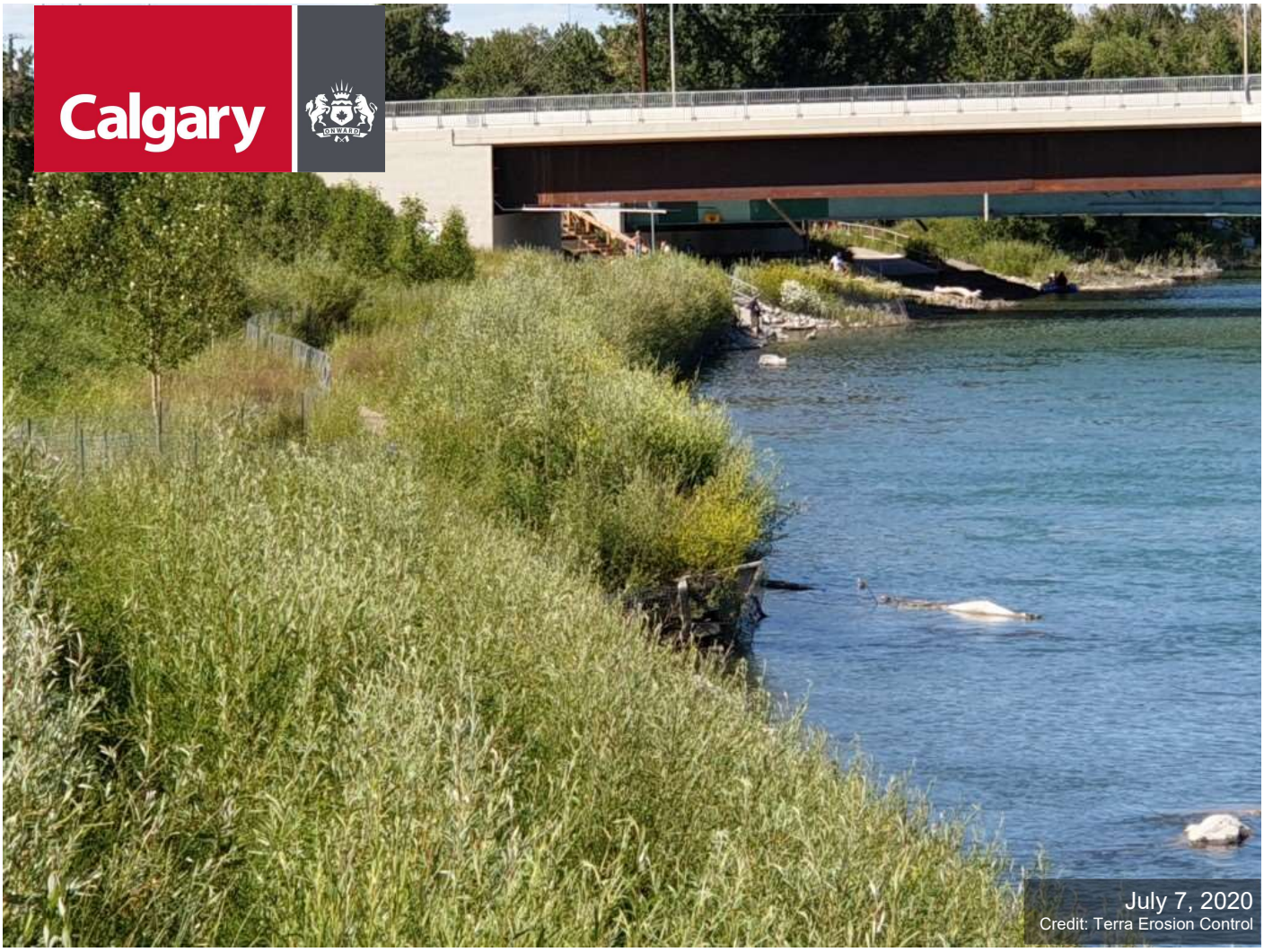

Bioengineering Demonstration and Education Project - 2020 Monitoring Report

The City of Calgary Riparian Monitoring Program

June 23, 2021

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The City of Calgary - Water Resources

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Executive Summary

This report is a summary of the second year of post-construction bioengineering effectiveness monitoring at the Bioengineering Demonstration and Education Project (BDEP) as part of the on-going City of Calgary Riparian Monitoring Program (RMP). Post-construction monitoring activities have previously occurred at the BDEP site in 2019 (KWL, 2020a), and baseline pre-construction data was collected in 2016 (Hemmera, 2017a; Hemmera, 2017b; Hemmera, 2017c). Monitoring activities are conducted in compliance with the Bioengineering Efficacy Monitoring Plan (BEMP) (Hemmera, 2018) that was approved by Alberta Environment and Parks (AEP) and The City of Calgary in 2018. The BEMP provides guidance to monitor 1) Fish and Fish Habitat; 2) Wildlife; 3) Riparian Health; and 4) Bioengineering Structural Integrity at BDEP Site 1, Site 2 and Site 4 over a 10-year period, with monitoring activities occurring in 2019, 2020, 2021, 2023 and 2028, or Years 1, 2, 3, 5 and 10 post-construction (Hemmera, 2018). Monitoring activities are intended to meet the goals listed below.

- To show how the bioengineering techniques used in the project have improved fish habitat in the area and specifically over a conventional riprap design site.
- To show how the bioengineering techniques used in the project have improved wildlife habitat in the area and specifically over a conventional riprap design site.
- To show how the project has improved riparian health and specifically how it has been improved over a conventional riprap design site.
- To show how the project has improved bank structural integrity and specifically how it has been improved over a conventional riprap design site.

