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Bridge River Project Water Use Plan

Carpenter Revegetation

Implementation Year 4

Reference: BRGWORKS-1

Period: 2017

Carpenter Reservoir Drawdown Zone Riparian Enhancement Program

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Executive Summary

2017 was the fourth year of the BRGWORKS-1 re-vegetation program on Carpenter Reservoir, this report represents the Year 4 Annual Report. The program shifted to an emphasis on riparian enhancements. Large-scale microtopography treatments were implemented in the Low Mud Flat, Gun Creek Fan East and Gun Creek Fan West terrain study sites. All riparian enhancement treatments in 2017 were stratified into polygons that were treated to diversify the relief and create microtopographic features ranging in elevation. Microtopography treatments were conducted over approximately 3 ha. In all, 9 polygons were used to test a broad range of terrain type and elevation influences on vegetation establishment success within the drawdown zone; two on the Low Mud Flat, 4 on Gun Creek Fan East and 3 on the Gun Creek Fan west.

In addition, planting and seeding trials were conducted to test whether combined restoration treatments would be beneficial to native plant recruitment and establishment. Focal species for planting were all from local sources. Kellogg's sedge (*Carex kelloggii*) and bluejoint reedgrass (*Calamagrostis canadensis*) were the dominant species planted. Also included in treatments were Canada wild rye (*Elymus canadensis*), foxtail barley (*Hordeum jubatum*), fowl bluegrass (*Poa palustris*) in addition to rooted stock of black cottonwood (*Populus balsamifera* ssp. *trichocarpa*) and live stake cuttings of willow species (primarily *Salix bebbiana*). Hand sown seeding trial areas were established within 4 of the machine treated polygons. Kellogg's sedge seed was hand sown and raked into the mounded substrate. Willow cuttings and rooted cottonwood were planted in the upper elevation polygons. Monitoring of treatment polygons and adjacent control areas will be conducted via the BRGMON-2 program. Monitoring will look for increased native vegetation diversity, cover, establishment and recruitment between trials and between treatment and control sites.

Water levels in Carpenter Reservoir during 2017 were relatively low compared to the 18 year averages. Treatment areas were inundated as early as the end of July 2017. Not all treatments were inundated in 2017. Full pool level was just under the 18 year average reached in late September 2017.

Monitoring via a weather station camera recorded the month of June as having the highest number of dust events. 3 percent of all images captured from 2017 displayed dust events, a 1 percent drop when compared to 2016 photos. Dust storms were primarily occurring in June and July. Dust storm generation sites continue to be observed along the eroding edges of the river at localized sites.

Public interest in BRGWORKS-1 2017 treatments was higher than in previous years. Feedback ranged from casual interest to concerns regarding impacts to heritage sites and threats to use of the area as a landing strip for airplanes. A public field tour and a Facebook posting were requested by local residents, and both were incorporated into the works project in 2017. The BRGWORKS-1 treatments in 2017 were based on a culmination of trials and experiences with treatments conducted over the previous 3 years.

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Summary Status Table

Table 1 BRGWORKS-1 Status 2015

OBJECTIVES, MANAGEMENT QUESTIONS and HYPOTHESES after 2014			
Study Objectives Numbers relate to MQ.	Management Questions	Management Hypotheses	Year 2017 (Status)
To design and implement a reservoir planting program for the western end of Carpenter Reservoir focusing on the area between Tyaughton Lake Road Junction and the Gun Creek fan.	MQ1 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?	H1 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.	YET _TO BE DETERMINED - Initial observations confirm dust is generated from localized areas of fine sands located along the immediate eroding banks of the Lower Bridge River. . We have yet to vegetate enough area to control dust at the Gun Creek and Lower Bridge River where dust is generated. The edge of the eroding banks immediate to the Bridge River are difficult to vegetate and may require other treatment method to control dust.
To focus on the planting of appropriate species of vegetation. This is done using information gained in the BRGMON-2 program.	MQ2 Will the planting of vegetation in the drawdown area increase the aesthetic quality and recreational opportunities in the western end of the Carpenter Reservoir?	H2 The planting of vegetation in the drawdown area does not increase the aesthetic quality and recreational opportunities in the western end of Carpenter Reservoir.	Public survey conducted during 2014-2015 provided baseline inputs of public perception of reservoir aesthetic and recreational use. Recreational use of region varied greatly. Aesthetic perception more than 50% negative. The survey also included questions regarding wildlife and dust storms. Public feedback showed that the 2016 fall rye treatment was positive aesthetically.

<p>To conduct evaluations of the program to assess the effectiveness of the planting program in establishing natural re-colonization of the area from Tyaughton Lake Road junction to Gun Creek fan (This will be covered under the BRGMON-2 program).</p>	<p>MQ3a Will the planting of vegetation enhance the quality of riparian habitats and increase their potential to support wildlife populations and provide localized improvements in the quality and productivity of aquatic habitats in Carpenter Reservoir?</p>	<p>H3a The planting of vegetation in the drawdown area does not enhance the quality of riparian habitats nor does it increase their potential to support wildlife populations and provide localized improvements in the quality and productivity of aquatic habitats in Carpenter Reservoir.</p>	<p>Wildlife sign and species observations have been recorded at all treatment plots. Observations included presence and use of site by mule deer. Incidental observations during project field work include peregrine falcon (red listed) on Gun Creek Fan East site. Other species with confirmed use at target re-vegetation site: beaver, Canada goose, mountain bluebird, river otter, long-toed salamander, western toad, savannah sparrow, spotted sandpiper, horse. A breeding bird survey was conducted in 2016 to form a baseline of breeding songbird species present in targeted re-vegetation and control areas 23 species identified in survey. LMF and GCFE displayed the lowest diversity. Most diverse vegetation structure and composition (Buffer mud flat) had most diversity in song birds.</p>
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To conduct evaluations of the program to assess the effectiveness of the planting program in enhancing the quality of riparian habitats, increasing their potential to support wildlife populations, and providing localized improvements in the quality and productivity of aquatic habitats in Carpenter Reservoir.	MQ3b Will the planting of vegetation provide localized improvements in the quality and productivity of aquatic habitats in Carpenter Reservoir?	H3b The planting of vegetation in the drawdown area does not enhance the quality and productivity of aquatic habitats in Carpenter Reservoir.	Studies conducted on the Arrow Lakes Reservoir indicate establishment of vegetation in the drawdown zone greatly increases the capacity of the site to host a diverse and abundant benthic community. Even though a direct correlation with sport fish production level was not found it was inferred that increased vegetation would provide cover and a source of food via increased presence of terrestrial invertebrates at the time of inundation. It is highly likely that successful establishment of vegetation in the Carpenter Reservoir drawdown zone will also result in an increase in benthic community productivity with associated benefits in productivity up the Reservoir's aquatic food chain.
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1. Introduction

2017 was year four of the BRGWORKS-1 re-vegetation project on the Carpenter Reservoir drawdown zone, this represents the Year 4 Annual Report. The Terms of Reference (TOR) for the original Water Use Plan project (BC Hydro, 2012) were revised over the winter of 2016-2017 (BC Hydro, 2017). Revisions were focused on shifting the emphasis of the program from a re-vegetation only focus to include a variety of riparian enhancement techniques to encourage natural colonization of the Carpenter Reservoir drawdown zone (BC Hydro, 2017).

The overall program schedule was extended during the TOR revision. The original program schedule took an experimental and staged adaptive management approach to re-vegetation treatments over 5 consecutive years. The focus was on identifying appropriate species and effective methods for re-vegetation and encouraging natural colonization (Scholz, 2015, 2017, 2018). After year 3 it became apparent that one of the program challenges were each treatment year was evaluated mid-growing season of the following year. This monitoring lag did not provide time for the monitoring program to gather data, assess results and apply learnings to

the subsequent year of treatment under the BRGWORKS-1 project. TOR revisions have added a lag year in 2018 where there are no treatments scheduled under the BRGWORKS-1 program. In addition, the program has been extended by two years for application of treatments to maximize the success of the program (2019-2020).

2017 was the first year under the revised TOR, and the emphasis of treatments shifted to machine contouring in the form of pit and mound creation on three of the targeted terrain type sites the Low Mud Flat, Gun Creek Fan East and Gun Creek Fan West side (Figure 1). In addition to micro-contouring, re-vegetation techniques were applied within the machine treated areas to create a complex of treatment polygons: machine work only, machine work planted, machine work seeded, and machine work live staked. Control areas were established adjacent to each treatment polygon via the BRGMON-2 program.

This report summarizes 2017 treatments including reference to prework requirements including an archaeology assessment. In addition, the results of 2017 dust storm monitoring for the year and community outreach and input are presented. The BRGWORKS-1 program has followed a staged adaptive management approach to re-vegetation that was continued through 2017.

