdown zone re-vegetation effort. *P. tremuloides* planted and established higher up in the drawdown zone could naturally spread down into lower drawdown elevations. In this way, high water years may kill back some of the suckers but the parent trees would remain at the higher elevations providing the vegetation material with the ability to recolonize when suitable conditions permit (Figure 9). It was notable that there was a high amount of old garbage on the beach in the form of old rusting metal and broken glass. It is likely there was some kind of historical industrial use of the site, or perhaps a dumping ground. The easy access from the highway makes this a likely spot for recreational use. The site itself appears as though it was at one time a fluvial out flow from water coming from Mowson pond and the surrounding drainages. There is currently no sign of a historical channel between the shallow beach and Mowson pond.

Gun Creek Fan East and West (GCFE, GCFW)

The Gun Creek Fan as an alluvial fan where Gun Creek flows into the Middle Bridge River. The fan is the

Figure 9 Clonal stand of aspen (*Populous tremuloides*) growing at the north east end of the Gun Creek fan.

largest on the Carpenter Reservoir landscape. The Gun Creek fan has experienced recent high disturbance flooding within the past decade which served to mobilize and reshape portions of the fan particularly around the outflow of the creek. The upper elevations on the east side of the fan is the site of a BC Hydro Recreation camp site that is used year round, though peaking in use during the summer

season by locals and visitors. The upper elevations on the west side of the fan is a Ministry of Transportation and Infrastructure gravel pit. Both East and west sides of the fan have vehicle access down to the water's edge. Both aspects of the fan have been observed to be utilized for recreation including 4X4ing, atving, fishing, boating, kite flying, and camping. At least one horse has been observed on the site. The east side of the fan is also the historic town site of Minto. Evidence of the town is still apparent from the air photos where historic roads are visible; from the ground old cement building foundations, fire hydrants, pipes, wires and metal and glass debris of all kinds are found. Tree stumps from pre reservoir times are found throughout the fan on both the east and west sides of the Gun Creek fan.

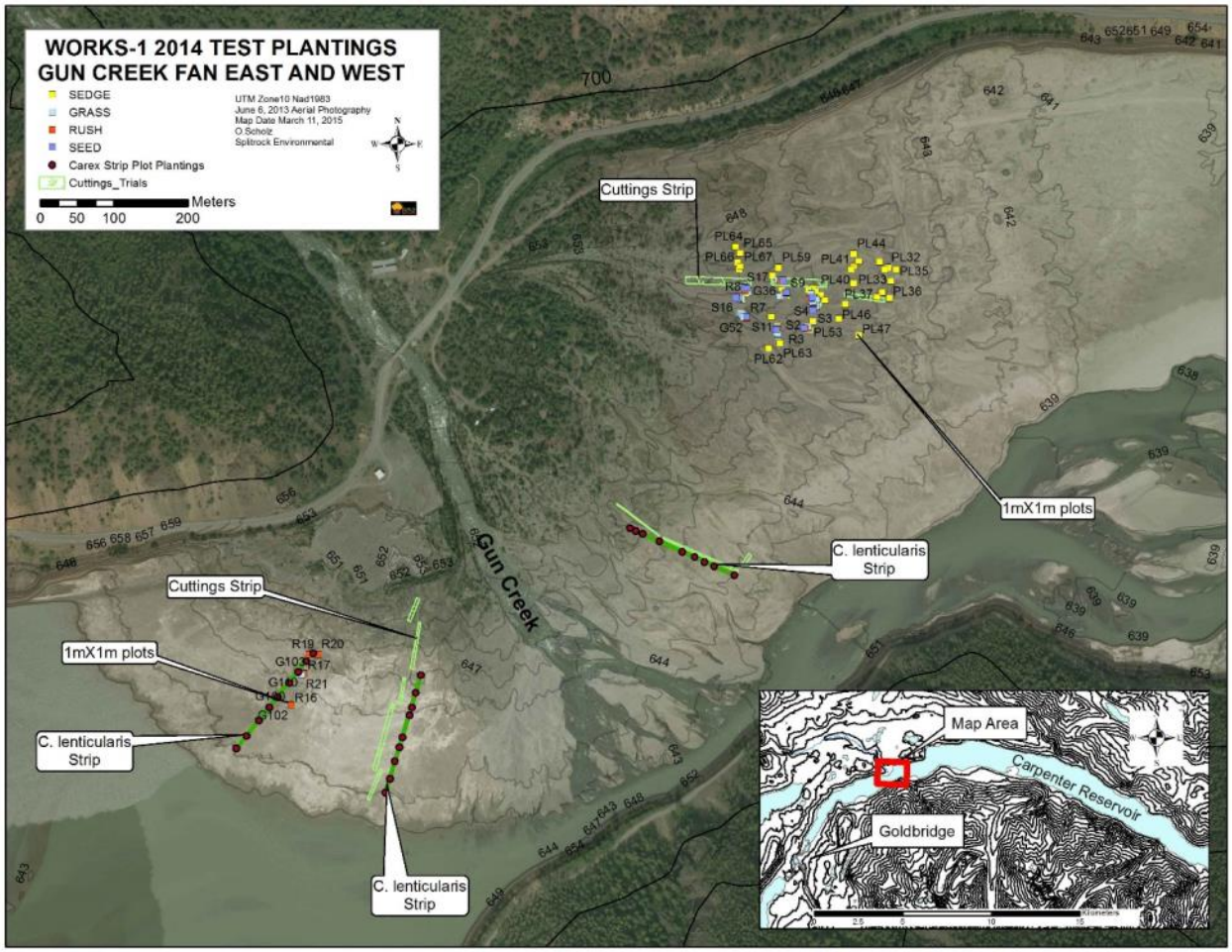


Figure 10 Gun Creek Fan east and west sides of the creek showing location of test planting sites.

The fan's substrate in general is very coarse with a dominance of boulders and cobbles. Substrate does vary considerably locally from fine silty deposits at the lower elevations and in microsite depressions, to coarse large cobble and boulder covered terrain particularly near the Gun Creek main channel. The west side of the fan tends to be slightly finer textured substrate with fewer boulders and cobbles at the surface and more sand and volcanic pumice rock deposits and drifts. The upper forested ecosystems of the fan are young interior Douglas-Fir (*Pseudotsuga-menziesii*) and Ponderosa Pine (*Pinus ponderosa*) forest that grade into deciduous cottonwood trees on the fringes of the reservoir and along Gun Creek. In the drawdown zone there is a general gradation from perennial grasses in the buffer zone shifting to annuals at lower elevations. Based on the BRGMON-2 study the upper drawdown zone elevations of the Gun Creek Fan, vegetation cover averaged around 25 per cent comprised of cottonwood and perennial grasses and herb species (Scholz and Gibeau, 2013) as elevation lowers the per cent cover drops and the species composition shifts to small annuals.

Steep Alluvial Fan

Two alluvial fans exist on the south shore of Carpenter Reservoir within the designated planting zone. The fans are fed by small tributary streams. The fans are characterized were characterized as steep during BRGMON 2 surveys in an attempt to separate out the very broad lowly sloped Gun Creek Fan.

Steep alluvial fans are typically >10° slope. The aspect of the south shore fans is a relatively cool north, the substrate of the fans is coarse composed of predominately angular to sub-angular gravels and cobbles. Access to the steep alluvial fan area was via the town of Goldbridge and following Truax FSR east to the fans then hiking through an old cut block. Both south side fans have been clear cut and re-planted within the past 20 years. A thin band of vegetation was preserved around the foreshore of the fans. This vegetation is dominated by large Douglas-fir and cottonwood and trembling aspen. Some remnant snags and stumps remain on the fans. The upper drawdown elevations have significant driftwood cover stranded from the previous high water events prior to the introduction of the buffer zone into the water management strategy. Cottonwoods can be observed advancing down into the buffer zone on the SAF sites (Figure 11).

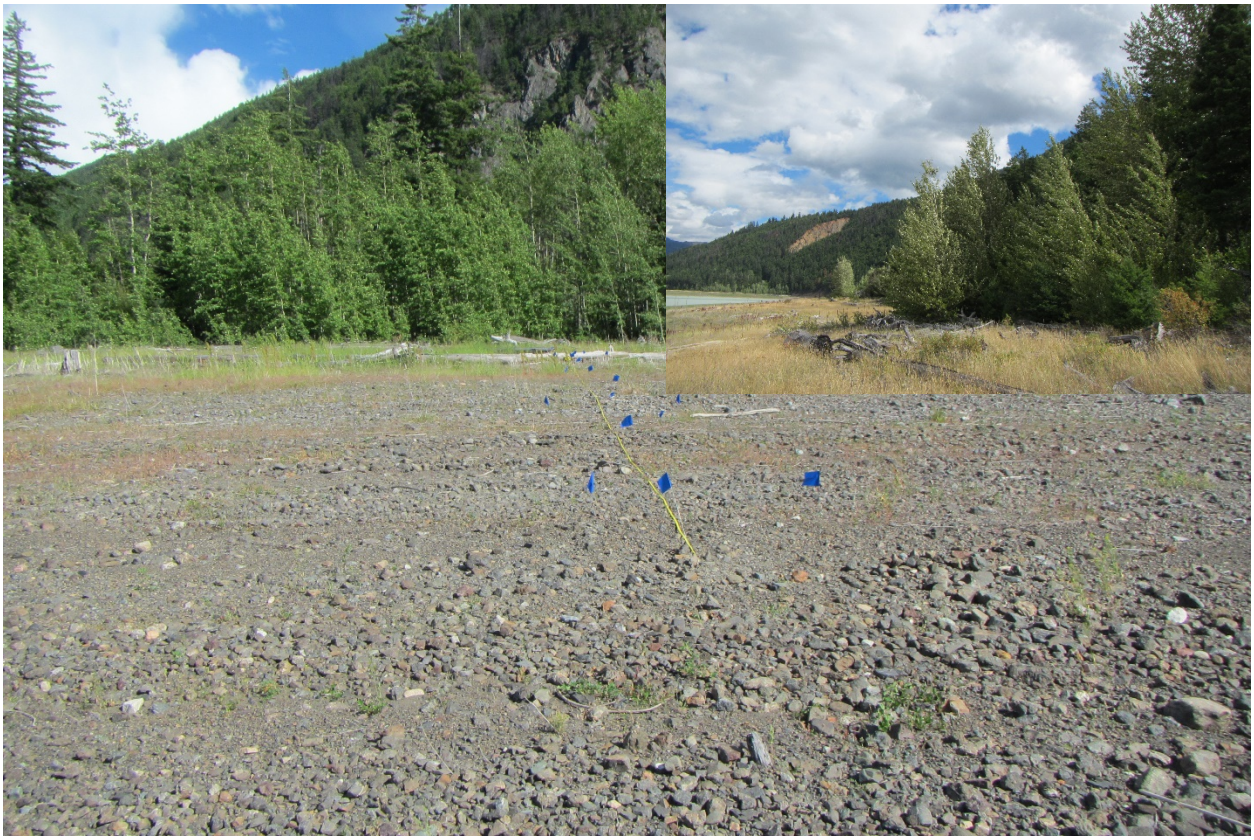


Figure 11 Layout for sedge strip planting on steep alluvial fan site, coarse angular substrate , driftwood at higher elevations, inset photo shows cottonwood encroachment into upper buffer zone on the SAF.

Water Levels and Drawdown Zone Elevations

To manage the reservoir for power generation, fish habitat, and to minimize spills from Terzaghi Dam into the Lower Bridge River, BC Hydro makes efforts to maintain a 3m elevation buffer zone around Carpenter Reservoir by having a target maximum elevation of 648.00masl for the end of snowmelt season in mid-August (BC Hydro, 2011). BC Hydro states that reservoir incursions above 648.0 m are expected as a

result of meeting other constraints with higher priorities, (Figure 12) shows Carpenter water levels since the inception of the buffer zone management target in 2000.