Key Results

Key results from each component of the 2020 post-construction bioengineering effectiveness monitoring at the BDEP are listed below. As discussed in more detail below, the monitoring results from the site show that the BDEP is providing better fish and fish habitat, wildlife habitat and passage, and riparian health over a conventional riprap design site. Bioengineering structural integrity is somewhat harder to compare with a conventional riprap design site in the absence of large flood conditions; however, similar erosion protection between the bioengineering techniques used at the BDEP and a conventional riprap design site is estimated based on literature values for shear stress resistance.

Fish and Fish Habitat

- Fish and fish habitat monitoring activities include water quality monitoring throughout all seasons, fish use surveys in winter and spring, fish spawning surveys in spring and fall, fish habitat assessments in summer, fish sampling by electrofishing and minnow trapping in summer, and photographic monitoring throughout all seasons. Comparisons between
- Water quality was observed to be consistent over the baseline, Year 1 (2019), and Year 2 (2020) monitoring years, and is consistent between the Upstream Control Site, Site 1 and Site 4. No effects on water quality were obviously discernible from the BDEP project.
- In 2020, fish were observed to be continuing to use the habitat enhancement structures provided by the BDEP as first observed in Year 1 (2019). Fish were observed using and were captured within

the vicinity of the habitat structures throughout the project area; and fish were observed in the fish shelters, boulder clusters, and surrounding habitats during winter, spring and summer assessments.

- Compared with the baseline desktop assessment of historic fish capture data from the Bow River, of the 22 species that have a probable potential of occurrence within the vicinity of the project, in 2020, 9 species were captured, including 5 sportfish and 4 non-sportfish species. In 2019, 10 were captured within the project area, including 6 sportfish and 4 non-sportfish species. Abundance of fish species at the BDEP could not be compared with fish sampling baseline data, as fish sampling surveys were not previously conducted in proximity to the BDEP sites; so comparison was limited to the baseline desktop assessment, as noted above.
- A total of 45 fish from 6 species were captured at Site 1, 42 fish from 8 species were captured at Site 2, and 33 fish from 3 species were captured at Site 4 using a single boat electrofishing pass in 2020. In comparison, in 2019 a total of 16 fish from 7 species were captured at Site 1, 8 fish from 2 species were captured at Site 2, and 24 fish from 6 species were captured from Site 4.
- Both minnow trapping and electrofishing Catch per Unit Effort (CPUE) in 2020 was greatest at Site 2, followed by Site 1, with Site 4 having the lowest. In 2019, minnow trapping and electrofishing CPUE was highest at Site 4, followed by Site 2, then Site 1 (Site 1 and Site 2 had equal minnow trapping CPUE). In 2020, the highest electrofishing CPUE by species was rainbow trout at Site 1, mountain whitefish at Site 2, and longnose sucker at Site 4. In 2019, the highest CPUE by species was rainbow trout and perch at Site 1, white sucker at Site 2, and longnose sucker at Site 4.
- Site 2 had the highest abundance and diversity of fish species in 2020, including five sportfish species (i.e., brown trout, burbot, mountain whitefish, northern pike, and rainbow trout). This is a change from 2019 results where only forage fish were captured at Site 2. Although Site 1 had the second highest fish abundance, it had the highest total number of fish captured, and the single highest number of one species captured (rainbow trout). This is also a change from 2019 where Site 1 had the lowest fish abundance, but the highest species richness, and highest abundance and diversity of sportfish. Of the captured fish at Site 4, there was a higher abundance of forage fish, with longnose sucker being most prevalent, which is consistent with 2019 results.
- As expected, species composition and fish abundance observed during 2020 was higher than 2019 as the BDEP sites naturalize following the construction of the fish habitat enhancements.
- In 2020, a spring spawning assessment could not be completed due to high flows and turbid water creating unsafe conditions. No redds or fish were identified in the surveyed reach during the fall redd survey. Six locations within the upstream extent of Site 1 (i.e., upstream of the Cushing Bridge) were sampled during the fall kick sampling survey and mountain whitefish eggs were observed at each location in the same manner as observed in 2019.
- Based on the fish use monitoring results, Sites 1 and 2 are providing higher quality fish habitat in comparison to Site 4, the conventional riprap design site. Species distribution and fish abundance that were observed during Year 2 monitoring are expected to vary in subsequent monitoring years as the BDEP sites naturalize following the construction of the fish habitat enhancements.

Wildlife

- The Year 2 (2020) breeding bird surveys resulted in the identification of 37 species including one listed species at the BDEP sites (bank swallow) compared to 31 species including three listed species in 2019 (least flycatcher, western wood-pewee, and bank swallow). The highest number of bird species and individuals identified in 2020 was at Site 1, followed by Site 2 and Site 4, which was consistent with 2019 results.

- The bank swallow colony identified in the baseline assessment at Site 2 was observed during 2019 and again in 2020 monitoring, indicating that construction did not result in fewer breeding colonies in the project area. No nests were observed at any of the sites in 2020, where stick nests were observed at Site 1 in 2019.
- Site 1 (50 individuals from 20 species) and Site 2 (29 individuals from 10 species) showed increased bird activity relative to Site 4 (19 individuals from 7 species) based on the results of the breeding bird and nesting surveys. This increased activity may be the result of differences in vegetation between the sites, with Site 4 having lower density vegetation.
- The wildlife camera monitoring program included four cameras that identified animals using the wildlife corridor created as part of the BDEP under the Cushing Bridge/17th Avenue SE bridge.
- A total of 7 wildlife species were identified through observations of 317 individuals. The most abundant species identified during the monitoring program was white-tailed deer (48%) followed by coyote (32%) and white-tailed jackrabbit (11%). This compares to a total of 212 individuals from 8 species that were observed in 2019, the most common of which was the white-tailed jackrabbit (21%), white-tailed deer (8%) and coyote (6%). Two new species were identified in 2020: common raccoon, and eastern gray squirrel.
- Deer and coyote presence observed on all four of the cameras throughout Site 1 and the increased mean use from 2019 and 2020, suggests that the wildlife corridor in the Project area is providing effective passage for large mammals. Thus, Site 1 is presumably providing better wildlife passage than Site 4, the conventional riprap design site, based on the findings in the reviewed literature that the riprap surfaces such as found at Site 4 are difficult for many species to traverse, especially ungulates and amphibians.