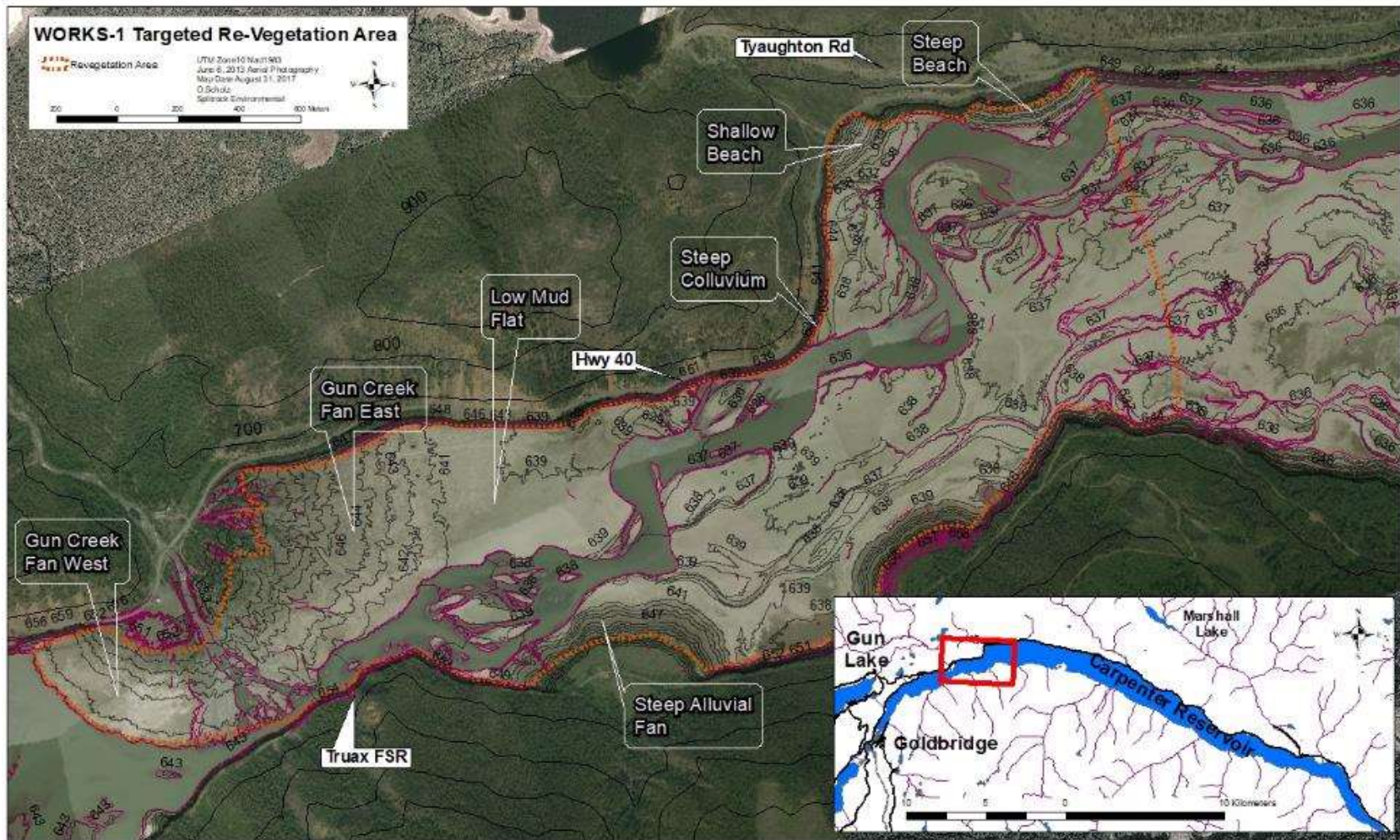


Figure 1. Target re-vegetation area of the Carpenter Reservoir drawdown zone. Terrain type areas referenced in text of the report are identified.

1.1 Project Location

The BRGWORKS-1 re-vegetation project is located at an area of the Carpenter Reservoir drawdown zone east of the town of Goldbridge BC (Figure 1, inset map, and Figure 2). The site is approximately 280 km north-east of Vancouver British Columbia in the Coast-Cascade Mountains. The area is located within St'at'imc traditional territory. The project area is in the Southern Interior ecoprovince and is within the Interior Transitional Ranges ecoregion. The project area is classified as Interior Douglas-fir very dry cold biogeoclimatic zone.

The target re-vegetation area includes the site that was once the historic town site of Minto BC. The town site is now within the reservoir drawdown zone. The Gun Creek fan that is central to much of the BRGWORKS-1 project, has a BC Hydro public recreation campground located on the east side of the Gun Creek fan. The Ministry of Transportation and Infrastructure has a dormant gravel pit on the west side of the Gun Creek fan. The bulk of the project treatment sites are accessed on the east side of the Gun Creek fan.

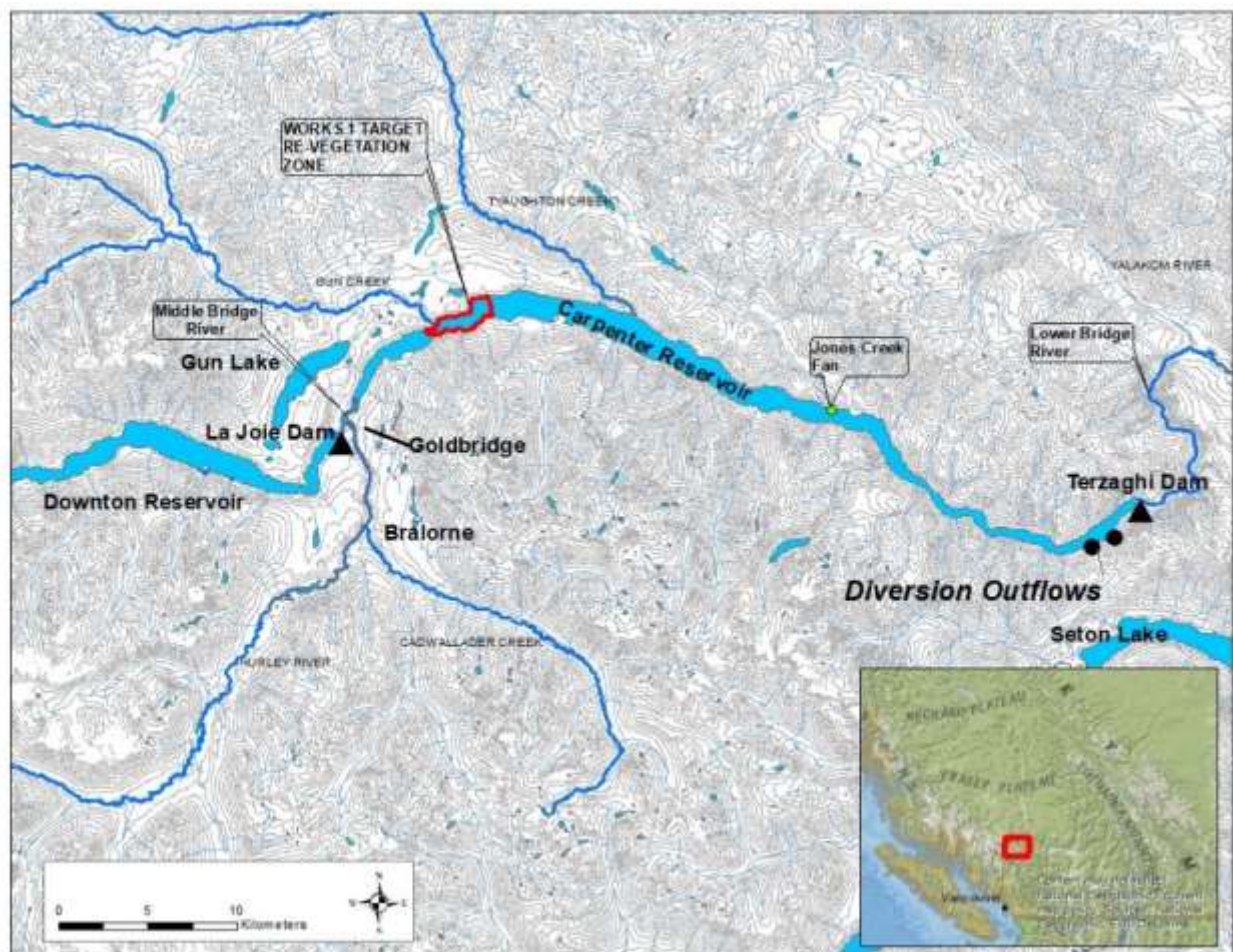


Figure 2. Carpenter Reservoir region and geographic location in the province. 292 ha targeted re-vegetation region of the Carpenter Reservoir BRGWORKS-1 Re-vegetation Project

2. Methods

2.1 Riparian Enhancements

2.1.1 Permitting

Maps were used and detailed gps data were sent to an archaeologist secured by BC Hydro to undertake the field impact assessment. The assessment was conducted in April 2017 by Amec Foster Wheeler and representative Archaeology technicians from the communities of Tsal'alh, Titq'et and Xwisten. Field crews used standard impact assessment techniques and analysed the areas within the identified treatment polygons [REDACTED].

The Gun Creek Fan East was historically the location of the historic mining town of Minto (Figure 3). The mining town was founded in 1934 and inhabited until 1941. The site was recently recognized as one of the locations of World War 11 Japanese interment camps occupied between 1942-1949. The town site of Minto was flooded by Gun Creek in 1950. (<http://www.lillooetbc.ca/Recreation-Activities/Golden-Miles-of-History/Japanese-Canadians-in-Lillooet/The-Minto-Japanese-Canadian-World-War-II-Interment.aspx>). While not considered a heritage site, Minto mine is a provincially recognized historic place on the on the Heritage BC web site, a result of the Japanese Canadian historic places recognition project (See discussion).

In addition to an archaeology impact assessment a Section 11 BC *Water Sustainability Act* permit was obtained dated April 26, 2017. Permit application was submitted by BC Hydro with assistance and documentation from Splitrock Environmental Sekw'el'was (Splitrock) (Permit # R3-3005963)

2.1.2 Machine treatments

A machine operator and a 200 series Hitachi excavator was retained via Bridge River Band contracting. Riparian enhancements were planned in the spring of 2017 to carry out the microtopographic manipulation of the substrate. The goal was to create substrate heterogeneity including high and low level sites and to diversify micro site elevations and aspects to promote capture of vegetation propagules and provide a diversity growing sites. This microtopography treatment is referred to as pits and mounds or rough and loose (Polster, 2009) treatments. Treatment areas were planned months in advance of implementation, in part, to allow time for an archaeological impact assessment. Treatments will be assessed for success under BRGMON-2 WUP monitoring program.