In five of the past 15 years the high water mark hit the 648m level and in two of those years the level rose another meter to reach the 649m elevation. The average of the past 15 years high water mark was at 646.25m and the average low pool level was at 622.5m. Occasions where there were incursions into the buffer zone above the 648m mark occurred above the 90th percentile. Reservoir water levels and inundation periods are crucial factors in determining the successful establishment and spread of vegetation in the drawdown zone. Currently within the drawdown zone substantial perennial vegetation growth occurs only above the 643m elevation in the mud flats west of the Gun Creek Fan (Figure 13). Below the 643m elevation vegetation cover is very sparse with small annual plant species averaging a total cover around 8 per cent (Scholz and Gibeau, 2014). Of the six transects located and surveyed in the LMF zone three had vegetation cover values below 5 per cent. Two of the low cover transects were located at the 636m or lowest elevation surveyed in the LMF. In 2005 the low pool level for the year was at 635m, meaning everything below 635m was submerged for the entire year.

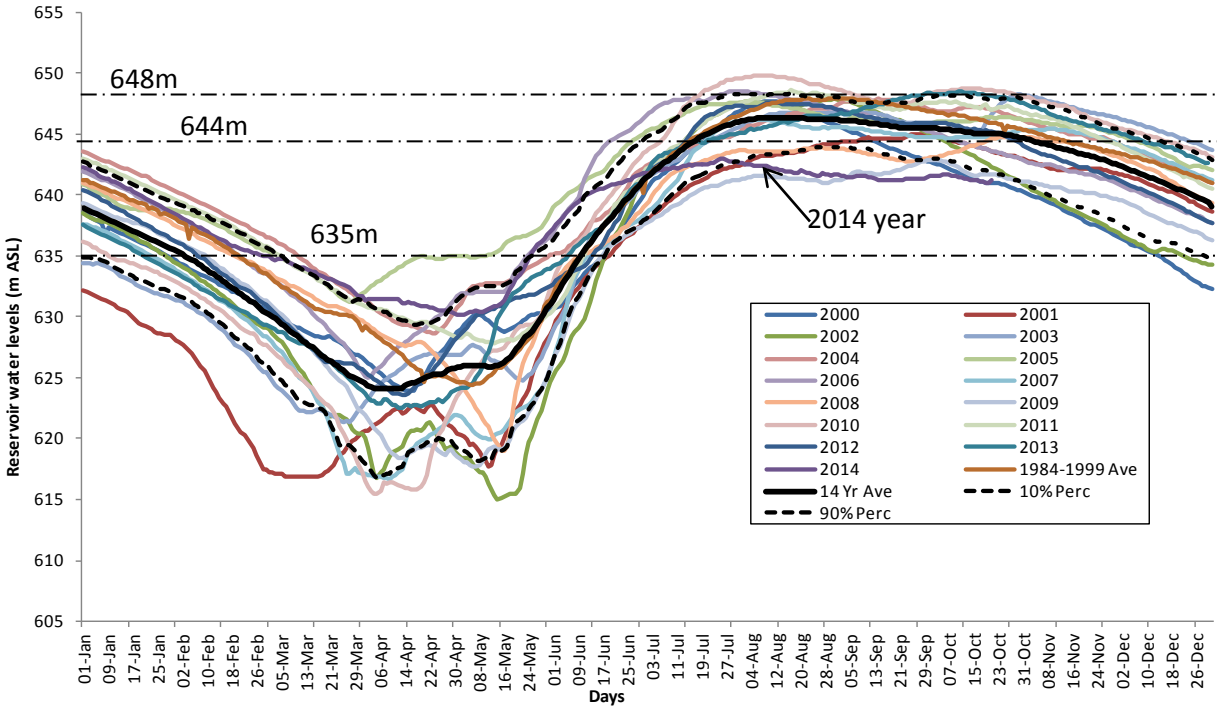


Figure 12 Graph of annual water levels of Carpenter reservoir since 2000. Includes 14 year average and the 10th and 90th percentile ranges. The 2014 planting year is indicated.

Figure 13 Looking out over the Mid Mud Flat area >643m elevation naturally vegetated with a mix of horsetail, sedges, grasses and annuals.

Figure 14 Pocked surface of the 636m elevation on the mudflats, an elevation that is most years largely inhospitable to vegetation due to duration of inundation and short growing season.

The BC government produced Field Manual For Describing Terrestrial Ecosystems (Ministry of Forests and Range and Ministry of Environment, 2010) site description section identifies and classifies the successional status of a plant community as a 'non-vegetated' site when;

> *"Vegetation is either absent or less than five percent cover because of substrate conditions or recent severe disturbance such as fire, mass-wasting, flooding, or anthropogenic causes."*

Table 2 Proportion of the growing season that elevations have not been inundated In Carpenter Reservoir over the past 14 years.

Elevation band (m ASL)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Average
616	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0
617	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	1
618	0	1	11	0	0	0	0	0	0	3	0	0	0	0	0	1
619	0	4	15	0	0	0	0	0	0	7	0	0	0	0	0	2
620	0	8	16	0	0	0	0	1	3	11	0	0	0	0	0	3
621	0	11	17	0	0	0	0	7	5	12	0	0	0	0	0	3
622	0	12	18	0	0	0	0	12	7	15	0	0	0	0	0	4
623	0	14	18	0	0	0	0	16	8	17	0	0	0	0	0	5
624	0	15	19	0	0	0	0	18	11	18	1	0	0	0	0	5
625	0	16	20	1	0	0	0	19	13	19	3	0	0	4	0	6
626	0	17	22	7	0	0	0	20	14	20	5	0	0	5	0	7
627	0	18	23	14	0	0	0	21	15	21	7	0	0	7	0	8
628	0	19	24	20	0	0	0	22	16	22	11	3	0	8	0	10
629	3	20	25	21	0	0	0	22	18	23	13	16	2	8	0	11
630	12	22	27	22	0	0	0	23	18	24	18	19	4	9	0	13
631	22	24	28	24	1	0	0	24	19	25	19	22	10	10	9	16
632	24	25	29	24	2	0	4	24	20	27	20	23	17	12	11	17
633	25	27	29	25	11	0	12	25	21	27	21	24	22	15	12	20
634	28	29	31	25	15	0	13	26	23	29	22	25	26	20	14	22
635	31	32	31	27	20	5	15	27	25	31	23	27	29	24	16	24
636	33	35	33	28	24	10	18	32	31	33	25	28	31	25	18	27
637	34	38	34	29	27	17	21	35	35	37	27	29	33	29	20	30
638	36	41	35	32	30	19	22	39	37	41	29	32	34	32	22	32
639	38	43	37	35	33	21	24	42	40	46	31	33	35	35	24	34
640	39	46	38	38	35	24	26	44	42	50	33	35	37	36	27	37
641	41	51	39	40	37	27	27	46	43	57	35	38	39	40	34	40
642	44	56	41	42	39	31	28	48	46	93	37	40	41	41	71	46
643	48	63	44	47	42	33	29	49	59	100	39	44	45	42	99	52
644	60	76	47	51	49	36	31	52	100	100	42	46	48	48	100	59
645	69	97	50	56	59	39	35	59	100	100	44	50	50	58	100	64
646	78	100	58	67	65	51	47	91	100	100	46	52	59	69	100	72
647	88	100	69	100	75	76	60	100	100	100	48	58	75	85	100	82
648	100	100	100	100	100	100	84	100	100	100	61	82	100	95	100	95
649	100	100	100	100	100	100	100	100	100	100	77	100	100	100	100	98
650	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
651	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

During most years, it is expected that elevations of 635m and lower in the Carpenter Reservoir are classifiable able as non-vegetated due long inundation and occasionally year long inundation. Based on inundation frequencies and duration of flooding as well as the LMF transect cover data from 2013. The identified WORKS 1 re-vegetation target zone begins at the 636masl. The vegetation cover on the LMF from 636m to 642m is very sparse. Based on the past 15 year average an estimated growing season between April 1st and September 30th (153days) on an average year the elevation that is exposed for more than 50 percent of the growing season is 643m. It is very difficult for perennial plants to survive with less than 50 per cent of the growing season spent inundated especially if this occurs in successive years (Anne Moody personal communication). Planting trials for the WORKS-1 are set to test this hypothesis.

METHODS

The 2014 field season was approved by BC Hydro on June 25th, 2016 monitoring and layout commenced immediately and planting initiated on July 1, 2014. Six terrain classes occur within the targeted re-vegetation zone. (Table 4), The steep colluvium zone (SC) was excluded from initial trials as they are deemed largely un-plantable due to substrate texture, terrain, disturbances and slopes. There may be opportunities for planting in the upper elevations of steep colluvium sites, this should be investigated more closely in the coming years of the project, The low mud flat (LMF) was already under water by the time of project commencement in 2014 so no planting was carried out in this zone. Planting took place between July and September with trials carried out on the terrain classes, steep beach (STB), shallow beach (SHB), steep alluvial fan (SAF) and on the east and west sides of the Gun Creek Fan (GCFE, GCFW).

Based on BC Hydro forecasting predictions Splitrock focused 2014 planting trials at elevations 644m and above (pers. comm. P.Vassilev, BC Hydro). It was estimated that planting above this level would give the plants at the low elevations a bare minimum of 10 days in the ground before being inundated.

Water levels were 641.19 masl on June 25th 2015 the first day of the project. The field work involved three approaches to test planting success across terrain and elevations of the targeted re-vegetation region of the Reservoir. Test planting materials included nursery grown plugs, live stake cuttings and seeds. Planting trials were carried out through the establishment of:

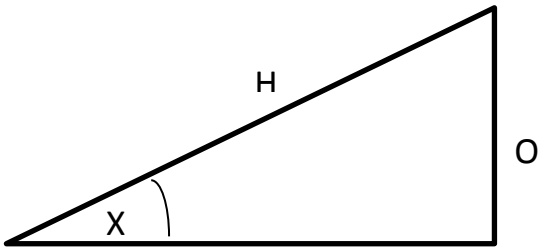
1. 1X1 meter plots that were selectively distributed across four stratified terrain classes and distributed across elevation bands between 644m and 648m.

2. Continuous strips or bands of sedges planted into 5 terrain classes from a low level of 644m to a height of 648m.

3. Strips of live stakes planted on 5 terrain class sites across the elevations 644 and 649m.

The 1X1m plots were mapped and surveyed prior to planting recording terrain type, site conditions, substrate textures and existing vegetation cover as well as wildlife sign. Monitoring plots were established for planting trials in pre-stratified terrain types and at identified elevations. Experimental plantings of were carried out using lakeshore sedge (*Carex lenticularis*), foxtail barley (*Hordeum jubatum*), blue wildrye (*Elymus glaucus*), blue-joint (*Calamagrostis canadensis*), slender wheatgrass (*Elymus trachycalus*), fowl bluegrass (*Poa palustris*) and Baltic rush (*Juncus balticus*). In addition, live stake cuttings were planted across 5 terrain sites between 644m and 649m elevation.

Lakeshore sedge (*Carex lenticularis*) planting plots (1m X 1m) were established within each terrain class site (Steep beach, shallow beach, steep alluvial fan, Gun Creek Fan) along elevations 644, 645, 646, 647, 648m for planting. Native grass species test plots were located higher in the drawdown zone at the 646m, 647m, 648 m elevations. Elevations were located in the field by consulting the daily issued water levels for Carpenter Reservoir as issued by BC



SIN X (H)= O

Figure 15 Formula used for determining test plot elevations 2015 WORKS-1

Hydro Power Records as a tangible benchmark in the field. Plot elevations were determined by standing at the water's edge setting up a clinometer on a tripod and using a 2 m staff gauge to measure the slope angle (X), and using a measuring tape to determine the slope distance. Elevations were determined using the appropriate trigonometric formula (Figure 15). Plots were laid out along the established elevation bands using a clinometer and reference staff. Plots were planted out with sedges, grasses, rushes as well as seed trials. The extent of the data collection is summarized in Table 3.