Riparian Health

- All three BDEP sites show significantly improved riparian health in comparison to the baseline condition (2016). The 2020 Riparian Health Assessment (RHA) rating for Site 1 was 49% compared to 43% in 2016, for Site 2 was 56% compared to 29% in 2016, and for Site 4 was 58% compared to 29% in 2016.
- There was a slight increase in RHA scores between 2019 and 2020 assessments for Site 4 and a slight reduction for Site 1 and Site 2. The main reason for the slightly increased RHA score for Site 4 was an increase in regeneration of preferred shrub species (increase in 2 points overall). The main reasons for the slightly reduced RHA scores were slightly lower cover of preferred shrub species at Site 1 due to slightly reduced survival (decrease in 1 point overall from 2019), and slightly more human-caused bare ground at Site 2 where a new trail has been created by the public along the top of bank (decrease in 1 point overall from 2019).
- The 2020 RHA scores for Sites 1, 2, and 4 result in the sites being categorized as *Unhealthy* (same category as the baseline and 2019 assessments); however, the limitations in the RHA method, particularly the low scores for the larger-scale parameters that are not influenced by site-level projects like the BDEP and lower scores due to site-level disturbances typical of urban areas are limiting a change in the riparian health category, despite the significant improvements in riparian health that are a direct result of the BDEP. It is possible that the riparian *Healthy* rating category may never be achieved due to these limitations in the RHA scoring. However, there is room for improvement in terms of weed control and bank root mass protection that could push all three sites into the *Healthy with Problems* category (60% and greater) with a little time and maintenance.

- Increases in the vegetation component of the RHA scores was the key factor in the increased 2020 RHA ratings compared to baseline (2016) results. At Site 1 the vegetation rating has increased by 13% over the 2016 rating, at Site 2 the vegetation rating has increased by 127% over the 2016 rating, and at Site 4 the vegetation rating has increased by 189% over the 2016 ratings. The key vegetation parameters that have led to improved RHA scores are increased tree regeneration of balsam poplar (*Populus balsamifera*) and aspen (*P. tremuloides*) (RHA parameters 1 and 2), increased regeneration of preferred shrub species (RHA parameter 3) and increased total canopy cover of woody species (RHA parameter 6). These increases in the vegetation rating parameters is directly attributable to the bioengineering work completed for the BDEP.
- Overall 2020 RHA ratings for Sites 1, 2, and 4 range from 29% to 53% higher than the RHA rating for a theoretical conventional riprap design site. The main reason for increased RHA scores for the BDEP sites is that vegetation ratings are 85% to 145% higher for Sites 1, 2 and 4 than a theoretical conventional riprap design site. The improving health trends are attributable to the successful bioengineering at the BDEP site.

Bioengineering Structural Integrity

- Flows in the Bow River at the BDEP were below the 2-year flood flow and shear stresses ranged from 10 to 39 N/m² in 2019 and 2020. Rainfall in Calgary was slightly above average at 416 mm in 2019 and above average in 479 mm. In particular, June and July rainfall were well above average; however, August and September were very hot and dry in 2020.
- In general, the physical condition of the bioengineering techniques, including fish habitat structures appears to be stable, with no signs of major erosion, scour, or displacement.
- Materials used in the construction of the BDEP were generally found to be in good to excellent condition and are serving their purpose appropriately.
- The fish shelters were observed to have some fine sediment deposited along the bottom but were otherwise clear and providing good fish habitat. No significant change in the condition of the timber crib wall was observed from as-constructed conditions, and there was no observed change in the deflection of the spanning members that are supported by the steel supports.
- Overall vegetation survival at the BDEP sites was 76% in 2020, with Site 1 vegetation survival of 74%, Site 2 vegetation survival of 68%, and Site 4 vegetation survival of 85%. This is slightly lower than the survival in 2019, where overall survival was 80%, Site 1 vegetation survival was 77%, Site 2 vegetation survival was 83%, and Site 4 vegetation survival was 77%. Differences in 2020 and 2019 vegetation survival results are due to either the different methods that were used to measure survival between the 2 years (actual count in 2019 versus visual estimate in 2020) and/or due to an expected reduction in survival as the site ages and natural competition occurs between the planted woody vegetation (refer to Box 1 in the main report).
- Survival of rooted live cuttings at Site 1-1 is approximately the same in 2020 compared to 2019. The increased survival at Site 1-1 in 2020 is likely due to replanting efforts. The survival of rooted live cuttings demonstrates that they can successfully be used as an option to conventional live cuttings. They have now been used in at least four other sites in Calgary – likely to facilitate summer construction.
- At Site 1, the combined survival of live cuttings in the timber crib wall and the vegetated soil wrap was 48% in 2020, which was slightly less than the survival of 50% observed in 2019. Live cuttings were replanted in 2020 at Site 1 in the area upstream from Cushing Bridge and in the vegetated timber crib wall. Survival was expected to be higher in 2020 due to replanting efforts; however,

many of the replanted cuttings were dead at the time of the inspection. It is understood that the contractor elected to remove the dedicated sprinkler too early, and the replanted live cuttings dried out in the hot and dry late summer period and died. Nevertheless, the remaining establishing vegetation in the timber crib wall is providing very good overhanging cover to enhance fish habitat and is overall a successful site.