Site selection was made taking into consideration machine access and operational efficiency as well as ecological characteristics. Three terrain sites were selected each with diverse characteristics and conditions. Polygon characteristics differed in substrate composition and cover, soil texture, aspect, existing vegetation cover and elevation. The areas chosen for



treatment included two sites on the Low Mud flat, 4 polygons on the Gun Creek Fan East and 3 polygons on the Gun Creek Fan West (Figure 3).

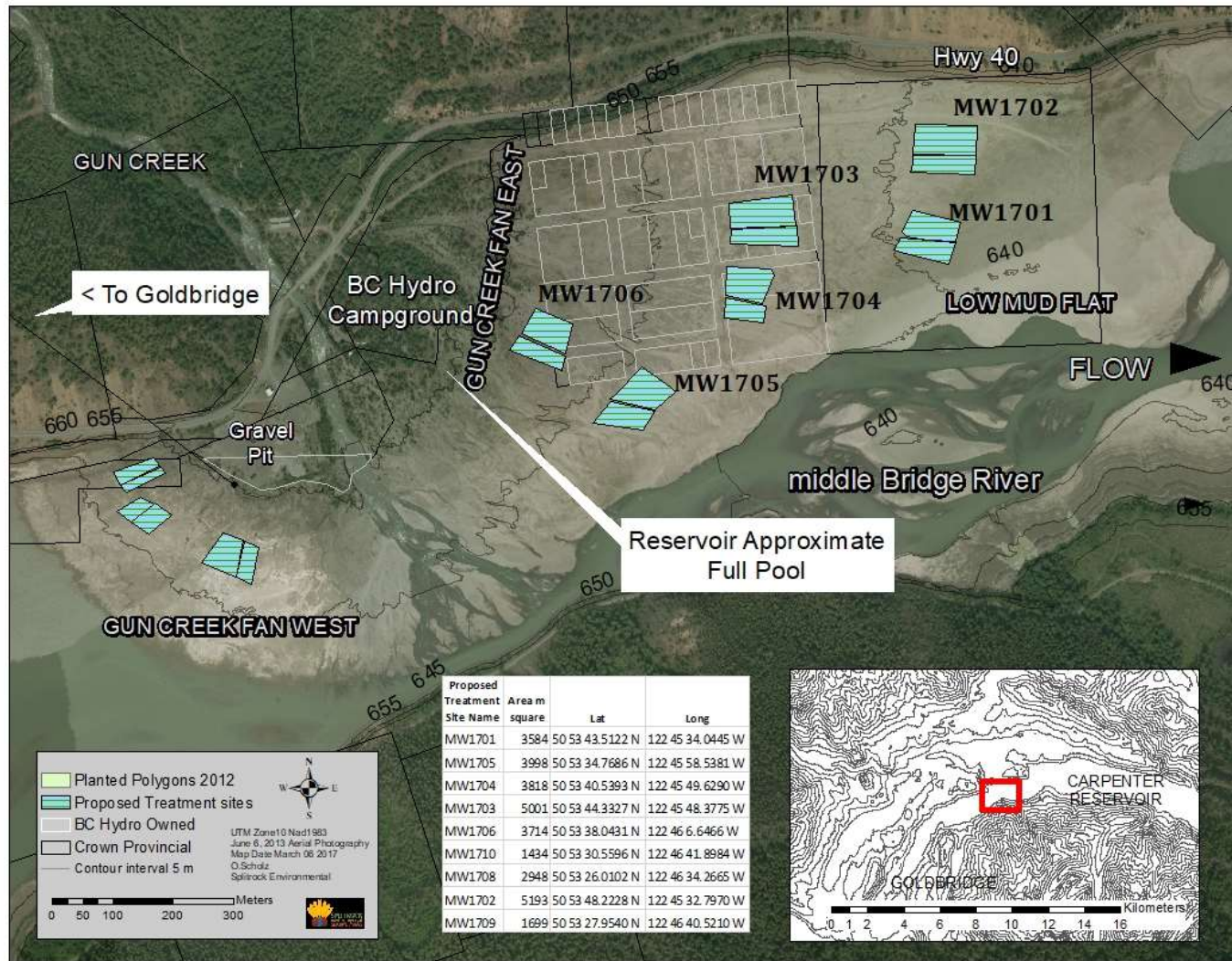


Figure 3. Map showing proposed sites for riparian enhancement treatment in 2017. Polygon areas were used in the field by archaeologists to assess the potential impact of riparian enhancement treatments. White lines demark historic lots from the town site of Minto.

2.1.3 Potted Plants

Nursery stock was comprised of only locally derived native species. Species used included Kellogg's sedge, bluejoint reedgrass, foxtail barley and fowl bluegrass all collected within 5 km of the treatment sites. Willow cuttings were harvested within 10 km of the site. Other native species used including Canada wildrye and black cottonwood were collected within 100km of the site. Potted plants were grown locally at the the Splitrock native plant nursery in Lillooet B.C. Seeds of most species including key species Kellogg's sedge were started soon after harvest and held over winter. Plants were grown in a temperature controlled greenhouse to extend the growing season. Most plants were grown as plugs in styro blocks. Black cottonwood and Canada wildrye were grown in 1-gallon containers. Willow was the only species planted as cuttings planted in 2017.

Plants were transported to the site in treeplanting style boxes and stored in a Fiberglass Insulated Seedling Transport (F.I.S.T[™]) canopy equipped truck to regulate temperature and moisture. On site reflective Silvicoil tarps were used to shade and control plant temperatures prior to them being planted. Crew technicians transported plants in planting bags lined with Silvicoil inserts to maintain optimum temperatures for plants. Planting was carried out using standard tree planting shovels. Planting sites were watered after planting.

2.1.4 Live Stake Cuttings

Willow species (*Salix spp.*) were harvested, stripped of side branches and transported to the planting sites. The cuttings were soaked for at least 24-hours and stored in the shade prior to planting. Willow cuttings ranged in diameter from 2 cm to 5 cm at the narrow end. Cuttings were planted into trenches excavated to 1-1.5 m in depth in the three polygons on the west side of the Gun Creek fan. Cuttings were hand planted in the base of the trenches within the machine work polygons. Cuttings were partially backfilled by hand to secure stem and to allow backfilling by machine. Cuttings were watered in and where necessary trimmed back to between 10 and 30 cm in length.



Figure 4. planting cuttings MW1708, machine digs trench, planters plant and backfill until cutting is stable. May 17, 2017.

2.1.5 Seeding Trials

Approximately 150m² to 200m² sections of four of the riparian enhancement polygons (MW1701,02,03,04) were hand seeded each with 1kg of Kellogg's sedge (previously lakeshore sedge) (*Carex kelloggii* W. Boot (Previously *Carex lenticularis* Michx.)) seed. The seeded areas were lightly raked by hand after seeds were sown.

2.2 Dust Storms

One of the objectives of the BRGWORKS 1 program is to reduce the frequency of dust storms occurring in the drawdown zone. In order to monitor dust storm frequency, a weather station equipped with a camera overlooking the re-vegetation treatment zone was installed on 5 Mile Ridge (Figure 5) . The camera is programmed to capture a still image every 5 minutes during daylight hours. The camera is focused on the target riparian enhancement area. The camera

and weather station require monthly visits to download data. Collected data was analysed for the number of images that display evidence of dust events.

During analysis, each image was reviewed and images displaying dust storm evidence were recorded. The identified dust event was classified by size as small, medium or large. The origin of the dust event was noted, and any notes regarding the image were added. After all dust events were identified, events were tallied to indicate the number of positive events. If images capturing events occurred in sequence less than 30 minutes apart, events were considered as part of one dust storm. Individual images were ranked for size of event, therefore individual storms spanning multiple images could contain a range of different sized events including small, medium and large. Images were also analysed for sites that are primary sources of dust generation.



Figure 5. Map showing location of the dust storm monitoring weather station with cameras orientation relative to project area.

2.3 Aesthetics and Recreational Use

A public survey was designed and has been solicited to locals in the Gold Bridge area. A public outreach event was attended on April 29th 2017, at the Gold Bridge Community Centre. A follow up field tour was held at the field treatment sites in July. A short public information article was posted to the Splitrock Facebook page as requested by local residents to explain the summer's riparian enhancement treatments.

2.4 Wildlife Use

Wildlife presence and use of the area is being monitored via recording wildlife and wildlife sign as a component of the data collected under the BRGMON 2 monitoring program. Incidental observations of wildlife presence and wildlife sign are also recorded during BRGWORKS-1 field operations and BRGMON-2 data collection. Locals provided wildlife observations as a component of the public survey conducted in 2014-2015 and results were reported in Scholz, 2015. A breeding songbird survey was carried out in 2016 (Heinrich, 2016) to establish avian species composition during breeding at both re-vegetation treatment sites and reference sites around the reservoir. The breeding bird survey was not conducted in 2017 but is scheduled for 2018.

2.5 Water Levels and Drawdown Zone Elevations

BC Hydro makes efforts to maintain a 3 vertical meter buffer zone around Carpenter Reservoir by having a target maximum elevation of 648.00 m above sea level. BC Hydro manages Carpenter Reservoir for power generation, fish habitat, and to minimize spills from Terzaghi Dam into the Lower Bridge River (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 such as safety.

Over the past 18 years, the average full pool level for Carpenter Reservoir has been approximately 646 m or 2 vertical meters below the lower elevation of the riparian buffer zone (Figure 6).