Table 3 List of data collected for each planting site.

Date	
Plot_No	
Slope	degrees
Aspect	degrees
Elevation	masl
Substrate cover (measured to total 100%)	Mineral Soil, Organics, Rock, Wood, Bedrock, Water,
Soil Texture	sand, loamy sand, sandy loam, fine sandy loam, sandy clay loam, loam, silt, siltloam, silty clay loam, clay loam, silty clay, clay
Coarse Fragment Shape	rounded, sub rounded, sub angular, angular
Coarse Fragment Content	as a percent
Degree of Compaction	loose, moderate loose, moderate, moderate-hard, hard
Drainage	spectrum from very poorly drained to very rapidly drained
Microtopography	smooth, channeled, ribbed (wave action), undulating,
Wildlife Sign	tracks, feces, bone..
Wildlife_Species	name species
Disturbance	any notable disturbances at site
Geomorphic Type	Wave action, Fluvial
Water Source	Precipatation, groundwater,
Vegetation Cover	% cover
Number of Species	Total number of plant species observed
X	UTM
Y	UTM
Landform shape	strait, concave, convex
NOTES	planted species
Plantform Planted	Sedge, Grass, Rush

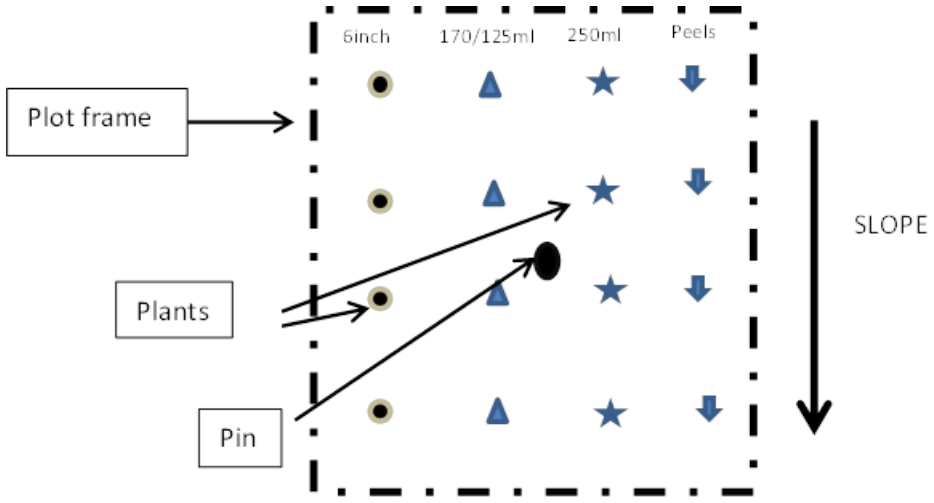
Figure 16 Example of before photographs that were captured for each plot that was planted.

Plot placement was chosen subjectively to represent observed microsites at established elevations within each terrain class site. Microsites were defined in the field to include variation in substrate texture, micro topography, micro aspect and occurrence of other structural features such as stumps or large woody debris. Plots were located on the steep beach, shallow beach and the east and west sides of the Gun Creek Fan. Surveys of each plot were carried out prior to planting. Plot locations were identified in the field utilizing a SX Blue sub-metre accuracy GPS receiver. Twelve inch nails were used to mark the center points of each 1m X 1m square plot. Each plot was oriented parallel to the slope. Flagging tape was used to make it easier to relocate plots for planting. Photographs were taken of each plot from the vertical, directly above the plot, and from a horizontal perspective with a 0.10m x1.0m tall meter board centred on the upslope side of the plots. Data was digitally collected on iPads using a form built in 'doforms' as well as on Flint hand held devices running EZyTag and windows mobile.

Plant materials source locations.

Potted plants

Lakeshore sedge plants were grown from locally harvested seeds from Carpenter and Downton Reservoirs, with an additional 1500 plants purchased from a regional Native plant nursery. Plants were transported to the site using a Fist truck to keep the plants cool as long as possible up to the time of planting. Plants were planted using tree planting shovels and transported to planting sites by planting bags in silva cool bags. For *Carex lenticularis* four rows of four plants were planted into each 1X1m plot (Figure 17) Grasses and rush plots were planted out with 9 plants per plot, 3 rows of 3 plants.



Carex lenticularis plants planted were categorized by either container size or origin. Three different sized containers stock were planted in the trial year, 6inch sand-which trays, 170/125m plugs, 250ml and 250 ml plugs from outsourced nursery. Planters were instructed to plant the different stock in set locations within plot frames in order to track the success of each different sized root stock (**Error! Reference source not found.**). Photos were taken of each plot after they were planted out.

In addition to the 1X1m plots, *Carex lenticularis* plants were planted in long strips perpendicular to the water. Four rows of plants in long strips were planted from 644m up to 649m on each of the main terrain types Shallow Beach, Steep Beach, Gun Creek Fan East and West Side and 2

Figure 17 Representation of a 1X1m plot frame with planted sedge plugs

sites on the Alluvial fan on the South shore of the Reservoir.

Planting was carried out by Spiltrock crew. Crew members all had planting experience. Access to the planting sites was by truck and on foot. Plants were transported to the site in a refridgerated truck or in a fist on a pickup truck. Plants were staged on site under silva cool tarps and, Plants were moved across the sites using an atv and in planting bags.

Table 4 Terrain Class areas for re-vegetation zone covered by WORKS-1 project.

Terrain Type	Area ha	% Works Re-vegetation Area
Steep Beach	2.91	1%
Shallow Beach	1.67	1%
Alluvial Fan *(Gun Creek Fan)*	55.01	23%
Steep alluvial fan	14.79	6%
Low mudflat	168.93	69%
	243.31	100%

Live Stake Cuttings

Live stake cuttings were also planted into each of the surrounding terrain sites. Black cottonwood (*Populus balsamifera*) and willow species (*Salix sp*.) were harvested and planted into the sites. Steel bars were used for making holes for planting the stakes on the steep and shallow beaches as well as the alluvial fan. All efforts were made to plant the cuttings >1m in the ground. With the variable and often rocky substrate planting depths for the cuttings varied from 0.5 to 1.25m. Cuttings were planted in strips consisting of two rows of stakes spanning across elevations on the beaches and alluvial fans. Cuttings were watered in after planting via a gas pump and hoses.

On the Gun Creek Fan three sites were planted with cuttings two on the east side and one on the west. On the fan where access was not an issue a small excavator was employed to plant the cuttings. Planting involved the excavator digging a 1-2 meter deep trench that cuttings were distributed through, spaced approximately 1 meter apart. Trenches were partially back filled by hand to stabilize cuttings and the machine returned and filled in the trenches. Cuttings strips spanned between 644 m and 649 m. Based on predicted water levels it was anticipated that cuttings would be watered by rising reservoir levels at least from below surface.

STB Container Plants

The substrate of the Steep beach varied from fine sands to coarse cobbles. Five trial sites of 1m X 1m plots were selected across the beach to test *Carex lenticularis* plantings with replicates at 5 elevation bands between 644m-648m, one extra *C. lenticularis* plot was planted out at 642.5m (PL16) (Figure 18,). Selected sites varied in substrate and microsite conditions. The eastern most set was a sandy site on a slightly convex section of the coast with a possible sub-surface moisture source. To the west the substrate becomes coarse with a mix of sand and gravel. The middle of the beach is generally coarse with several concave micro draws one of which was planted with replicate plots set at different elevations (644, 645, 646, 647, 648m). The far west end of the beach was again a finer sandy substrate with remnant occurrences of old stumps. A set of replicate plots were planted around 5 of the stumps, the elevation of each was recorded to assess if there would be any benefit to having plants growing beside them.

An additional 29 plots were planted with 5 species of grasses and 1 rush (Figure 18). Twelve plots were sown with two species of grass. Nine plants were planted into each grass plot for a total of 261 plants. Seeds of bluejoint (*Calamagrostis canadensis*) and Canada wildrye (*Elymus canadensis*) were hand sown into plots and raked in. Half of each of the seed plots was watered in (Figure 20).

Table 5 1mX1m plots planted and seeded across the STB polygon in 2014.

SPECIES (Planted)	Plots	646 m	647 m	648 m
slender wheatgrass (*Elymus trachycaulus*)	6	2	2	2
fowl bluegrass (*Poa palustis)*	6	2	2	2
bluejoint wheatgrass (*Calamagrostis canadensis)*	3	1	1	1
foxtail barley (*Hordeum jubaturm*)	6	2	2	2
blue wildrye (*Elymus glaucus*)	6	2	2	2
Baltic Rush (*Juncus balticus*)	2	2	2	2
SEEDED				
bluejoint wheatgrass (*Calamagrostis canadensis)*	5	2	2	2
Canada wildrye (*Elymus canadensis*)	7	2	2	2
TOTAL	41	13	13	13

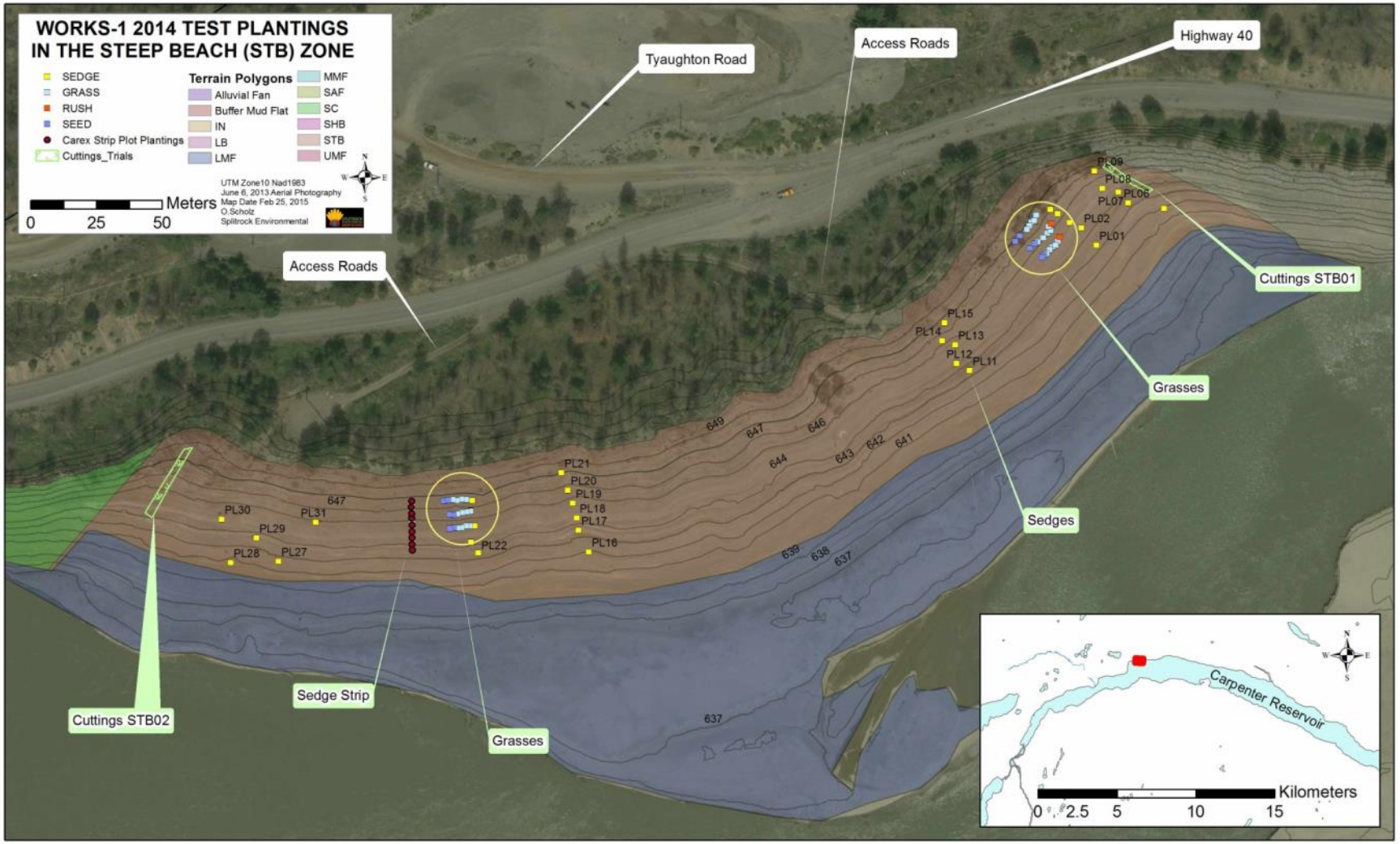


Figure 18 Steep beach test planting sites.