- While the brush mattress, brush layer and contour fascine survival at Site 1 is lower in 2020 than 2019, there is overall good and vigorous growth establishment in this portion of Site 1 that is indicative of a successfully establishing site.
- At Site 2, the survival for the live staking technique was found to be higher than the brush mattress, contour fascine, and the hedge brush layers techniques in 2020. Survival for all of the techniques was found to be lower in 2020 compared to 2019 as mentioned above. Despite the lower survival values in 2020 compared to 2019, these techniques demonstrate overall good and vigorous growth establishment in 2020.
- At Site 4, vegetation survival was highest for the soil covered riprap with container plants, and void-filled riprap and plug planting techniques; however, woody vegetation vigour (a measure of vegetation health), was observed to be low over the whole site due to herbaceous vegetation competition. A comparison of the existing riprap retrofit void-fill techniques finds that void-fill with topsoil and plug planting (with an overall survival of 100% in 2020 and 96% in 2019) is more successful than void-fill with pitrun and live staking (with a survival of 54% in 2020 and 60% in 2019).

Key Recommendations

Key recommendations for future monitoring years are listed below.

Fish and Fish Habitat

- Use the fish use and population data collected in 2019 and 2020 to make comparisons and trends with data collected in subsequent monitoring years to meet the requirements of the BEMP (Hemmera, 2018). Any remedial actions needed to meet the BEMP requirements that are identified for the site by the monitoring team should be considered for implementation by The City.

Wildlife

- Based on the perceived success of the wildlife corridor at Site 1, it is recommended to consider creating a City-wide design standard to infill riprap void-spaces with smaller sized gravels or topsoil. This would improve wildlife passage under bridges in Calgary, but also at all locations where riprap is used on the riverbank as a means to improve wildlife passage and habitat on riverbanks.

Riparian Health Assessment

- Future monitoring should be continued to confirm findings to date that BDEP has contributed to long-term improvements in riparian health.
- The results of the 2021 revisit RHI of BOW95 should be compared against the RHA scores collected for Sites 1, 2 and 4 to provide an independent confirmation of the impact that the BDEP has had on riparian health.
- Given the limitations of the soil / hydrology component of the RHA ratings for sites on the Bow River in Calgary, additional methods to assess improvements in riparian health should be investigated. Based on discussions with The City, it is proposed that the Bank and Riparian Quality Index (BRQI)

that was developed as part of the RMP (KWL, 2018) be included in 2021 to achieve this purpose. The inclusion of this new method will require AEP's approval.

- Better control of weeds should occur at the BDEP sites as many species of invasive weeds and disturbance increaser species were documented. With better maintenance focused on weed control and some additional growth time, it might be possible for all three sites to obtain the "*Healthy with Problems*" category.

Bioengineering Structural Integrity

- Based on the success of the rooted live cuttings at Site 1, they appear to be a viable approach for constructing bioengineering projects. They are recommended to be used within various bioengineering structure types when timing constraints result in construction outside of the recommended period for using dormant live cuttings.
- The contractor should carefully consider the impact of early removal of irrigation at the Site since live cuttings replanted in the timber crib wall in 2020 mostly died due to early irrigation removal. It is recommended to replace the dead replanted live cuttings in 2021 and provide on-going irrigation throughout the summer.
- It is recommended to replace an approximately 11 m long section of contour fascine on the upper northwest corner of Site 2.
- It is recommended to use hedge brush layers where brush layers are being considered despite the additional cost. In a hedge brush layer, potted plants are used in combination with conventional live cuttings which improves overall biodiversity and habitat for wildlife.
- It is recommended to continue detailed monitoring of the three techniques used to retrofit existing riprap at Site 4 to determine the preferred approach. If live cuttings are used in future applications of this type, they should be placed in the openings in the riprap prior to backfilling with growing substrate versus installation after void-filling.
- It is recommended to replant Site 4 in areas where the survival target of 75% was not achieved.
- It is recommended to measure vegetation parameters (e.g., cover and vigor) in 2021 and following years using both the transect and quadrat methods to facilitate better data comparison and consistent data.

Final Acceptance Certificate

- Because FAC is expected to be issued in 2021, any replanting that occurs in 2021 should be subject to an additional 1-year warranty period to ensure that establishment occurs.
- It is recommended that The City consider setting aside a budget to address maintenance concerns that are identified by the BDEP monitoring team after FAC has been issued but during the remaining monitoring years in 2023 and 2028.
- It is also recommended that The City staff perform annual inspections post freshet to monitor the structural condition of the site and later in August / September to assess vegetation establishment and success on non-monitoring years.

References

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1. Introduction

The purpose of this document is to report on the activities and results of 2020 bioengineering effectiveness monitoring at the Bioengineering Demonstration and Education Project (BDEP) as part of the on-going City of Calgary Riparian Monitoring Program (RMP). This is the second year of monitoring at the BDEP site. Long-term monitoring of the BDEP is described in the Bioengineering Efficacy Monitoring Plan (BEMP) and consists of post-construction monitoring of: 1) Fish and Fish Habitat; 2) Wildlife; 3) Riparian Health; and, 4) Bioengineering Structural Integrity at BDEP Site 1, Site 2 and Site 4 over a 10-year period (Hemmera, 2018). The BEMP is provided in Appendix A.

Monitoring activities are intended to meet the goals listed below.

- To show how the bioengineering techniques used in the project have improved fish habitat in the area and specifically over a conventional riprap design site.
- To show how the bioengineering techniques used in the project have improved wildlife habitat in the area and specifically over a conventional riprap design site.
- To show how the project has improved riparian health and specifically how it has been improved over a conventional riprap design site.
- To show how the project has improved bank structural integrity and specifically how it has been improved over a conventional riprap design site.