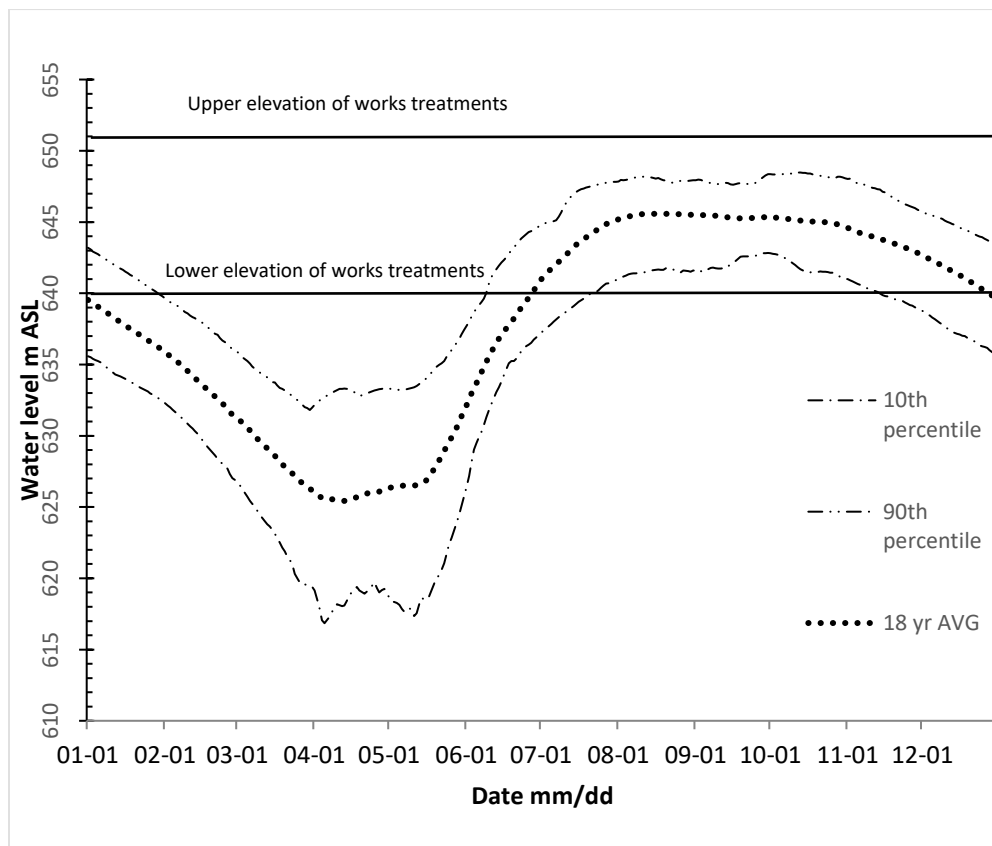


Figure 6. Carpenter Reservoir annual water levels from 2000-2017.

3. Results

The results section is divided into five sections to address re-vegetation, dust storm frequency, aesthetic and recreation use, wildlife use and water level results.

3.1 Riparian Enhancements

3.1.1 Permitting

The archaeological impact assessment covered the nine designated riparian enhancement treatment polygon areas (Begg, 2017). No artifacts were found and no other archaeological concerns were raised on Gun Creek Fan East. [REDACTED]

[REDACTED] Part of the MW1710 area was removed from treatment creating two smaller polygon areas separated by a no treatment zone. The remainder of the polygons were treated as delineated. The riparian enhancement polygons were treated using a Hitachi 200 excavator.

3.1.2 Machine Treatments

Treatment polygons were located to span a range of elevations across three of the terrain treatment sites, Low Mud Flat, Gun Creek Fan East and Gun Creek Fan West. The polygon areas were situated to avoid, as much as was possible, overlap with other past BRGWORKS- 1 treatments and to avoid the heart of the historic Minto town site. Each polygon was established to treat approximately a half hectare. Adjacent polygons also had to have a comparable sized area meeting the same criteria as the treatment sites to serve as a control site.

The machine treatment polygons were placed at elevations spanning 639m through 649m (Figure 11 Figure 12) and included a range of substrated from fine silts and sands to very coarse cobble boulder.

Treatments commenced in the Low Mud flat MW1702 and MW1701 on May 09, 2017. Machine work took seven days. MW1702 was treated using a strait edged 'clean-up' bucket on the excavator to enable efficient construction of very large mounds on the very soft silt-sand substrate (Figure 7) . MW1702 mounds were created to be much larger than those typically constructed using a rough and loose substrate treatment (Polster, 2013). In MW1702, large linear mounds were sculpted by the excavator keeping in mind that when submerged the fine substrate material would face strong settling forces.



Figure 7. Polygon MW1702 being constructed using an excavator fitted with large volume clean-up bucket.

Machine treatment progressed from the low elevation sites towards the upper drawdown zone elevations on Gun Creek Fan East. The machine was then transported to the Gun Creek West fan and treatments were carried out there.

The machine's clean-up bucket was swapped out for the digging bucket part way through MW1701. The larger outside mounds of MW1701 were created with the clean-up bucket, and the smaller inside mounds including the entire west edge were made using the digging bucket (Figure 8).



Figure 8. Two left hand rows of mounds done with clean-up bucket, right side done with toothed clean up bucket.

The digging bucket was used throughout the rest of the treated polygons. The mid and upper polygon substrate on Gun Creek fan east were very coarse in comparison with the low mud flats which were predominantly silts and fine sands. The mid and upper elevation polygons were compact boulder and cobble dominated substrates requiring a digging bucket to be used for mounding (Figure 9).



Figure 9. MW1706 ,very coarse rocky substrate.

After machine treatment was completed, polygons were flagged to separate out smaller, sub-polygon treatment zones. Half of each of the treated polygons were planted, and half were left machine treated only. In addition, MW1701, MW1702, MW1703 and MW1704 had additional areas were flagged for seeding trials. Topography, photo-monitoring, substrate moisture readings and vegetation cover were monitored for all polygons and associated control polygons under the BRGMON 2 program.

3.1.3 Planting

BRGWORKS-1 treatments to date have focused on planting and seedling trials (Sholz, 2015, 2016) with some moderate successes observed with planting Kellogg's sedge, bluejoint reedgrass, fowl bluegrass and foxtail barley (Scholz and Gibeau, 2017). There have also been moderate successes with willow cuttings and seeding trials using Kellogg's sedge. A crew of 6 planted and seeded plugs, cuttings and rooted container plants into designated areas of machine treatment polygons (Figure 11, Figure 12). Planting treatments were applied between May 15 and May 25th 2017. Weather conditions during the two week planting period gradually warmed from low teens to low 20's (Figure 10). After planting temperatures cooled and fluctuated with generally cool temperatures for several weeks post planting. Several mm of precipitation fell just prior to and after planting making for relatively good weather conditions

surrounding the planting treatment period. By planting and seeding we aimed to test if there would be a quicker response in increased native vegetation cover, diversity, establishment and recruitment of native species in revegetated vs machine treatment only polygons.

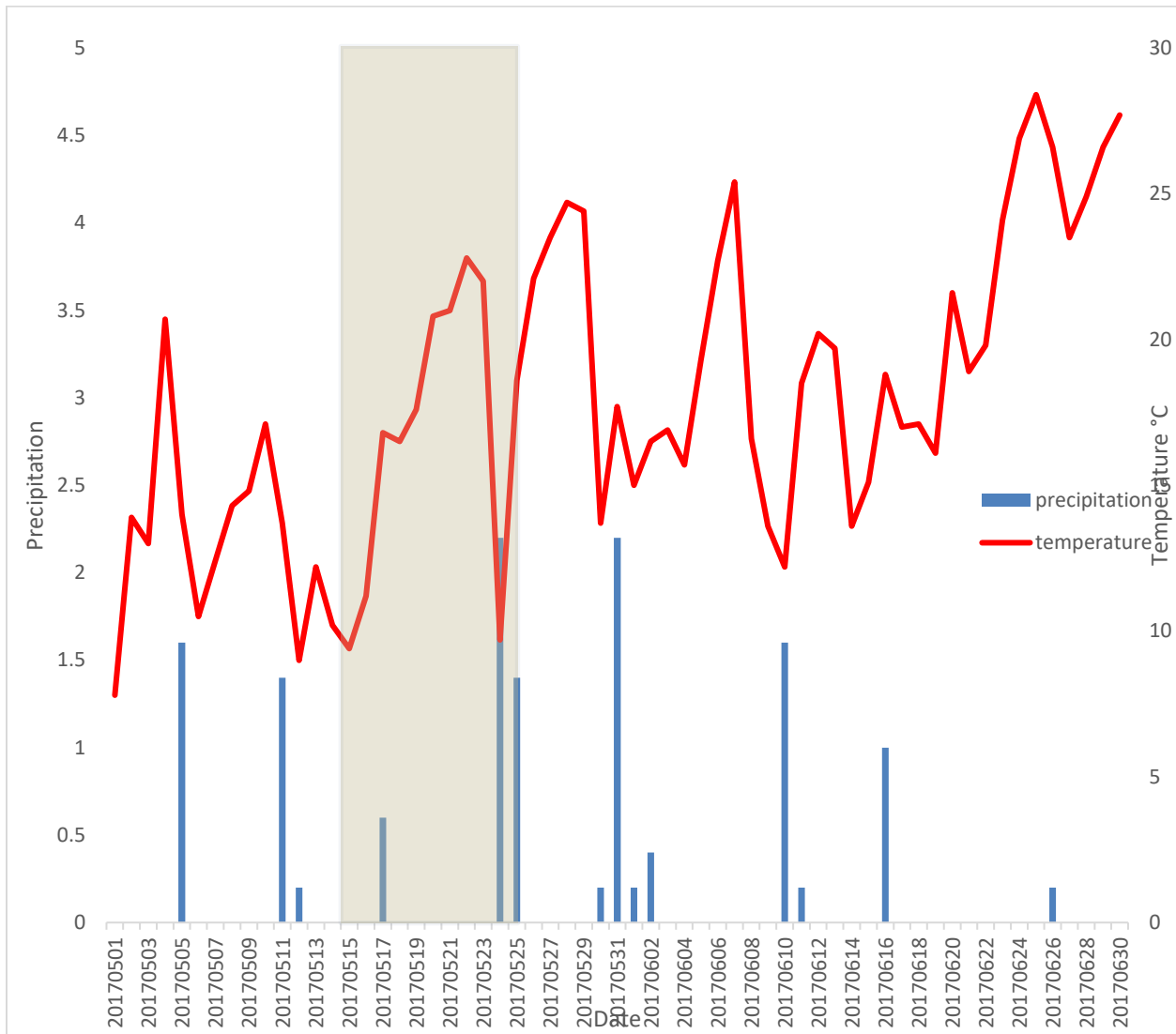


Figure 10 local weather around BRGWORKS-1 treatment period in 2017 (May-June).