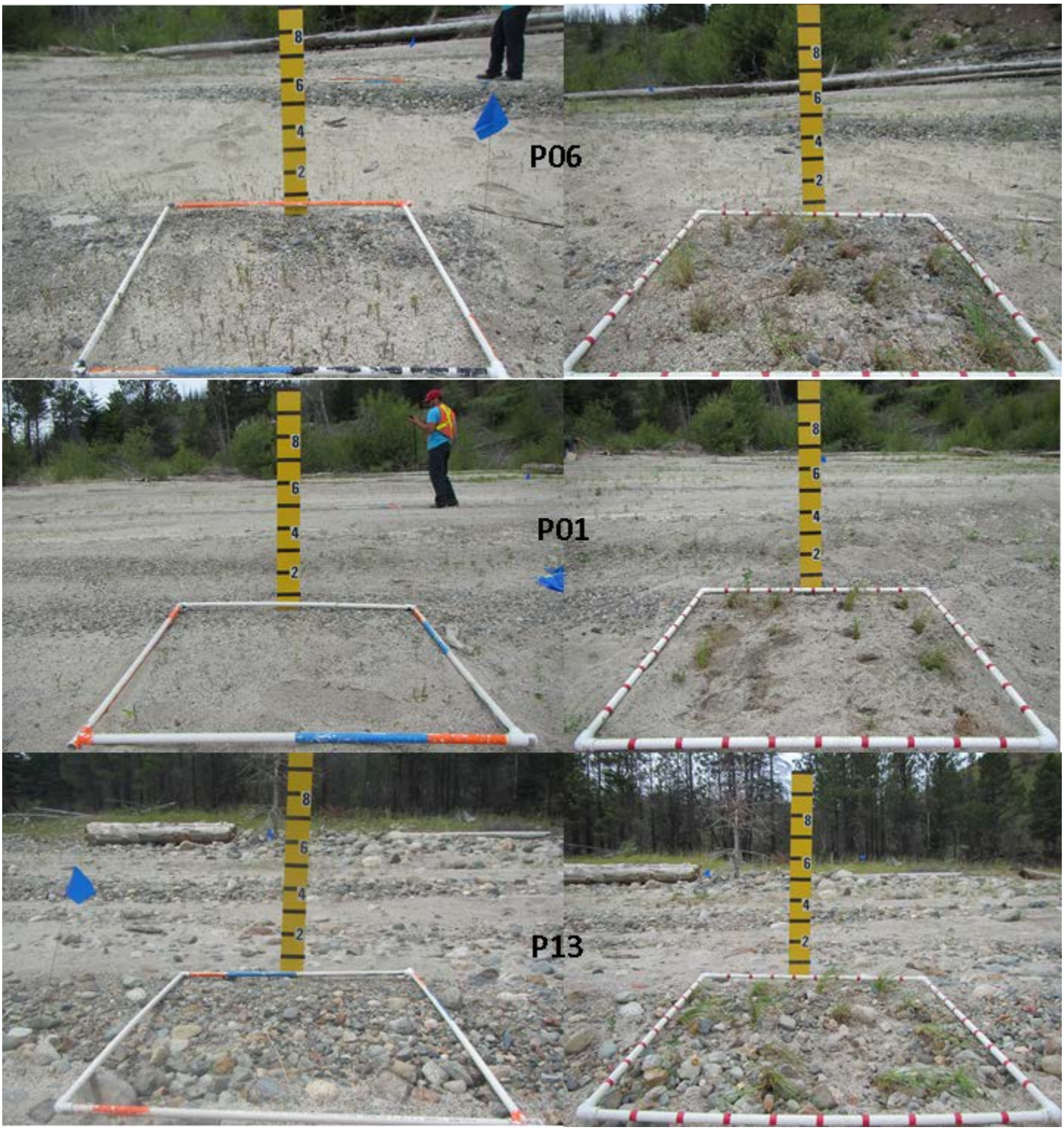


Figure 19 The Images represent examples of 1mX1m plots planted across the 6 microsites of the Steep Beach zone in June 2014. Photos span from east to west along the beach with left images before planting and right after.

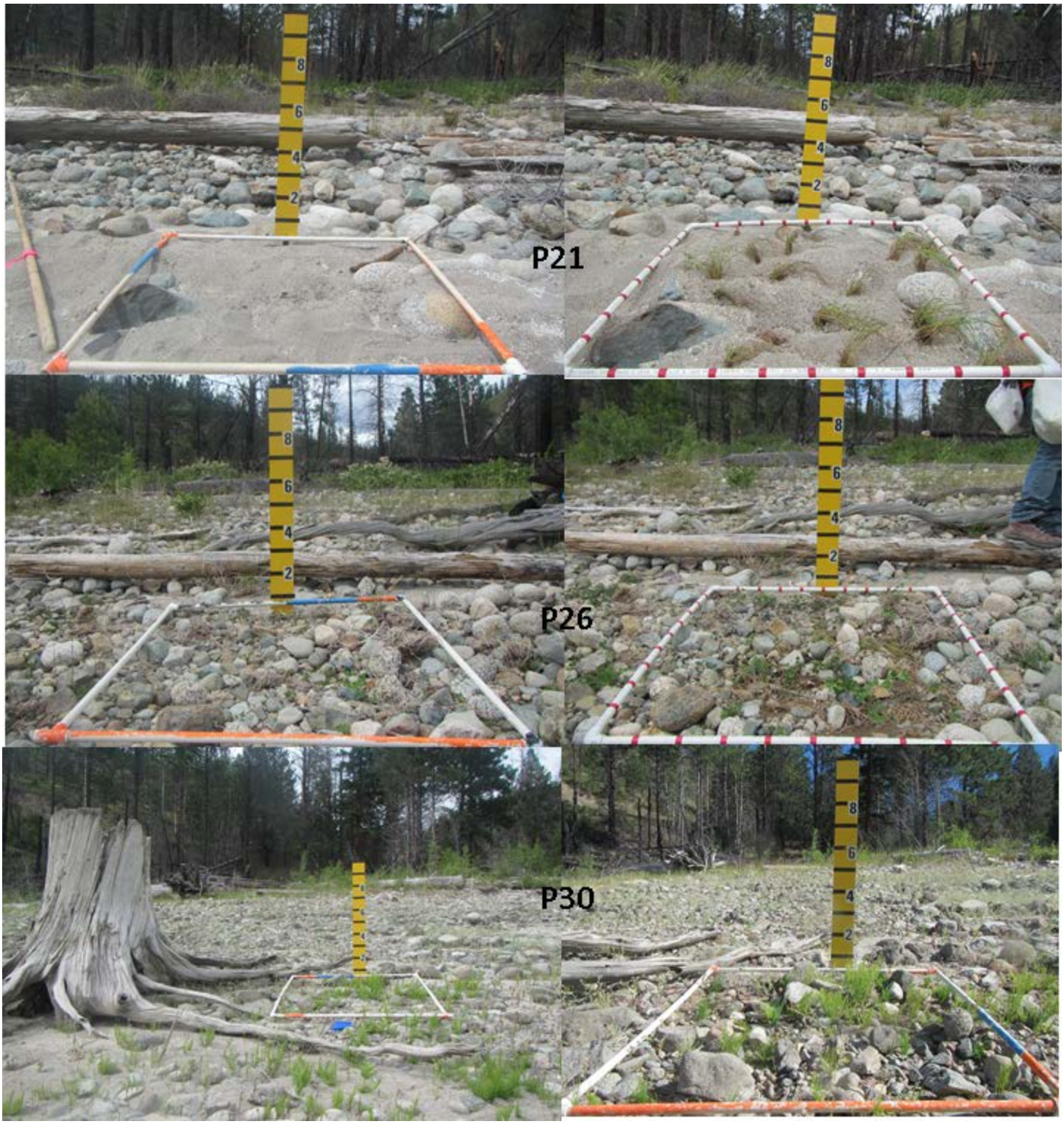

P21
P26
P30

Figure 20 Watering half of seeded plots on the Gun Creek Fan.

In addition to 1mX1m plots a paired continuous strip of Carex lenticularis plugs were planted on the STB spanning between 644m and 648m. Plugs were spaced 0.5m apart up the slope; in total 162 plants were planted in the strip. The site of the strip of sedges on the steep beach was a 12.25° slope, the planted strip was 19.38m in length with an aspect of 180° (Figure 21). Plants planted in the strip were grown in 6 inch bookcase containers, it was noted that the upper half of the plugs were root bound but the lower half fell apart as the plants were planted. Several extra plants were planted above and below the lower and upper ends of the strip. The substrate at the strip planting site was a coarse cobble sand. It was observed at the reservoir water's edge that

Figure 21 Blue flags mark the centre of the Strip Plot STB01 July 03 2014, 162 plants were planted in two parallel rows into the sand cobble substrate.

the cobble soils were more stable and resistant to wave action than the sand as the wave action shifted the finer soils forming a short stepped concave sweep to the shores edge (Figure 22). The higher cobble component stabilized the shoreline eliminating the step and maintaining a convex shape at the water's edge. Based on this observation it appears plants planted into the finer loose soils will be highly disturbed if not dislodged by the wave action, where the cobble areas though more difficult to plant, may stabilize the plants.

STB Live Stakes

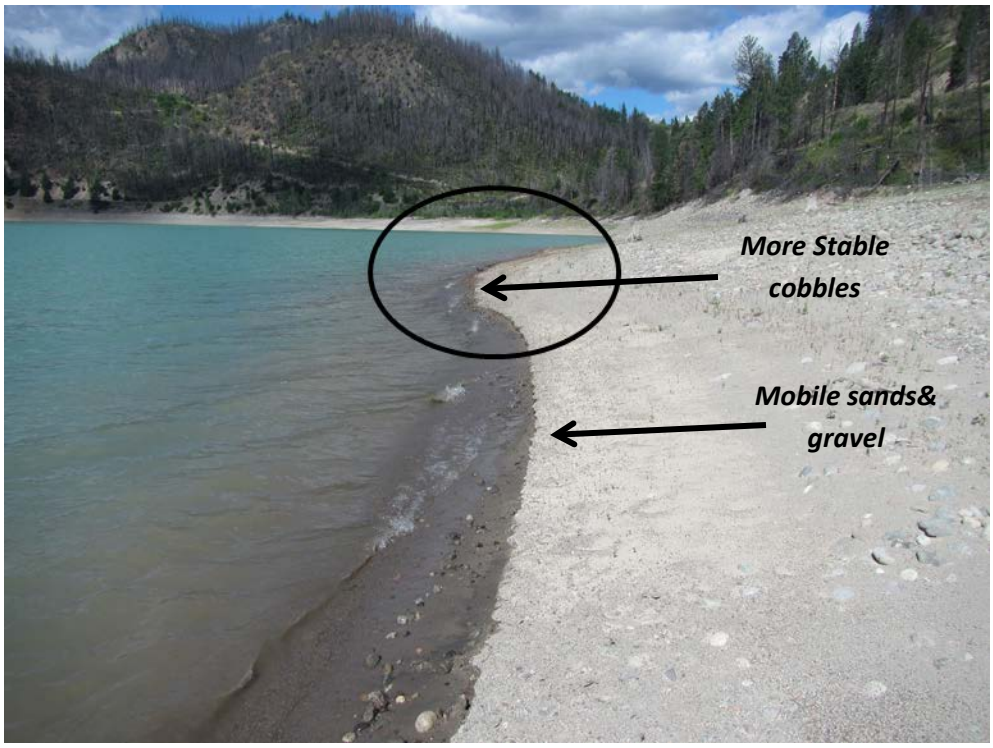


Figure 22 Wave action along the water's edge finer sands in the foreground

Live stakes were planted at two sites on the steep beach polygons one at either end of the beach. The East end had a sandy gravel substrate with the prospect that there was sub-surface water. 70 cuttings were planted at the east end and 108 at the west. The cuttings were planted from 644m up to 648m. All of the cuttings were *Salix* species harvested from the buffer mud flats several km west of the site. Cuttings were planted by hand using steel bars, stakes were planted .5 to 1.5m deep and watered in (Figure 18).