1.1 Background

Alberta Environment and Parks (AEP) and The City of Calgary (The City) partnered to undertake the BDEP with administration through AEP's Southern Alberta Fisheries Habitat Enhancement and Sustainability (FISHES) Program. The project was conceived after the 2013 flood with design completed between July 2016 and September 2017. Construction occurred from February 2018 to June 2019.

The BDEP includes 680 m of the right bank of the Bow River in the community of Inglewood Calgary. It extends from about 80 m upstream of Cushing Bridge (Blackfoot Trail/17 Ave SE) to about 600 m downstream. The BDEP is composed of Site 1, Site 2 and Site 4 as shown on Figure 1-1.

A list of bioengineering techniques used in the BDEP is provided in Table 1-1.

It is expected that the Final Acceptance Certificate (FAC) will be issued in 2021 since it is the final year of the warranty period under the construction contract. Effectiveness monitoring will continue until 2028.

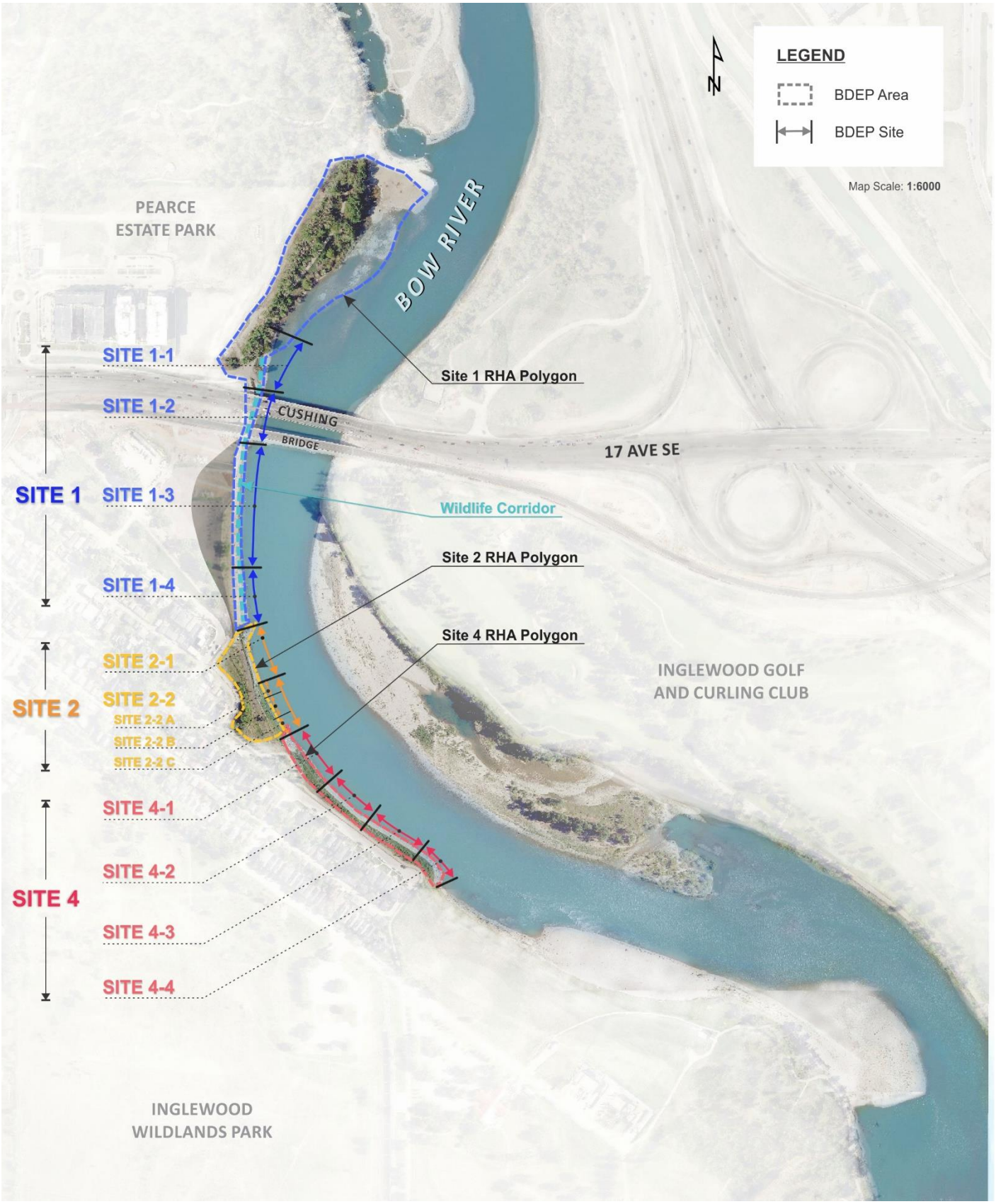


Figure 1-1: BDEP Sites

(Note: Site 1-2 and Site 4-4 are not part of the monitoring program as no bioengineering techniques were applied there – see Table 5-1)