All planting and seeding treatments in 2017 were carried out within riparian enhancement polygons. Approximately half of each of the riparian enhancement polygons were planted with rooted container plants. Vegetation species mix was varied from polygon to polygon and included a focus on using Kellogg's sedge at the lower drawdown elevations (MW1701, MW1702, MW1703, MW1704, MW1705). At higher elevations species planted were shifted to mix of native grasses at all of the mid and upper elevation polygons. Rooted cottonwood trees and some shrubs were planted in the upper drawdown elevations (MW1706, MW1708, MW1709, MW1710) (Table 2). In total, 13,895 rooted plants were planted into sections of each of the 9 polygons planted (Table 2). Planting densities varied by polygon with lower elevation polygons having more plantable areas than upper elevations where rock took up more of the substrate cover.

Table 2. Vegetation added to riparian enhancement polygons in 2017.

Species\Polygon	elevation 639m-640m		642-643m		643m- 644m	647m- 649m	646m-647m		647m- 649m
	NW1701	NW1702	NW1703	NW1704	NW1705	NW1706	NW1708	NW1709	NW1710
Kellogg's sedge	3041	2420	1608	1872	1278				
bluejoint		168	300	444	420	390	594	144	
reedgrass									
Canada wildrye					25	25	21	25	45
Fowl Bluegrass			24	30	108	126	150		
foxtail barley			24	30	120	108	60	120	
black						100	25	25	25
cottonwood									
willow cuttings							37	107	102
Total	3041	2588	1956	2376	1951	749	947	421	172
Approximate area m ²	1630	2662	2358	2152	2029	1863	1629	1437	951
average planting density (plants/m ²)	1.87	0.97	0.83	1.1	0.96	0.4	0.58	0.29	0.18

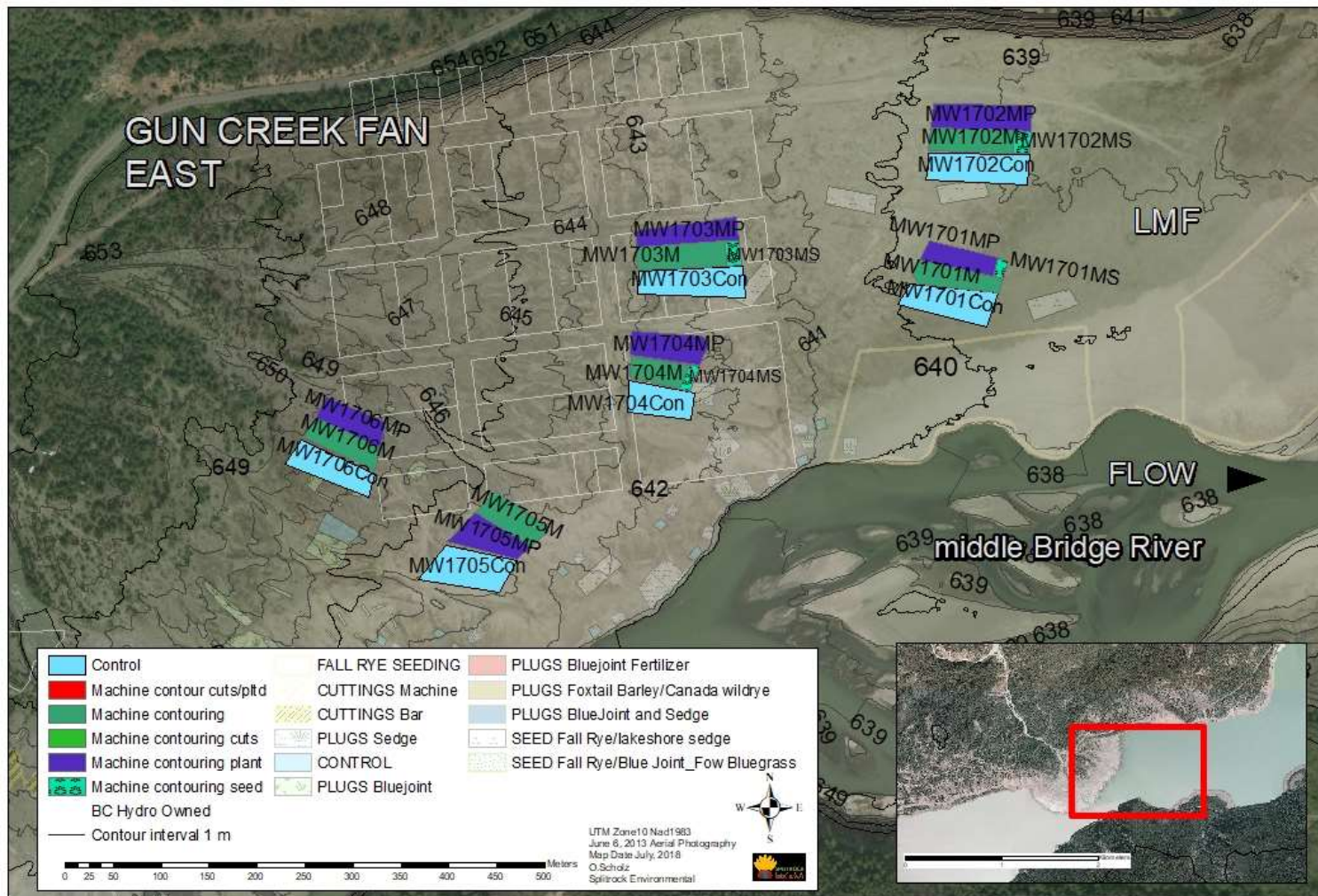


Figure 11. Map of Gun Creek Fan East riparian enhancement polygons.

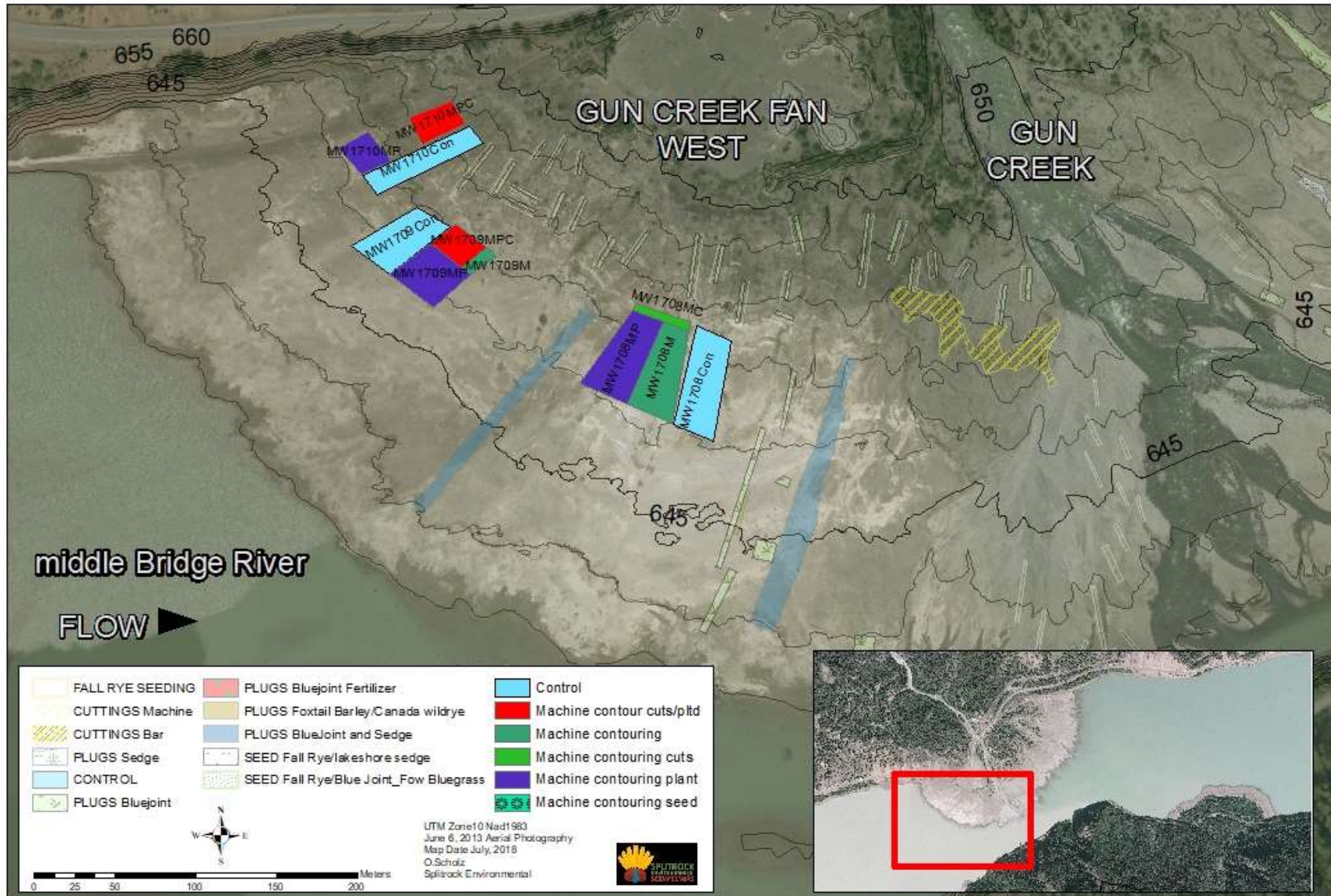


Figure 12. Map of Gun Creek Fan West riparian enhancement polygons.