Figure 24 Live Stake cuttings at the west end of the STB site.

Figure 23 Live stake cuttings at the West end of the steep beach polygon STB02.

Table 6 Summary table of fall 2014 survey results of 1X1m plots on Steep Beach Re-vegetation site.

Species planted	Number Planted	Number Observed Surviving	Per Cent Cover Vegetation	Avg Ht of Plants cm	% Survival
C. lenticularis	492	197	7.40	8.83	40
J. balticus	18	6	4.00	4.50	33
E. glaucus	54	31	6.92	10.00	57
C. canadensis	27	14	5.00	10.67	52
P. palustris	54	41	6.50	10.00	76
H. jubatum	54	27	3.75	8.00	50
E. trachycaulus	54	19	3.17	8.00	35

A survey of the Steep Beach planting trials carried out in September seemed to indicate a 40% survival of the C. lenticularis plugs (

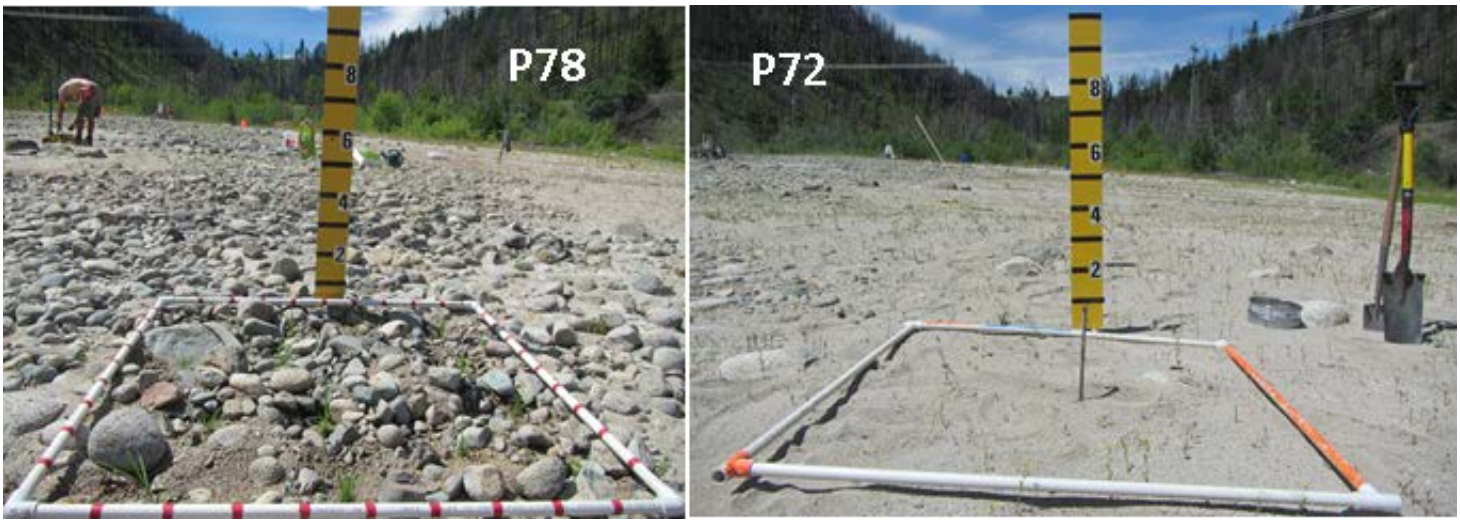
Table 6). Survival of other planted species ranged from a low of 33 and 35 % in Baltic rush and Slender wheatgrass (*E. trachycaulus*) to a high of 76 per cent survival in blue wildrye (*E. glaucus*). The plots will be surveyed at the optimum growing period in early June 2015 to better confirm survival rates as part of the BRGMON 2 Monitoring program.

SHB Container Plants

Planting trials conducted on the shallow beach included ten 1mX1m plots each planted with 16 sedge plugs along with 30 plots each filled with 9 plants of either one of 5 native grass species or Baltic rush (*J. balticus*). In addition, a strip of *C. lenticularis* plants was planted out at the west end of the shallow beach spanning elevations from 644m through 648m. A section of willow live stake cuttings were also planted at the east end of the beach. Live stakes were installed by hand using iron bars and watered in.

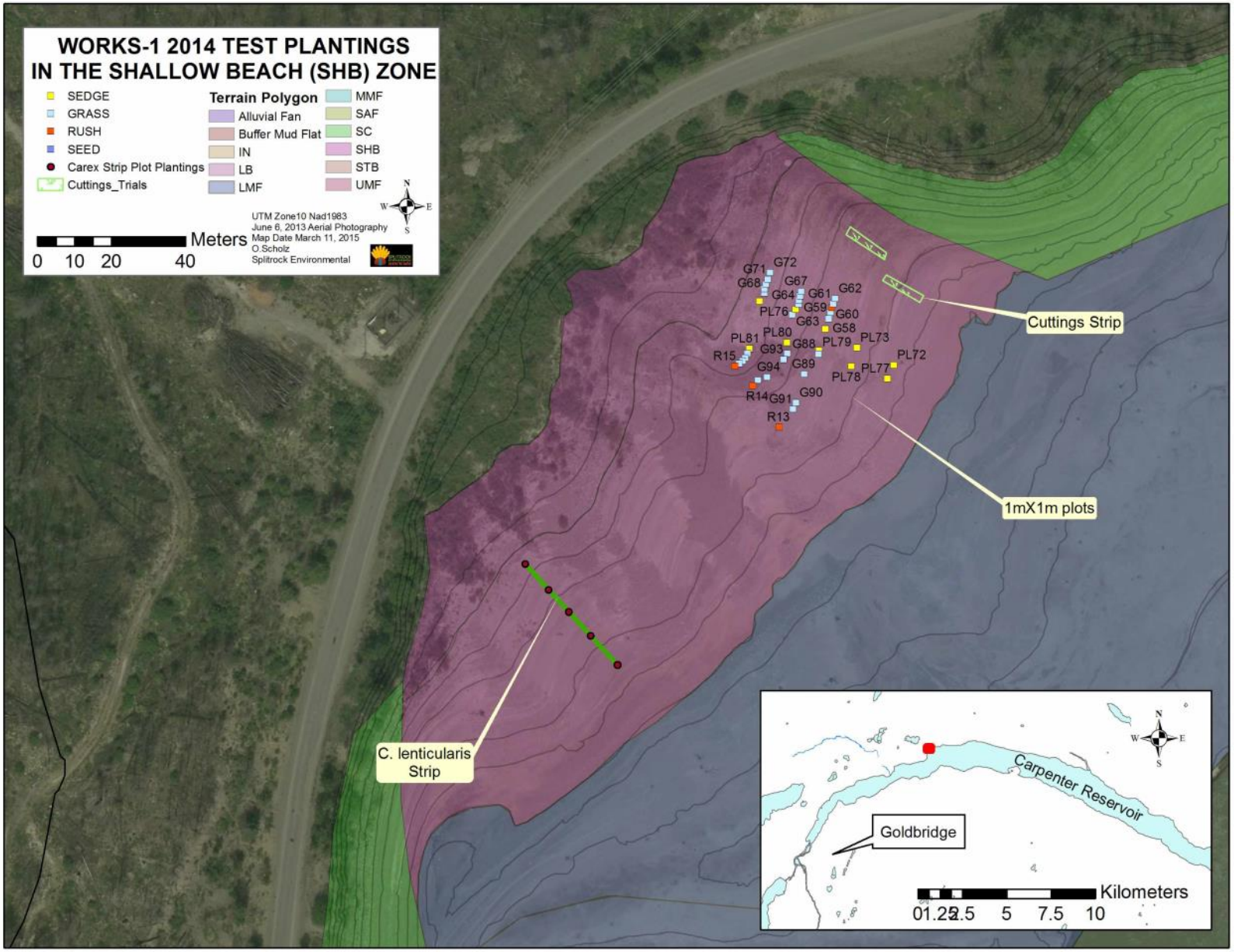
1X1m plots were planted into two microsite types differing on variations in substrate textures that varied between fine sands to coarse cobbles at the shallow beach site (Figure 25). Replicate plots of all test species were planted into the two substrate types at 5 elevation bands in the shallow beach (644m, 645m, 646m, 647m, and 648m). A similar replicate was planted with 5 grass species at 3 elevation bands (646m, 647m, and 648m).

In addition to 1X1m plots, a strip of sedges were planted at the west end of the beach. In total 293 sedge plugs were planted into a strip of 4 rows that spanned 37m across 5m of elevation.



The strip was on a 6° slope with sedges spaced 0.5m apart.

Figure 25 Sedge plots at the 645m elevation showing the substrate variation of fine and coarse substrate textures.


WORKS-1 2014 TEST PLANTINGS
IN THE SHALLOW BEACH (SHB) ZONE
SEDGE
GRASS
RUSH
SEED
Carex Strip Plot Plantings
Cuttings_Trials
Terrain Polygon
Alluvial Fan
Buffer Mud Flat
IN
LB
LMF
MMF
SAF
SC
SHB
STB
UMF
Meters
0 10 20 40
UTM Zone10 Nad1983
June 6, 2013 Aerial Photography
Map Date March 11, 2015
O.Scholz
Splitrock Environmental
G71 G72
G68 G67
G64 G61 G62
PL76 G59
G63 G60
G58
PL81 PL80
G88 PL79 PL73
R15 G93
G89 PL72
G94 PL77
PL78
R14 G91 G90
R13
Cuttings Strip
1mX1m plots
C. lenticularis Strip
Carpenter Reservoir
Goldbridge
Kilometers
0 1.25 2.5 5 7.5 10

SHB Live Stakes

Live stake cuttings of willow (*Salix sp*.) were planted on August 6th, using the iron bar hand planting technique at the east end of the beach (Figure 26). In total 86 cuttings were planted into two sections 44 at the 644-645m elevation and 42 between 645-646m. Given the easy access to the beach from Hwy 40 and the fact that people had been observed recreating on the beach zone cuttings were placed at one side of the beach and a large gap was maintained between sections to allow for easy passage around the cuttings. A long continuous strip of cuttings would pose a barrier of sorts to access across the beach which may not be desirable in such a unique site given the fact that there is obvious public use. Mule deer (Odocoileus hemionus)

Figure 27 Watering in cutting on the shallow beach site September 2014.

and beaver (Castor canadensis) are noted in the area and damage may need to be addressed as the project moves forward.

Gun Creek Fan (GCF) East

GCFE Container Plants

Sixteen Carex lenticularis plugs were planted into each of forty 1mX1m plots on the Gun Creek Fan east. Carex plots were distributed across 8 micro sites and over 5 elevation bands from 644m to 648m. Micro sites were identified on site including substrate texture gravel, sand, silt, cobble, mixed, aspect, micro topography and proximity to residual stumps (Figure 28). As at the other sites the four available sizes of

Figure 28 Examples of variation in microsite and substrate textures across the Gun Creek Fan east.

container were planted in columns in each plot. Plots were oriented parallel to the slope. The plants were watered after planting.