Table 1-1 Summary of Bioengineering Techniques used in the BDEP by Site

Site	Technique Name	Description
Site 1	Rooted Live Cuttings (Site 1-1)	Insertion of long live cuttings that have been rooted out in the lower portion and leafed-out in the top portion. They can be used in a similar manner to live cuttings but can be installed outside the live cutting dormancy period.
	Vegetated Soil Wraps (Site 1-3)	Consists of brush layers interspersed between layers of soil wrapped in natural geotextile materials that provides soil reinforcement.
	Vegetated Timber Crib Wall (Site 1-3)	Consists of a hollow, box-like interlocking arrangement of structural timber, filled with suitable backfill material and layers of live cuttings.
	Brush Mattress (Site 1-4)	A layer of interlaced/adjacent live cuttings placed on the face of the riverbank.
	Brush Layer (Site 1-4)	Row(s) of live cuttings placed in a criss-cross or overlapping manner between layers of soil, with tips protruding beyond the face of the fill.
	Contour Fascine (Site 1-4)	Fascines are live cuttings that are tied together in long bundles. Contour fascines are installed in shallow trenches constructed on contour and anchored in the trench using stakes.
Site 2	Box Fascine (Site 2-1, Site 2-2 A/B/C)	Fascine bundles placed at the toe of an eroding bank and secured between wooden poles.
	Brush Mattress (Site 2-2 A)	A layer of interlaced/adjacent live cuttings placed on the face of the riverbank.
	Contour Fascine (Site 2-2 A)	Fascines are live cuttings that are tied together in long bundles. Contour fascines are installed in shallow trenches constructed on contour and anchored in the trench using stakes.
	Hedge Brush Layer (Site 2-2 B)	Row(s) of live cuttings and rooted stock placed in a criss-cross or overlapping manner between layers of soil, with tips protruding beyond the face of the fill.
	Live Staking (Site 2-2 C)	Insertion of live cuttings into the ground in such a manner as to promote root growth and leaf-out.
Site 4	Soil-Covered Riprap (Site 4-1)	Covering existing riprap bank protection with soil and vegetation to improve riparian, aquatic and terrestrial habitats while also improving aesthetics.
	Void-filled riprap with plugs (Site 4-2)	Planting material inserted into void-spaces in existing riprap bank protection and planted with live cuttings or container shrub plantings to improve riparian, aquatic and terrestrial habitats while also improving aesthetics.
	Void-filled riprap with live staking (Site 4-3)	Live staking of existing riprap to improve riparian, aquatic and terrestrial habitats while also improving aesthetics.
	Riprap control site (Site 4-4)	No bioengineering techniques at this site.
Common to all sites	Container Shrub Planting	Planting of container stock seedling species that are selected for beneficial attributes such as fast-growing, natural colonizer, deep rooting, nitrogen fixing, and food production.
	Native Species Seeding	Planting of native streambank/riparian species that are selected for beneficial attributes such as fast-growing, natural colonizer, deep rooting, nitrogen fixing, and food production.

1.2 Monitoring Schedule

The monitoring schedule outlined in the BEMP is for monitoring activities to occur in years 2019, 2020, 2021, 2023, and 2028, which correlates to year 1, year 2, year 3, year 5, and year 10 post-construction. In the event of a significant flood(s) (defined as a 10-year return period flood or greater), contingency monitoring may be required to assess potential damage to the project. Should this occur, a resetting of the monitoring frequency will also be required and will be dependent on the timing of the flood event(s). Reporting of the monitoring results will occur for each monitoring year, as well as discussed cumulatively and comparatively at either the five- or ten-year post-construction monitoring interval (Hemmera, 2018).

1.3 Approach to Compare Monitoring Results

To meet the objective of comparing the monitored data collected at the BDEP site to a conventional riprap design site, the original approach discussed in the BEMP was to compare monitoring results for Sites 1 and 2 to Site 4, which would then be considered a control site (Hemmera, 2018). As discussed in the BDEP 2019 Monitoring Report (KWL, 2020a), it was determined that Site 4 would be suitable for use as a control site for comparison of Fish and Fish Habitat and Wildlife monitoring components. However, as the riprap extent at Site 4 only covers up to the 5-year return period flood elevation, with riparian planting above, it is not suitable for use as a control site for comparing the Riparian Health and Bioengineering Structural Integrity components. Thus, these two components are compared to a theoretical riprap design site, with rock armour installed to a 100-year return period flood elevation.

Parameters for the theoretical conventional riprap design site were developed based on the RMP project team's experience. The Riparian Health Assessment (RHA) score for a theoretical conventional riprap design site for riparian health is 38% (27/72) with a vegetation score of 33% (9/27) and soil/hydrology score of 40% (18/45) and would be in Unhealthy condition as discussed in the *BDEP - 2019 Monitoring Report* (KWL, 2020a). The RHA score is equivalent to a Riparian Health Index (RHI) score – see Section 4. The permissible shear stress for a conventional riprap design site with Class 2 riprap (d_{50} = 500 mm) is approximately 400 N/m² (Fischenich, 2001).

Photo 1-1: BDEP Site 2 on July 31, 2020

2. Fish and Fish Habitat

Fish and fish habitat were assessed at BDEP Sites 1, 2, and 4 in a baseline assessment in 2017 as part of the BDEP design and construction contract (Hemmera, 2017a), and in 2019 and 2020 as part of the RMP. Future fish habitat monitoring under the RMP is planned for 2021, 2023 and 2028. The 2020 fish and fish habitat assessment work is described in detail in the *2020 Monitoring Report: Bioengineering Demonstration and Education Project* (Hemmera, 2020) provided in Appendix B. A summary of the report is provided below.

2.1 Methods

Baseline fish and fish habitat data were collected for Sites 1, 2 and 4 via desktop and field assessments in 2017 as described in detail in the *Bow River Fish and Fish Habitat Report* (Hemmera, 2017a) and summarized in the BEMP (Hemmera, 2018).

The 2020 assessments of fish habitat and fish use were completed by a crew of biologists, led by a Qualified Aquatic Environment Specialist (QAES). Assessments for Sites 1, 2, and 4 were completed in multiple seasons (spring, summer, fall, and winter) in 2020 using methods as summarized in Table 2-1, which are the same as those used in 2019. Sampling locations used were also the same as those established in 2019 and are shown in Appendix B – Figure 2.