3.1.4 Live Stake Cuttings

The three polygons on Gun Creek Fan West were treated with live stakes of willow. In all, 246 willow stakes were planted into trenches in polygons MW1708, MW1709, and MW1710.

3.1.5 Seeding

Approximately 1 kg of Kellogg's sedge seed was hand sown into each of the low lying polygons MW1701, MW1702, MW1703 and MW1704. Areas sown with sedge seed were lightly raked after seeding to assist with seed burial and improve chances of germination.

3.2 Dust Storms

Weather station camera data for 2017 covered the period of March 29 through November 30. The month of May was not sampled due to a technical error. A total of 886 images were identified with dust events. Of the dust events captured, 62 % were classified as small, 28 % as medium and 10 % as large (Figure 13, Figure 14, Figure 15). In 2017, a total of 150 individual dust storm events were recorded between June and November.

The majority of the dust events and days with dust storms were recorded in June and July prior to Reservoir inundation (Table 3). As noted in previous years, much of the dust arises from the river banks and fluvial bars along and within the middle Bridge River, . These sites are characterized by loose very fine silts and sands that are exposed through active water and wind erosion. The majority of dust generating sites are covered in water when the reservoir is at 642 m in elevation. Carpenter Reservoir reached 642 m in elevation on August 21, 2017. Dust generation is also observed at sites where repeated vehicle traffic occurs on Gun Fan East (Figure 16). Eight dust events were attributable to vehicles driving on the Gun Creek Fan. Most dust storms were observed moving from west to east away from the town of Goldbridge. Dust clouds appear to be most dense at the site of origin, and dissipate by the time the western edge of the photo frame is reached.

Table 3. Summary of Dust Storm Events captured on images June-Nov 2017.

Month	Total No. images	Total No. of images with dust events	% of images with dust	No. Small events	No. Medium events	No. Large events	Total No. dust events	No. days surveyed	No. dust days
April	4488	208	0.05	10	8	2	13	28	9
May	NA	NA	NA	NA	NA	NA	NA	0	NA
June	5541	351	0.06	212	108	30	54	30	20
July	5829	208	0.04	91	31	7	53	31	20
August	5274	112	0.021	66	24	19	26	31	14
September	4450	5	0.001	5	0	0	2	30	2
October	3855	0	0.000	0	0	0	0	31	0
November	3041	2	0.001	0	2	2	2	30	1
Total	32478	886	0.03	384	173	60	150	211	66



Figure 13. Example of a small highly localized dust event, possibly a vehicle. June 28, 2017



Figure 14. Example of medium sized dust event. June 11, 2017



Figure 15. Example of a dust storm rated as large. June 13, 2017



Figure 16. Example of vehicle driving on Gun Creek Fan East creating a small dust event.

3.3 Aesthetic and Recreational Use

No additional surveys were conducted in 2017. Hiking and off road vehicle driving were once again observed to be the most common recreational activities engaged in the target re-vegetation area during implementation of the program. For details, refer to the 2015 BRGWORKS-1 report for overview of recreational use at the site as compiled from the public survey. An information table was hosted at a Goldbridge community event on April 29th 2017. At this event the BRGWORKS-1 project was discussed one on one, with over 20 members of the local community.

The riparian enhancement treatments drew public attention. During construction, it was noted that most passerbys on Highway 40 at least slowed and often stopped to watch the machine's progress. The riparian enhancements drew attention from the local regional government representative (D. Demare) who expressed an interest and concerns with the treatments. We were alerted to observations of people hauling soil away from the mounded sites on the Low Mud Flat. In response, an information article was posted to the Splitrock Environmental Facebook page on July 18, 2017. The article was aimed at educating the public about the objectives of the riparian enhancement treatments (See appendix). In addition a public tour of the re-vegetation and riparian enhancement works was hosted by Splitrock on June 22, 2017 (Figure 17) (See Appendix for event poster). Thirteen people attended the field tour including the BC Hydro natural resource specialist. Questions and concerns raised during the tour included concern regarding the site being in close proximity to the location of a Japanese interment camp that was being commemorated with a sign at the campground entrance (Figure 19). Also, there was concern for heritage of the site in general with some of the riparian enhancement polygons being directly within the historic town site of

Minto. In general, there was support for the re-vegetation efforts being made on the Gun Creek Fan. After the field tour an additional issue was brought forward by a local pilot who conveyed information that some pilots use the mud flats as a landing strip and there was concern that the mounding treatment would eliminate the possibility of this use. It is of note that there is an actual airstrip very close to this site, at the east end of Gun Lake.



Figure 17. Public outreach and information tour on Gun Creek Fan East. June 22, 2018.

3.4 Wildlife Use

A breeding songbird survey was carried out in May 2016 (Heinrich, 2016) and was to be repeated in 2017. The survey was not carried out in 2017 due to scheduling issues. It was decided that there would be no setback to monitoring with a postponement of surveying until 2018. At this time, a full set of monitoring trials could be carried out in the late spring and early summer of 2018 (3 sessions). Surveys will be repeated at the 8 point count stations established in 2016. Wildlife sign is also monitored as part of the BRGMON 2 data collection.

3.5 Water Levels

Carpenter Reservoir water levels maintained a relatively low elevation during 2017. The reservoir was draughted down to below the 10th percentile low point recorded over the past 18 years. Levels bottomed out at 615.16 MASL on May 5th.

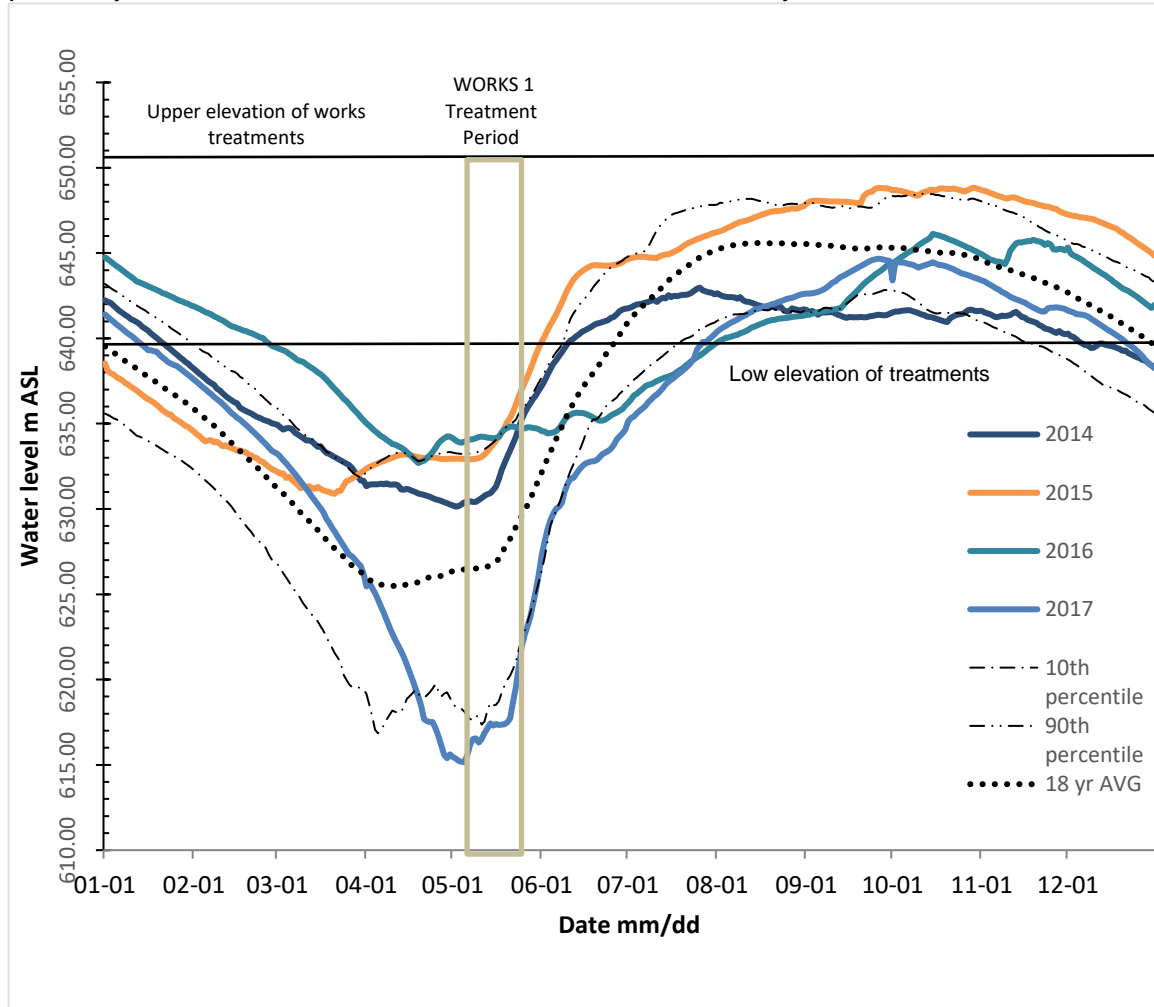


Figure 18. Carpenter water levels for BRGWORKS-1 treatment period.