Five native grass species were planted on the Gun Creek Fan east side using 1X1m plots. Grass plots were distributed across three elevation bands 646m, 647m and 648m. At each elevation band replicated across 3 microsite types for a total of 45 plots planted. Additional plots of Baltic rush and hand seeded plots using Canada wildrye (*Elymus canadensis*) and Bluejoint (*Calamagrostis canadensis*) were established alongside the grass plots.

A Strip of sedges was planted towards the south end of the east side of the fan. A total of 930 plugs were planted in the strip spanning 155m from the 644m to 648m elevations. All planted plants were watered into place.

GCFE Live Stake Cuttings

Live Stake Cuttings were installed across two locations on the east side of the fan (Figure 10). The strips of willow and cottonwoods were planted employing an excavator to dig trenches 1-2m in depth and approximately 1.5 m wide. Cuttings were installed manually until cuttings were stable enough to allow the machine to finish the bulk of backfilling without knocking them over. Cuttings were harvested from the local region, they were a minimum of 3cm diameter up to 7cm diameter. Cuttings were soaked in water for at least 24hrs prior to planting The northern most trenches (Strip ID 2) were split into three sections, the southern one (Strip ID 1) was a single strip (Table 7). Cottonwood stakes were spaced approximately 1 m apart in the trenches. Trenches were excavated to over 1m in width, cottonwoods were planted along the south edge of the trenches and willows on the north side (Figure 29). In total 530 cottonwood stakes and 220 willow stakes were planted into the east side of the Gun Creek Fan.

Table 7 Summary of live stake cuttings planted at the Gun Creek Fan East.

CUTTINGS PLANTED FOR WORKS PROJECT 2014 July and August

Location	strip ID #	Elevation	Cottonwood	Willow	Date
GCFEast	2	644-645.5	150	50	AUG 05-6, 2014
GCFEast	2	645.5-646.5	80	30	AUG 05-6, 2014
GCFEast	2	647-648	50	50	AUG 05-6, 2014
GCFEast	1	644-648	250	90	July 23-24 2014

Figure 29 Live stake cuttings at the Gun Creek Fan east side, planting with a combination of machine and manual labour.

Gun Creek Fan (GCF) West

GCFW Container Plants

The Gun Creek Fan west was also planted with test plantings, two long sedge strips were planted on the west side as well as native grass and Baltic rush 1X1m plots. Species stock was low by the time of the project planting on the west side of the fan so only three species of grass (Foxtail barley, Slender wheatgrass and Fowl bluegrass) were planted out at the 646m, 647m and 648m elevations on coarse and finer substrate textured microsites. The north and south sedge strips each spanned for 166m in length with the northern strip taking 1334 plants and the southern one 1358.

GCFW Live Stake Cuttings

Only willow species (Salix sp) were planted on the west side of the fan. In total 267 willow cuttings were planted out on the west side running in 5 sections from 644m up to 651m elevations. Cuttings were planted employing an excavator that dug trenches 1-1.5m deep. Cuttings were hand planted to a depth that stabilized them in the trenches and then back filled by the machine.

Table 8 Summary table of Live stake Cuttings Planted at the Gun Creek Fan West Site

CUTTINGS PLANTED FOR WORKS PROJECT 2014 July and August

Location	strip ID #	Elevation	Cottonwood	Willow	Date
GCFWest	3	644-645	0	45	27-Aug
GCFWest	3	645-647	0	90	AUG 28-29
GCFWest	3	647-648	0	37	AUG 28-29
GCFWest	3	648-650	0	65	AUG 28-29
GCFWest	3	650-651	0	30	AUG 28-29

Figure 30 Gun Creek Fan west sedge strip planting and live stake cuttings trenches. Lower right photo taken from Truax FSR as machine was backfilling planted trenches.

Steep Alluvial fan

SAF Container Plants

One of the two alluvial fans found on the south shore of Carpenter Reservoir was planted with three strips of sedges and two strips of live stake cuttings. The sedge strips were spaced along the fan to test the variation in aspect and substrate texture as well as crossing elevations from 644m to 648m. Sedges were planted using shovels and planting bags, sedges were all plugs. In total 1136 plugs were planted into 3 strips on the south shore Alluvial Fan site (Table 9).

SAF Live Stake Cuttings

Two hundred and forty-five willow cuttings were planted at the steep alluvial fan site. Cuttings were all planted by hand using steel bars, access issues made it difficult to get a machine to the alluvial fan site. The substrate terrain at the alluvial fan was coarse but particle size was mostly cobble and gravel sized making it possible to make 0.5-1.5m holes by hand using the steel bars. Cuttings were watered in using a pump and hoses.

Table 9 Summary table of plugs planted to Alluvial Fan Site 2014

ID	# Plants	Date Planted	Elevation Span	Length	Slope degrees	Azimuth
AF01	464	02-Jul-14	644-648m	58.6	4.5	47
AF02	448	02-Jul	644-648m	56.6	4.1	350
AF03	224	02-Jul	644-648m	28.6	8.25	313

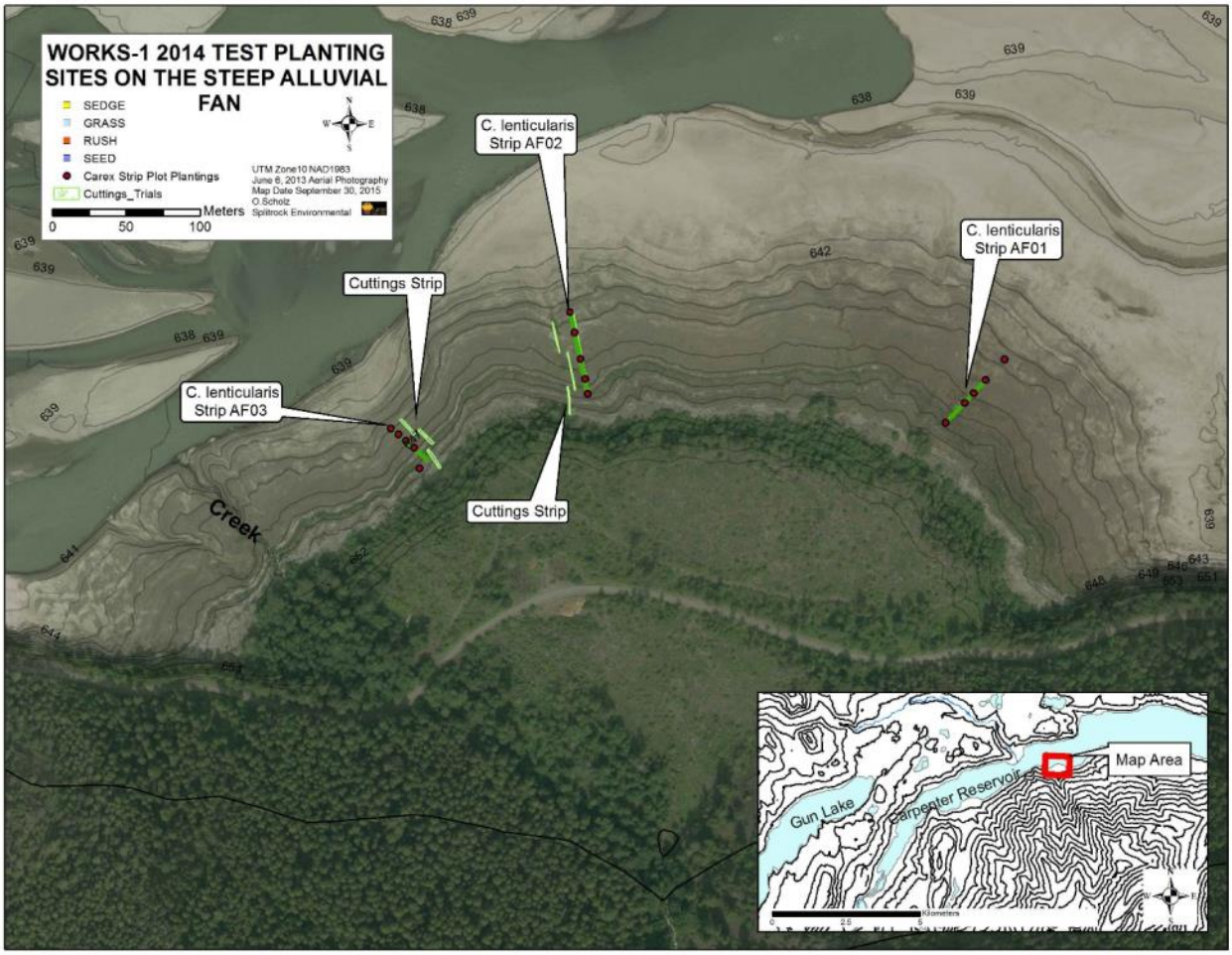


Figure 31 Alluvial Fan sites on the south shore of Carpenter Reservoir. Planted sedge strips and live stake cuttings of willows (*Salix sp*)

Figure 32 Alluvial Fan Planting Trials 2014.

RESULTS

In the 2014 season, reservoir levels peaked at 642.97m mark on July 26th,. Water levels held around the 642m elevation until August 14 and then held between 641m and 642m for the rest of the growing season (Figure 33). None of the initial year's test plots experienced any flooding with the exception of two 1X1m plots on the Steep beach site planted at the 642.5m mark.

Between June and September 2015, a total of 7652 rooted plants were planted into the Carpenter Reservoir target re-vegetation area. In addition, 1521 cuttings were planted into targeted trial areas. Almost all planted plots were installed at or above the 644m mark based on the predicted water levels for 2015. At the time of the commencement of the project the low mud flat area which makes up nearly 70 per cent of the target re-vegetation area, was already under water as water levels were over 641m. In 2014 the water levels peaked just under 643m in July and they stayed above 641m for the rest of the growing season. This was a relatively low high pool level compared to the previous 14 years (Figure 33). High water levels in 2014

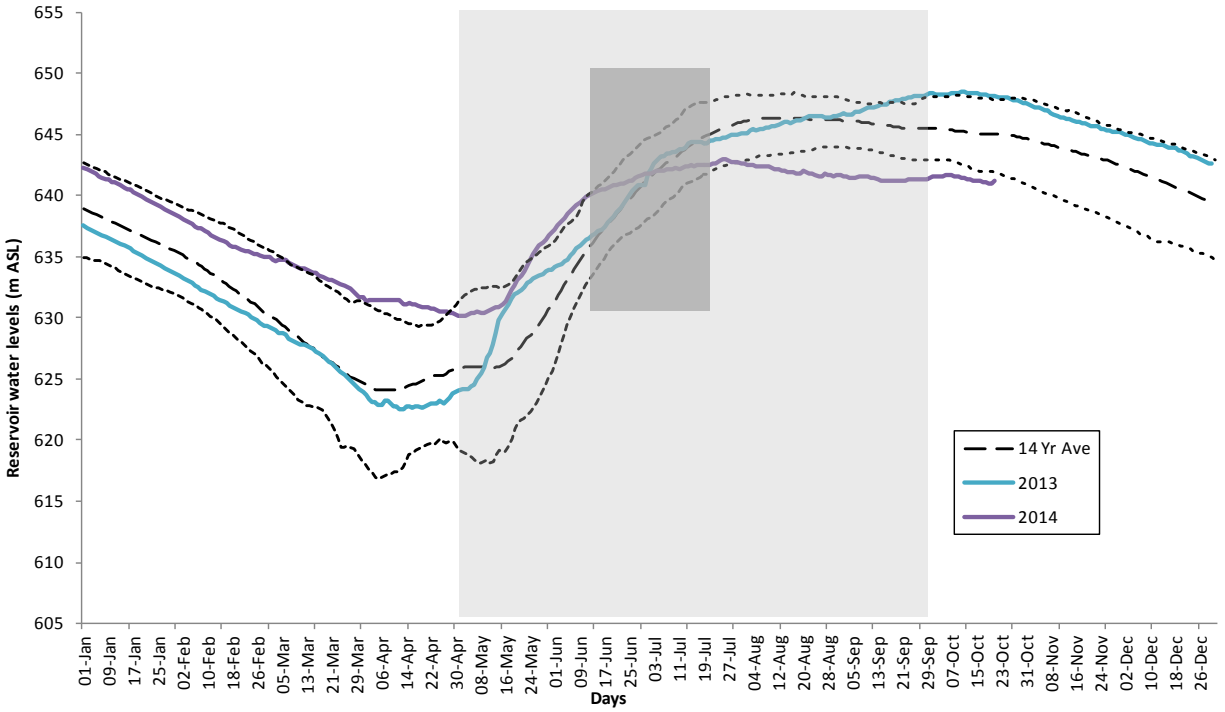


Figure 33 Graph highlighting 2013 and 2014 in context of the 14 year average water levels. 2014 the year of initial planting was a somewhat anomalous year with levels remaining relatively high for the first half of the year and then the high water levels remained relatively low during the usual high pool level period. Growing season is shaded as is main period of planting for 2014.

mid-summer were below the 10th percentile for the previous 14 years.