Table 2-1: Summary of Field Assessment Methods and Timing

Field Assessment	Methods	Site(s) and Timing			
		Winter	Spring	Summer	Fall
Fish Use	Visual assessment of fish use of near bank habitat via underwater photography and snorkel survey.	Jan 7, 2020	-	-	-
Fish Spawning Use	Visual surveys conducted from bank for rainbow trout (Spring) and brown trout (Fall) redds.	-	Jun 18, 2020[1]	-	Dec 2, 2020
	Sampling of mountain whitefish eggs via kick sampling.	-	-	-	Dec 2, 2020[2]
Fish Habitat Assessment	Collection of in-stream and near stream condition, documentation of fish habitat enhancements.	-	-	Sep 17 – 18, 2020[3]	-
Water Quality	Collection of water quality parameters from Site 1 and Site 4 and the upstream control location.	Jan 7, 2020	Jun 18, 2020	Sep 17 – 18, 2020	Dec 2, 2020
Fish Sampling	Fish capture via single pass boat electrofishing and overnight set gee-style minnow traps.	-	-	Sep 17 – 18, 2020[4]	-
Photographic assessment of physical condition and stability	Establishment and assessment of photo monitoring stations.	-	-	Sep 17 – 18, 2020	-

Notes:

1. Fish Spawning Use assessment was hampered by high river flows and turbid water; snorkel surveys and spawning surveys could not be completed.
2. Survey extents were from 500 m upstream of Site 1, through all riverine habitat adjacent to Site 2 and Site 4, to 500 m downstream of the downstream end of Site 4.
3. Survey extents were from 100 m upstream of Site 1, through all riverine habitat adjacent to Sites 2 and 4, to 600 m downstream of the downstream end of Site 4.
4. The location of the boat electrofishing pass shown in Appendix B – Figure 2

2.2 Results

Fish Habitat Characteristics

Baseline fish habitat characteristics were collected as part of the fish habitat assessment on March 27, 2017 (Hemmera, 2017a) and 2019 data were collected from July 20 to August 1, 2019 (KWL, 2020a). The assessed reach of the Bow River is characterized as low gradient (i.e., 0.2%) with a regular meander pattern that is frequently confined by its valley walls. Representative photographs of the fish assessment, a summary of the fish habitat characteristics observed at each Site (i.e., Site 1, Site 2, and Site 4) during the summer fish habitat assessments and a detailed fish habitat map of the assessed reach are presented in Hemmera's 2020 report in Appendix B. Fish habitat within each site in the BDEP area (i.e., Site 1, Site 2, and Site 4) is summarized below, including commentary on changes from the baseline conditions. A comparison of fish habitat at Site 1 and 2, and the control site at Site 4 is also provided per the monitoring objectives.

The following abbreviations are used below:

- RBD – right downstream bank
- LDB – left downstream bank

Site 1

The location of Site 1 is shown in Figure 1-1. Fish habitat and bank stability conditions are as follows:

- Upstream of Cushing Bridge: Baseline (2017) observations were that fish habitat consisted of riffle (RF) habitat transitioning into deep run (R1) habitat through the mid channel, with alternating deep (P1), moderate (P2) and shallow (P3) pool habitats along the RDB (Hemmera, 2017a). Similar fish habitat conditions to the baseline assessment were observed in 2020 with fish habitat consisting of riffle (RF) habitat transitioning into deep run (R1) habitat through the thalweg and mid channel. A key difference was a shallow run (R3) along the RDB that was partially created as part of the BDEP. The banks along the upstream section of Site 1 are relatively stable.
- At Cushing Bridge: Baseline (2017) observations were that fish habitat within the area immediately surrounding the Cushing Bridge consisted of R1 habitat through the mid channel thalweg, and P1 habitats along both the RDB and LDB (Hemmera, 2017a). Similar fish habitat conditions to the baseline assessment were observed in 2020 where fish habitat consisted of R1 habitat through the mid channel thalweg, and P1 habitat along the RDB; however, P1 habitat was not observed along the LDB immediately downstream of the bridge.
- Downstream of Cushing Bridge: Baseline (2017) observations were that R1 habitat extends through the reach downstream of the Cushing Bridge. An abandoned bridge abutment was present mid-channel downstream of Cushing Bridge. Observations from 2020 are that fish habitat within this reach remains consistent with observations made during the baseline conditions assessment where R1 habitat extends through the downstream section of R1. The RDB is considered stable in this reach.

Water depths in Site 1 have not changed significantly from baseline condition. Maximum water depths observed in 2020 range from 0.53 m in R3 habitat (slightly deeper than observed in 2019 at 0.40 m) to approximately 7 m in R1 and P1 habitat, consistent with the 2017 and 2019 observations. The 7 m deep scour hole is in the P1 habitat adjacent to Site 1 downstream of the Cushing Bridge. This pool habitat is considered very important habitat, providing overwintering habitat and thermal refuge from summer water temperatures approaching or exceeding tolerance thresholds for trout (Hemmera, 2018).

Substrates in Site 1 have not changed from baseline conditions, except for the riprap apron and fish boulders placed along the toe of the bank in the reach downstream of Cushing Bridge. Otherwise, substrates throughout Site 1 consist primarily of boulder and cobbles in R1 and RF habitat. Pool habitat (P1) substrates consist primarily of boulder, cobble, and fines; consistent with substrates observed in the baseline assessment (Hemmera, 2017a).

Baseline, 2019 and 2020 assessments of cover were similar as cover throughout Site 1 is provided primarily by depth and turbulence, with limited overhanging cover provided by woody vegetation along the LDB. Boulder substrates that are present throughout run and pool habitats likely provide instream cover for fish. The constructed fish shelters and boulder clusters along the RDB in the reach downstream of the Cushing Bridge provide additional instream cover above what was observed during the baseline assessment. Deciduous trees, shrubs, and grasses were present and providing limited cover along both the RDB and LDB during baseline, 2019 and 2020 assessments.