Reservoir levels remained at or below the lowest 10th percentile point through much of the 2017 growing season peaking at a full pool level of 644.67 m at the end of September 26, 2017. The 2017 full pool level was just below the 18 year average full pool level. Reservoir levels did not affect BRGWORKS-1 treatments until the end of July when levels rose above 640 m. Water levels rose above 642 m at the end of August.

4. Discussion

2017 BRGWORKS-1 riparian enhancement trials built upon experiences from previous years but also took a new direction with the introduction of riparian enhancement treatments using substrate modification. Machine treatments used a similar approach to a typical rough and loose treatment prescription (Polster, 2013) with the exception that at the lowest elevations, very large mounding was imposed using the larger clean-up bucket on the excavator. This was done to produce larger microtopographical features to increase the chance that the alterations would maintain their shape after being exposed to the leveling, settling and smoothing effects brought on by inundation. Microtopographic measurements were carried out via the BRGMON-2 monitoring, and 2018 monitoring should detect how much settling occurs after flooding. In MW1702, a mound was constructed to be approximately 5 m above the reservoir bed. The top of this mound was observed as a small island protruding from the water on July 31 when water levels were at 640.23 m. The mound was eventually submerged as water levels reached 644.6m by the end of August completely inundating MW1701, MW1702, MW1703, MW1704 and part of MW1705. Mw1706, MW1708, MW1709 and MW1710 were unaffected by reservoir levels in 2017.

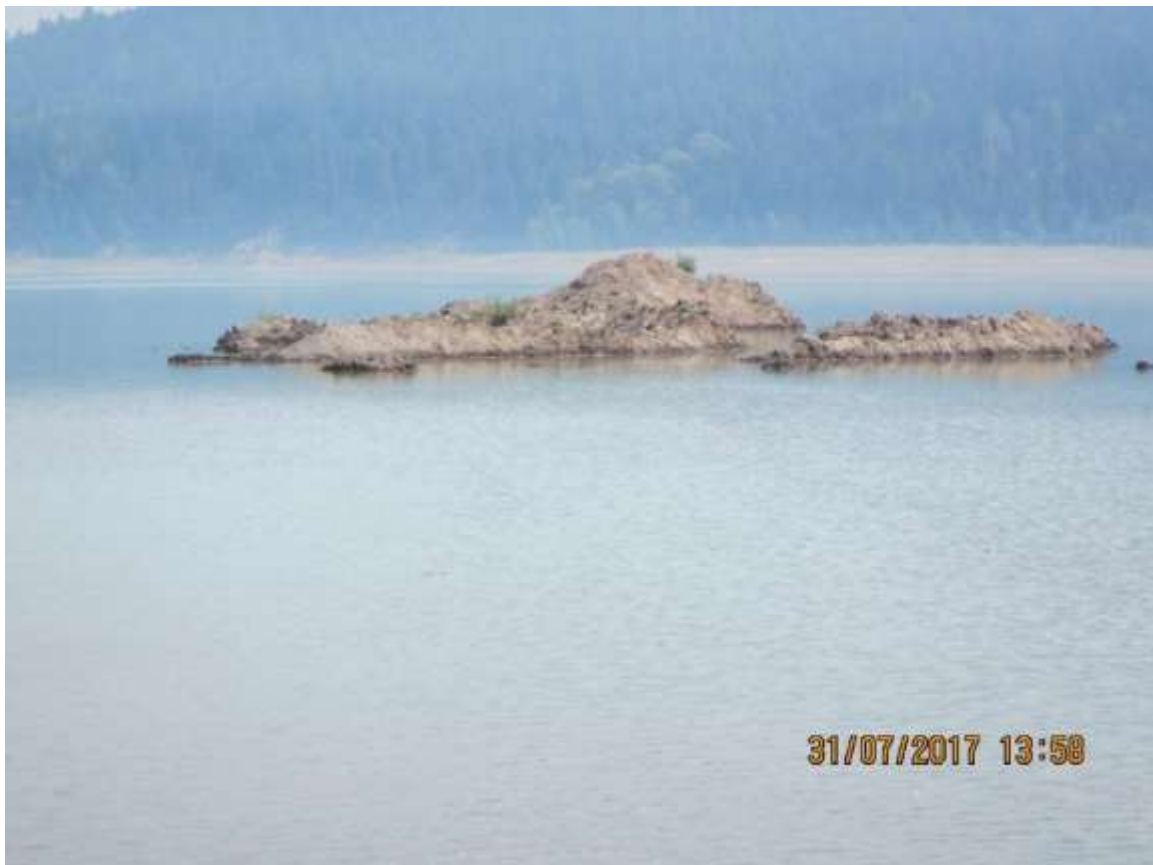


Figure 19. Peaks of tallest mounds in MW1702. July 31, 2017 (640.23m)

Riparian enhancements were distributed across sites and elevations on the LMF, GCFE and GCFW. Machine treatments were followed with planting of rooted native herb,

shrub and tree species selected based on on site conditions and elevation within the drawdown zone. Kellogg's sedge has proved to be very successful from previous treatment years, in particular, 2015 and 2016 plantings (Scholz and Gibeau, 2016). Bluejoint reedgrass, foxtail barley, fowl bluegrass and Canada bluegrass were also species observed with successful establishment. 1 kg of locally harvested Kellogg's sedge seed was hand sown into 4 polygons within MW1701, MW1702, MW1703 and MW1704. Kellogg's Seed trials were intended to test if there is a benefit to seeding in conjunction with machine treatments to enhance establishment of perennial native species. Hand seeding trials were initiated on the Low Mud Flat in 2015 and 2016 (Scholz, 2015, 2016). Previous treatments were carried out with handseeding on the Low Mud Flat. 2018 BRGMON 2 monitoring should reveal if there is recruitment from the seeding effort.

Live stakes had been observed to have some moderate success at previously treated sites. Willows consistently had more success than cottonwoods (Scholz and Gibeau, 2016). A small trial of cuttings was integrated into the riparian enhancements to test if enhancements may affect cutting survival. Willow cuttings were planted within the matrix of the riparian enhancement areas on the Gun Creek Fan West side. In addition, rooted stock of black cottonwood plants were planted into riparian enhancement polygons at upper elevation areas as a response to the observed consistent poor performance of live staked cottonwoods in previous years (Scholz and Gibeau, 2017).

In 2017 we carried out a diversity of treatments to test for efficacy of machine treatments and to combine previous year's experience with revegetation trials. In addition site specific control areas were established providing a solid reference for testing the efficacy of individual and combined treatments (Table 4). Monitoring under the BRGMON-2 program in the coming years will investigate how successful each of the treatments has been at trapping, establishing and recruiting native vegetation cover, increasing native species diversity and increasing native vegetation cover. It is anticipated that each of the varying treatment combinations will show results across different timeframes and under varying inundation regimes.

Table 4. 2017 Riparian enhancement Enhancement Polygon treatment summary. Treatment Summary.

Treatment	Treatment Objective	Success Indicators	Anticipated Time Frame for results	Polygons Label See (Figure 11, Figure 12)
Machine Treatment only	Test if microtopography manipulation alone enhances capture, establishment and recruitment of native vegetation.	An increase in native species diversity, density and cover observed within several growing seasons, relative to other treatments and control sites.	5 years	MW1701, MW1702, MW1703, Mw1704, MW1705, Mw1706, MW1708, MW1709, MW1710

Carpenter Reservoir Drawdown Zone Riparian Enhancement Project
 2017 Year 4

Machine treatment with planting	Test if adding full grown native plants will enhance establishment and recruitment of native vegetation	An increase in native species density, cover, establishment and recruitment is observed compared to other treatments and control areas.	2-3 years	MW1701MP, MW1702MP, MW1703MP, Mw1704MP, MW1705MP, Mw1706MP, MW1708MP, MW1709MP, MW1710MP All polys
Machine treatment with seeding	Test if adding Kellogg's sedge seed to machine treatments will enhance establishment and recruitment of native vegetation.	Observe successful establishment and recruitment of Kellogg's sedge.	3-5years	MW1701MS, MW1702MS, MW1703MS, MW1704MS
Machine treatment with Live stake cuttings	To test if live staking within machine treatment areas enhances establishment of more complex riparian vegetation and enhances future recruitment and establishment of native vegetation.	Survival, vigorous growth and ultimately seeding and recruitment.	5 years	MW1708MPC, MW1709MPC, MW1710MPC

An interim archaeological impact assessment (AIA) was carried out covering all of the proposed machine treatment sites in 2017 (Begg, 2017. See Appendix). [REDACTED]

[REDACTED] In discussions with the archaeologist it was indicated that future areas identified for machine treatments will require archaeological impact assessments to be carried out prior to machine works. If the decision moving forward is for more riparian enhancement excavations, these areas should be targeted for treatment as early as possible to ensure time for both AIA and planned riparian enhancements and revegetation treatments to be carried out as prescribed.