Carex lenticularis was the most frequently planted species with 6509 plugs planted into the target re-vegetation area on Carpenter Reservoir. 1296 sedge plugs were planted into 81 1mX1m plots and 5213 were planted into strips spanning from 644m up slope to approximately the 648m elevation band.

Table 10 Summary Table of trials carried out for the WORKS-1 Re-vegetation Program on Carpenter Reservoir in 2014. Greyed area represent numbers of 1X1m plots, clear background represents numbers of individual plants.

Vegetation Type	Steep Beach	Shallow Beach	Gun Creek Fan East	Gun Creek Fan West	Alluvial Fan	Total Plots	Total plants
Sedges (*C.lenticularis*)	31	10	40	0	0	81	1296
Grasses	27	27	45	9	0	108	972
Rush (*J. balticus*)	2	3	9	5	0	19	171
Seeds	11	0	15	0	0	26	0
Carex Strip Plantings	162	293	930	2692	1136	0	5213
Strips of willows	178	86	220	262	245	0	991
Strips of cottonwoods	0	0	530	0	0	0	530

Table 11 Summary total of number of individuals planted out into the WORKS target Restoration area in 2014.

Vegetation	Total
sedges	6509
grasses	972
rushes	171
cuttings	1521

Dust Monitoring

In 2014 consultation was carried out with BC Hydro dust monitoring specialists, and out of this it has been agreed that effective monitoring of dust storm frequency could be obtained through the setup of a weather station equipped with a digital camera to record images of the reservoir. Captured images could be analyzed to establish a frequency of dust event occurrences on the Carpenter Reservoir. This would allow a comparison over time to see if there is a reduction in occurrence after the revegetation effort. A programmable meteorological equipment station was ordered to enable logging temperature, wind speed, wind direction, precipitation, as well as being able to take photos at regular intervals in any weather conditions. The station will be powered by solar panels and batteries on site and will be downloaded on a monthly basis. Suitable locations for installing the camera were searched out with a sample view from investigated locations depicted in Figure 34.

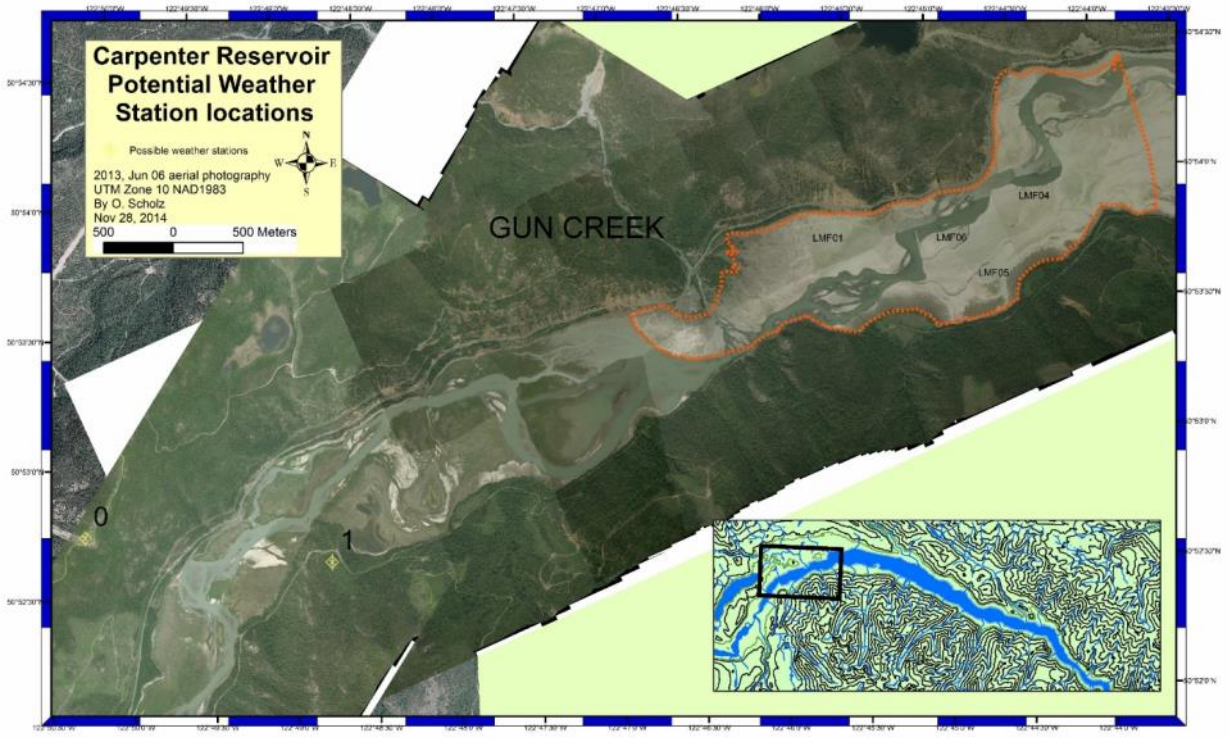


Figure 34 Possible locations for dust monitoring station, top left image from site (0), and top right image from site (1) with the revegetation target area outlined in red.

Aesthetic and Recreational Opportunities

In order to assess the highly subjective objectives of improved aesthetics and recreation we turned to public outreach to solicit feedback on public perception and use of the area. We targeted the Goldbridge and Bralorne area residents by attending one of the area's annual community events. At the event we hosted a booth with a poster highlighting the project and we spoke to people and had people fill out a survey developed request input on many of the objectives of the WORKS Project (See appendix for copy of survey or go to https://splitrock.typeform.com/to/R5Sk5C for online version). 23 forms were filled out at the outreach event and an additional 9 were completed online. To put the number of respondents in context, the population of Goldbrige is around 40 and Bralorne's sign reads 77; therefore 20 % of the local population participated in this survey. There are people that live around Gun Lake that have participated in the survey.

Wildlife

Wildlife monitoring data collected was of any sign and presence at 1X1m plot locations as well as anecdotal observations of wildlife while conducting revegetation and monitoring. Additional anecdotal wildlife information can be gleaned from the public survey. During plot monitoring in

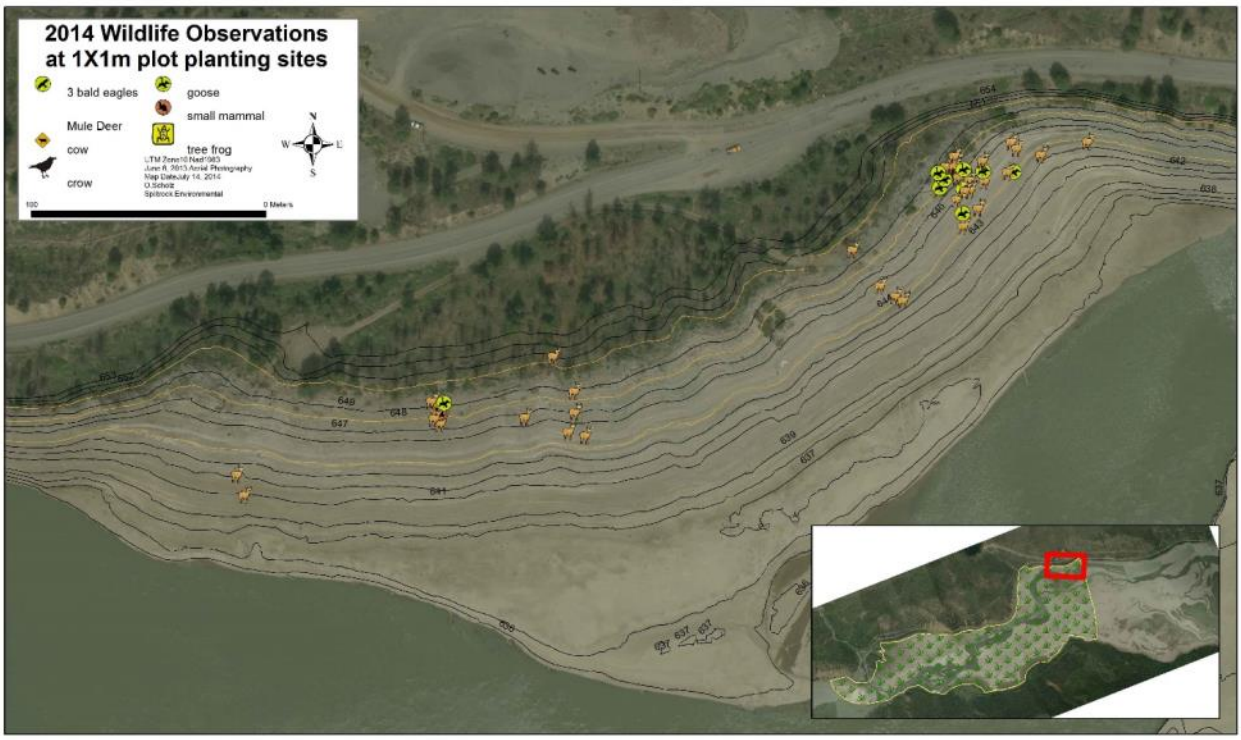


Figure 35 Steep Beach terrain wildlife sign observations.

June and September any signs of wildlife presence at the site of the plot were recorded. Mule deer were the most common wildlife sighted mainly in tracks and droppings. Mule deer sign was observed at all of the terrain types that had 1X1m plots Steep beach, Shallow Beach, and the Gun Fan east and west. In addition to mule deer, Canada geese prints and droppings were observed on the Steep Beach site, cow and crows were observed on the Shallow Beach site and a tree frog was observed at the Gun Creek Fan east side. Small mammal prints were recorded at the steep beach, beaver tracks and drag marks from pulling brush down to the water were also noted at the steep beach in the historic Salix planting site. Beaver damage may be a concern for some of the live stake plantings and may indicate a need to protect cuttings. If 2015 monitoring shows sign of beaver damage the project may need to consider protecting cuttings with fencing, cages or painting the stems.

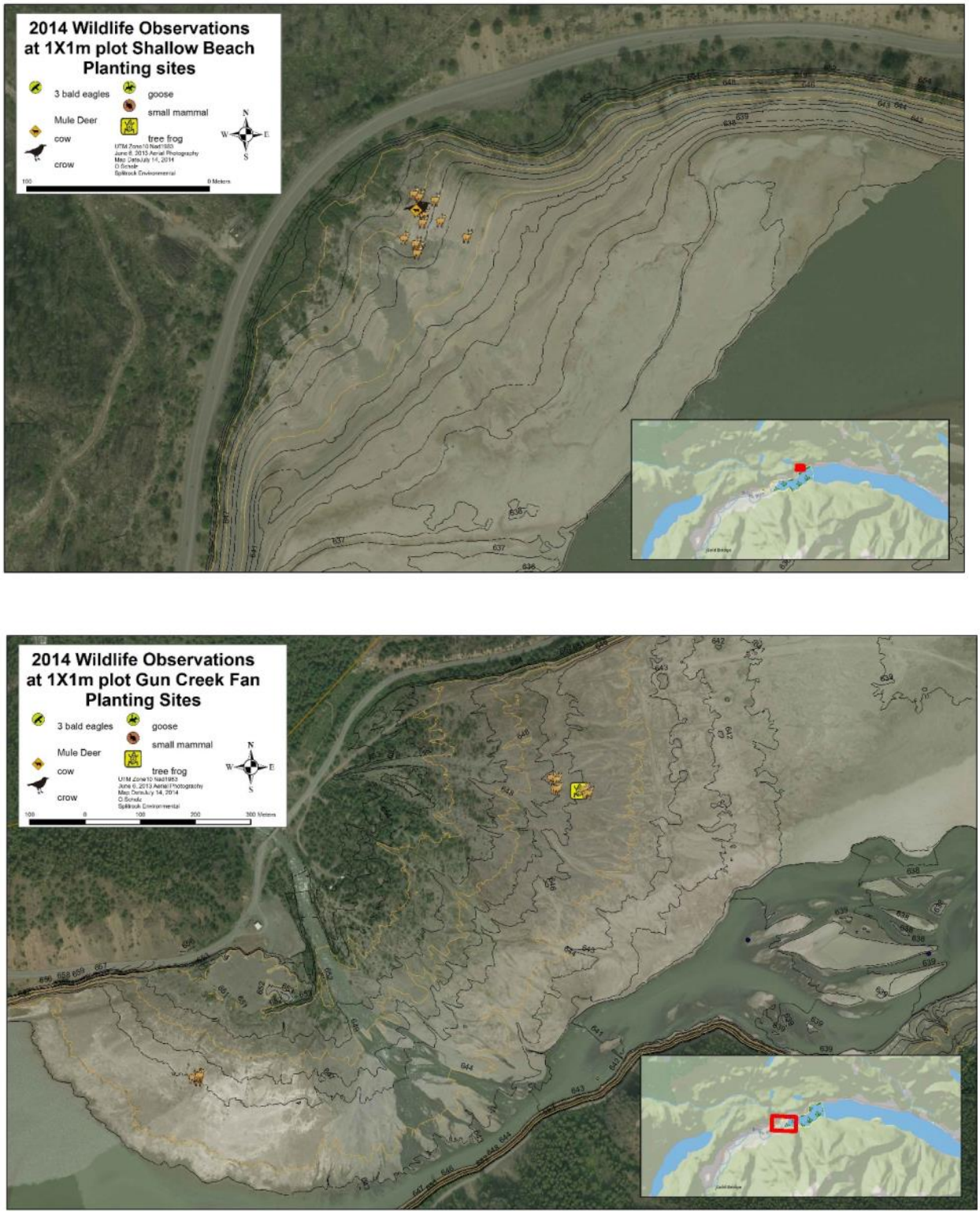


Figure 36 Series of maps of sites with 1X1m plots and observed wildlife sign at the sites at shallow beach above and the Gun Creek Fan below, records were from August 2014.

Aquatic Habitat

Another aspect of the Works project was to measure if there was any benefit to the quality of the aquatic ecosystem in the revegetated area. Other WUP project leaders studying the aquatic ecosystem (BRGMON4 Carpenter Reservoir and Middle Bridge River Fish and BRGMON 10 Carpenter Reservoir Productivity Model) have been contacted to request their studies include the WORKS1 target restoration area in their sampling as a means of assessing change on the quality of Aquatic habitat.

DISCUSSION

2014 was the implementation year for the BRGWORKS1 revegetation project, Phase 1. The project was not approved to go until late June with the result that planting could not commence until June 25th. This start is fairly late when considering the rising water levels of Carpenter that usually peak during June-August leaving at most several weeks of growth before inundation (Figure 12). The timing of planting misses a significant portion of the window of growth that exists in the region. Plant growth can start as early as mid-April. *Ideally planting would be carried out on the site in mid to late April depending on the weather*. Later planting dates mean higher temperatures at the time of planting and shorter initial growing season. Temperatures were in the mid to high 30's during 2014 planting placing a great deal of stress on the plantis in the very open hot conditions of the reservoir drawdown zone.

Planting trials for 2014 were kept at the 644m elevation and higher based on Hydro's predicted water levels for Carpenter Reservoir that year. Levels were anticipated to reach 644m by July 10th and inch up to 647m by the beginning of September. The July 10th expectations would mean lowest plantings would have at two weeks to settle in before being flooded. As it happened the Carpenter Reservoir water levels never reached 644m during 2014. As mentioned the levels started out high relative to the previous 13 years but then dropped to well below the average levels over that time frame (Figure 33). In 2014 none of the planted vegetation was inundated except for two plots on the Steep Beach site that were established at the 642.5m elevation. The concern about the short duration of time plants would have before being flooded turned to the length of time plants would have to endure without water, i.e. Drought. There was no contingency plan to irrigate plants after planting except for at the time of planting. *In future efforts it would be beneficial if a contingency plan were in place in the event of drought and no flooding to allow irrigation to assist plants through the first growing season.*

Cuttings planted by hand with steel bars were inserted to depths of 0.5 – 1.5m, the variation in depth may be a factor in cutting survival. *Follow up monitoring could include pulling dead stems and measuring and recording depth to which the cutting was planted to monitor for possible depth effect on survival*.

On the Gun Creek fan the substrate was so coarse with boulders that a machine was necessary to ensure adequate depths were obtained with the excavations. Even with the machine

excavation the only trench that hit ground water was at the 644m mark on the Gun Creek Fan east side. Cuttings were planted in August with the thought that water levels were going to slowly rise until early September. The reservoir water levels never exceeded 644m, the lowest elevation planted with cuttings. This meant that as with the planted plants cuttings were not inundated in 2014. The lowest elevation cuttings will have likely experienced sub surface moisture from high water. Cuttings were kept long 1-4m above the ground with the thought that some of the longer cuttings would keep the cuttings above water for a longer period of time before flooding allowing a longer period of growth.

Grasses both native and exotic were found to dominate ground cover at and above the 648m elevation (Buffer zone). Trembling aspen (*Populus tremuloides*) was observed encroaching into the drawdown zone at a number of sites. *P. tremuloides* may be an ideal species to plant in the upper buffer zone where it could establish and spread into the drawdown zone via root suckering. Rhizomatious species in addition to willows (*Salix sp*.) cottonwoods and aspens (*Populus sp.*) may include snowberry (*Symphorocarpus*) rose (*Rosa*) and dogbane (*Apocynum sp*) in general may be ideal candidates to plant in the upper buffer zone and may be worth experimenting with at each of the upper terrain classes.

A key area of the targeted revegetation project is in the low mudflat zone below 642m elevation. The high water levels at the time of project approval meant there was not enough time to test either seeds or planting below the 642m elevation. These areas will be planted out in 2015. All plot locations were visited in September to monitor for initial survival. This monitoring visit was beyond the scope of the BRGWORKS 1 project and should fall into the BRGMON 2 (there was no 2014 budget for BRGMON 2) monitoring of the project. This data will be reviewed and analysed as part of the BRGMON2 report for 2015. Data included photographs, and a repetition of the data collected for each plot prior to planting.

CONCLUSION

The BRGWORKS-1 project is targeted to revegetate approximately 243ha of the Carpenter Reservoir drawdown zone. 2014 was to be the first year of a staged approach to the revegetation effort called Phase 1. The late project start and early high water levels limited the areas that could be planted in the initial year. Planting trials were carried out across 4 terrain types; Steep Beach, Shallow Beach, Gun Creek Fan east and west and a south shore Alluvial Fan. A total of seven native forbs were planted in the first year of the project 5 native grasses, one rush and one sedge. Lakeshore sedge (*Carex lenticularis*) by far the most frequently planted species with 6509 plugs planted in total crossing 4 meters of elevation. Nine hundred and seventy-two grass plugs (5 species Bluejoint wheatgrass, fowl bluegrass, slender wheatgrass, blue wildrye, foxtail barley) and 171 Baltic rush were planted out into 1X1m plots at trial sites. In addition to plugs live stake cuttings were planted out in August including 991 willows and 530 cottonwoods. Plans were developed for the compilation and installation of a weather monitoring station to assess dust storm frequency and a public outreach and a survey was initiated to monitor and assess public aesthetic perception and recreation use, of the

targeted revegetation area as well as information on wildlife, dust storms and general vegetation.

Recommendations for Phase2:

- Continue to monitor 1X1m plots under the BRGMON 2 project.
- Focus more use of cottonwoods particularly at the Gun Creek Fan area.
- Identify and target microsites for planting plugs and cuttings where survival may be more successful ie have access to sub surface or surface water.
- Implement planting program including seeding, plugs and cuttings as early in the year as weather allows. Scope out site and conditions in early Spring to establish starting dates.
- Keep in mind that planting failures in 2014 may have been significantly influenced by late planting date and the lack of inundation and not necessarily the site conditions.
- Carry out trials including seeding and planting in the low mud flat areas establish monitoring protocol.
- Increase to area plantings at locations that indicate successful establishment.
- Carry out assessment of planting potential on Steep colluvium sites.
- Install weather monitoring and camera station as soon as possible in the meantime note and photograph dust storm points of origin if applicable.
- Consider implementing a maintenance regime for planted plants in the event that the planted vegetation is not inundated in a given year. (watering through first season)
- In future assessments of hand planted cuttings measure dead cuttings planting depth to determine if this was cause of failure.
- Determine target percentages of survival success for planted plants and cuttings.

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APPENDIX

Carpenter Reservoir Drawdown Zone Re-Vegetation Community Survey

SPLITROCK ENVIRONMENTAL SEKW'EL'WÁS

DUST STORMS

How often have you experienced dust storms coming off Carpenter Reservoir? _____ Do they occur every year? _____

What month/s are you most likely to experience dust storms? _____

What is the impact of the dust storms on you personally? _____

What is the impact of the dust storms on the community or the environment? _____

What could be done to reduce dust storms? _____

Any Other Comments:

_____

_____

_____

AESTHETIC QUALITY

How do you rate the aesthetic quality of Carpenter Reservoir? (1 being least favourable and 4 most favourable) 1 ☐ 2 ☐ 3 ☐ 4 ☐

What qualities provide the greatest aesthetic appeal to you? _____

What qualities provide the least aesthetic appeal to you? _____

What would you change to increase the aesthetic appeal? _____

Any Other Comments:

_____

_____

_____

_____

Carpenter Reservoir Drawdown Zone Re-Vegetation Community Survey

RECREATIONAL OPPORTUNITIES

Do you use Carpenter Reservoir for recreational uses? ☐ Yes ☐ No

If Yes, how many times a year do you use Carpenter Reservoir for recreational use? ☐ under 20 days ☐ 20-50 days ☐ 50-80 days ☐ more than 80 days

What months do you use the reservoir for recreational use? _____

What recreational activities do you enjoy on Carpenter Reservoir? _____

What are the recreational values for tourists? _____

What would you change to increase the recreational values? _____

Any Other Comments:

_____

_____

_____

WILDLIFE

How often do you see wildlife on the reservoir? ☐ Never ☐ under 20 days ☐ 20-50 days ☐ 50-80 days ☐ more than 80 days

What wildlife have you observed using Carpenter Reservoir? _____

On what part of the reservoir have you observed wildlife? _____

What months of the year are you most likely to observe wildlife? _____

What domestic animals have you observed on the reservoir? _____

What would you change to increase/decrease wildlife use? _____

Any Other Comments:

_____

_____