Relative to previous years of the BRGWORKS-1 program field treatments, 2017 drew much more public attention than in previous years. Crews were approached in the field by curious locals and members of the public. There was general support for the intentions of the project, but there was concern regarding further destruction of the remnants of the historic town of Minto. Minto Mine is a provincially recognized historic place on the on the Heritage BC web site, a result of the Japanese Canadian historic places recognition project.

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2017 Year 4

“Minto was one of four Japanese-Canadian relocation centres in the Bridge River-Lillooet area established by the BC Security Commission as “self-support” sites, through which family groups who had the financial means could remain together. During this period, the Japanese-Canadian presence transformed the town, which soon had vegetable and flower gardens, with the town’s crops becoming a source of produce for the larger mining towns nearby.”
<https://heritagebc.ca/japanese-canadian-map/>

The site is recognized under S. 18 of the Heritage Conservation Act which states:

S. 18 *The minister may acknowledge the heritage value of any heritage site or heritage object by issuing a certificate or, with the permission of the owner, by installing a commemorative plaque or marker.*

A commemorative sign has been recently posted at the entranceway to the Gun Creek Recreation Camp Ground (Figure 20). Although there does not appear to be any further protection for the site, prior to future treatments notification of plans should be issued to the local community allowing for input and support for the riparian enhancements.



Figure 20 Commemorative sign located at the campground entrance.

No wildlife surveys were carried out in 2017. Breeding bird and auditory amphibian surveys will be moved to be a part of the 2018 field season and will be reported as an independent report in 2018.

All works efforts will be monitored under the BRGMON-2 program including topographic measurements, soil moisture readings and vegetation diversity and cover. Recommendations for future BRGWORKS-1 program efforts will be based on treatment response results from the BRGMON-2 monitoring program. 2017 BRGWORKS-1 treatments will be monitored in 2018 and will be reported in the 2018 BRGMON-2 final report.

The management questions for the BRGWORKS-1 program:

- 1) Will riparian enhancement in the drawdown area mitigate the effects of dust storms resulting from reservoir drawdowns particularly in the western end of the reservoir near the Town of Gold Bridge?
- 2) Will riparian enhancement in the drawdown area increase the aesthetic quality and recreational opportunities in the western end of the reservoir?
- 3) Will the program 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?

To address H_1 hypothesis: "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". Evidence from monitoring indicated dust is arising from very specific locations along the banks of the middle Bridge River. These sites have not been specifically targeted for restoration, and they would be very challenging to revegetate given their low elevation locations below 640 m and erosion activity. These sites may be better suited to an approach geared more towards reducing dust via rock placement. The one site of dust origin that is at a higher elevation is along the east side of Gun Creek. This area has fines that are prone to dust generation. The site is being treated through the planting of cuttings and bluejoint reedgrass that could serve to reduce dust generation when the plants are well established.

Addressing the H_2 hypothesis: "The planting of vegetation in the drawdown area does not increase the aesthetic quality and recreational opportunities in the western end of the reservoir". This is a difficult question to measure. All indication is that where plantings have been successful, if even in the short term, perception improves. This was noted when the 7ha fall rye treatment area and the Low Mud Flat Kellogg's sedge polygons planted in 2016 greened up. Recreational use of the area is diverse and often includes atv and 4X4 driving that appears to be indifferent to riparian enhancement efforts. The riparian enhancement treatments are attracting attention, but it cannot be stated that the peaked interest is an indication of an improvement in aesthetic quality, or that there is an increase in recreational opportunities.

Addressing the H_{3a} Hypothesis: “The planting of vegetation in the drawdown area does not enhance the quality of riparian habitats nor does it increase their potential to support wildlife populations and provide localized improvements in the quality and productivity of aquatic habitats in the reservoirs.” It may be stated that having more native vegetation growing at a site is an improvement in terrestrial habitat quality. Increases in vegetation cover means increased potential shelter and food values to wildlife. It is difficult to attribute increased habitat use within riparian enhancement areas especially due to the relatively small areas being targeted with treatments. Anecdotal observations indicate treatment areas are being utilized by wildlife species. Breeding bird studies have been initiated with the aim of establishing species diversity enabling tracking any shifts in species over time as riparian enhancements proceed.

Addressing hypothesis H_{3b}: “The planting of vegetation in the drawdown area does not enhance the quality and productivity of aquatic habitats in Carpenter Reservoir”. In communications with C. Perrin project manager for BRGMON 4, he indicated that his previous work on Arrow Lakes Reservoir clearly indicates a correlation between increased vegetation cover, quality and productivity of the benthic community and therefore aquatic habitats within reservoirs (Perrin and Stockner, 2002). One may qualify H_{3a} by stating it would require the successful establishment of planted vegetation to both the terrestrial and aquatic ecosystems.

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Acknowledgements

Thank you to the awesome hard work of the Splitrock crews who worked with care under sometimes harsh weather conditions to bring the spark of life into a barren expanse. Thanks to the wonderful Splitrock nursery staff who raised healthy plants for the project. Thanks to Bradley Jack and Xwisten for providing machine contractor services, Mike Allen for exceptional machine work and Bruce Vaughan for support. Thanks to Matt Begg and Richard Brolly for organizing a timely implementation of the AIA.

Thank you also to St'a'timc Eco-Resources for supporting Splitrock in carrying out this challenging project. This is an important project for the St'a'timc, where some of what has been lost may be restored.

APPENDIX

Copy of the text article posted July 18, 2017 on the Splitrock Environmental Facebook page and shared via the Bridge River Valley Community Association.

The Mystery of the Gun Creek Crop Circles

Okay, well they aren't exactly crop circles but if you have been out in the Goldbridge area this summer you might have found yourself thinking 'What the heck has been happening out around the Gun Creek Fan area of Carpenter Reservoir?' It looks like the remnant site of a giant sand castle building party or some alien craft landing sites. Well to answer your justifiable curiosity, what you are witnessing are in fact **experimental riparian enhancement trials**. What the heck are those you will probably ask? Well the massive landscaping work is the result of efforts by Splitrock Environmental and Xwisten's excavator and heavy machinery operator to implement large scale experimental plots. The plots are intended to encourage natural re-vegetation down into plant unfriendly Carpenter Reservoir drawdown zone.

The trials were designed to create micro topography (mounds and depressions) on sites that are otherwise completely flat and compact due to years of repeated flooding. The effects of the newly created pitted and mounded areas include;

- creating varied roughened and loosened soil conditions that **provide microsites** with cooler facing slopes and moisture collecting depressions.
- Dramatically increasing overall surface area **heightening infiltration of precipitation and slowing runoff**.
- The pits will act like pockets and **capture both wind and water born seeds** trapping them in greater numbers than flat ground.
- The depressions will **funnel moisture** and diversify moisture retention,
- The north facing slopes **protect from drying effects** of the sun and wind.

Splitrock crews planted our nursery grown native sedges and grasses into sections of the treatment areas to determine if planting speeds up re-vegetation. In addition, seeds of vegetation superstar Kellogg's sedge *Carex lenticularis* (a native species able to survive the extremes of annual drought and flooding inherent in a reservoir's operation) were sown into test plots. A ton of work went in to these trials and a litany of monitoring was carried out. We will be monitoring closely over the next few years in an attempt to answer the question of whether we can do anything to support natural colonization into the Carpenter Reservoir drawdown zone. If you are up in the area be sure to check out some of the sites, they can not be missed! Please resist the urge to clamber, drive, dig, climb, and comb through the sites as every bit of disturbance can be a setback to re-vegetation in this extremely harsh growing environment. Be sure to let us know if you have any further questions. And for the alien conspiracy theorists out there sorry to burst your bubble.

THURSDAY
JUNE
22



Carpenter reservoir enhancement tour

Gun Creek Campground 1 pm to 2pm

Come learn more about the riparian enhancements and revegetation efforts taking place on the Carpenter Reservoir.

Take a tour of the site to see what has been completed, what has been successful and what has not.

Provide feedback on the issues surrounding the reservoir - dust storms, vehicle access, recreational, aesthetic and wildlife values.

FOR MORE INFO 250 256-0002 or manager@splitrockenvironmental.ca



File: R3-

3005963 Apr 26, 2017

Via Email: Jason.watson@bchydro.com

Jason Watson
6911 Southpoint Street
Burnaby, British Columbia
V3N 4X8

**Re: Section 11 Water Sustainability Act Application “Changes In and About a Stream”
– Maintenance of minor and routine nature by a public utility – Gun Creek Fan
Area.**

Staff with the Ecosystems Section of the Ministry of Forests, Lands and Natural Resource Operations have reviewed the above mentioned authorized change application. A Section 11 *Water Sustainability Act* Change Approval is not required for the proposed work as long as the work is done in accordance with BC Regulation 36/2016 – Part 3.

As per section 38 (1) A person proposing to make an authorized change, other than an authorized change described in Section 39 (1) (o) to (s), (2) and (5), must

- (a) Provide a notice, signed by the person or the person's agent, to a habitat officer of the particulars of the proposal at least 45 days before beginning the authorized change, and*
- (b) Obtain from a habitat officer a statement of the Terms and Conditions described in section 44 (2) [protection of aquatic ecosystems] on which the authorized change can proceed.*

The terms and conditions you must follow for your works are outlined here:

http://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterrights/terms_and_conditions_for_cias_th_ok_2016.pdf

It is the proponent's responsibility to ensure their activities are in compliance with all legislation, including the *Fisheries Act*, as well as with local government bylaws and regulations.

If you have further questions please contact the undersigned at 250-371-6219.

Yours truly,



Mark Phillpotts
Ecosystems Biologist

**Ministry of Forests, Lands and
Natural Resource Operations**

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