Deep run (R1) and pool (P1) habitat is likely used as 'suitable' holding, feeding, and overwintering habitat for adult and juvenile fish, with shallower R3 habitat functioning as holding and rearing habitat for juvenile fish. P1 and R1 habitat within the downstream section of Site 1 likely provides 'important' overwintering habitat, with a maximum water depth of approximately 7 m. Gravel and cobble substrates located at the downstream end of R3 habitat on RDB above Cushing's Bridge provides 'suitable' spawning habitat for rainbow trout and brown trout, and mountain whitefish spawning likely occurs over cobble and large gravels located in R1 habitat throughout the site.

Site 2

The location of Site 2 is shown in Figure 1-1. Fish habitat within Site 2 remains consistent with observations made during the baseline conditions assessment (Hemmera, 2017a), where fish habitat consists almost entirely of a R1 habitat, with a P1 habitat located immediately downstream of riprap groynes constructed out into the Bow River at the upstream extent of the RDB of Site 2, adjacent to a City of Calgary pathway in Inglewood (Appendix B – Attachment C).

Bankfull width, substrate and cover are also consistent with baseline conditions. Bankfull width and wetted width are relatively uniform throughout Site 2, approximately 170 m and 90 m respectively. Water depth is relatively uniform through this section, ranging from 1 m to 2 m. P1 habitat immediately downstream of the upstream riprap groyne has a maximum depth of 4 m. Substrates consist primarily of boulder and large cobbles in R1 habitat and boulder and riprap within P1 habitat downstream of riprap groyne structures.

Cover is provided primarily by depth and turbulence, and by boulder and riprap substrates. Large woody debris has accumulated within the P1 habitat immediately downstream of the upstream riprap groyne along the RDB. Large woody debris provides suitable overhanging and instream cover. Overhanging cover was otherwise severely limited throughout Site 2 according to the baseline, 2019 and 2020 observations; however, deciduous shrubs were present along the RDB and will likely provide cover in the future as they mature.

Deep run (R1) habitat likely provides 'suitable' holding, feeding, and overwintering habitat for adult and juvenile fish. P1 habitat present downstream of riprap groynes provides a velocity refuge for fish as well as 'suitable' holding, feeding, and potential overwintering habitat for juvenile and adult fish. There is 'marginal' spawning habitat for salmonids through this section of the Bow River due to the larger size of substrates.

Site 4

The location of Site 4 is shown on Figure 1-1. Fish habitat within Site 4 remains consistent with observations made during the baseline conditions assessment (Hemmera, 2017a) and during the 2019 site assessment (Hemmera, 2019), with fish habitat comprised primarily of R1 habitat, transitioning into R2 habitat at the downstream end of the site (Hemmera, 2017).

Bankfull width, substrate and cover conditions are also consistent with baseline conditions. Bankfull width and wetted width are relatively uniform throughout Site 4, ranging from 100 m to 230 m and 78 m to 170 m respectively. Substrate consists primarily of cobble and boulder with a maximum depth of approximately 1 m in the thalweg. Cover is provided primarily by depth and turbulence and partially by large riprap present along the RDB and boulder substrate (Appendix B – Attachment C). Site 4 continues to have little to no overhanging cover as a result of bank armouring along the RDB and lack of mature bank vegetation.

Deep run (R1) habitat provides 'suitable' holding and feeding habitat for adult and juvenile fish. R3 habitat present at the downstream end of Site 4 provides 'suitable' holding and feeding habitat for juvenile fish. Due to the maximum depth of approximately 1 m, this section of the Bow River provides 'marginal' overwintering habitat. There is 'marginal' spawning habitat for salmonids (e.g., brown trout and rainbow trout) due to the lack of suitable gravel substrates through the reach.

Site 1 and 2 Fish Habitat Comparison with Site 4

The comparison of Site 1 and 2 fish habitats to Site 4 habitat is consistent with the findings in the 2019 report (KWL, 2020a). BDEP improved the bank stability and fish habitat at Site 1 and 2, with key features including the constructed fish shelters and boulder clusters along the RDB in the reach downstream of the Cushing Bridge. Additionally, the deciduous shrubs planted along the RDB at Site 1 and 2 have the potential to provide overhead cover for fish as they mature. This compares to Site 4 that does not provide cover because of the bank armouring along the RDB and does not provide refugia within the bank in the form of shelters.

Water Quality Field Parameters

Baseline sampling of in-situ water quality parameters was conducted on March 27, 2017 and included dissolved oxygen, conductivity, pH, and water temperature (Hemmera, 2017a). In both 2019 and 2020, the same data were collected but sampling was conducted over the course of the year (Table 2-1). The locations where water quality sampling stations were established in 2019 are presented in Figure 1-1. These water quality stations were also used for the 2020 monitoring to allow for year over year comparison.

The results of water quality sampling of in-situ water quality parameters at the Upstream Control site, Site 1 and Site 4 are shown in Table 2-2 for baseline 2019 sampling and 2020 sampling. The results for Site 1 and Site 4 were compared to standards identified in the Canadian Council of Ministers of the Environment (CCME) Guidelines for the Protection of Freshwater Organisms (CCME, 1999) and were also compared with the parameters collected in the upstream Control Reach to confirm that water quality parameters were within the natural variation for the Bow River.

Overall, all water quality parameters measured in Site 1 and Site 4 and the Upstream Control Site were within federal guidelines (CCME, 1999). Results from water quality measurements in 2020 were similar to measurements recorded in 2019, with similar seasonal variability in temperature, dissolved oxygen and conductivity. Site 1 and Site 4 values were also within the natural variation of the Bow River as determined by comparison to the Upstream Control Site. In addition, Site 1 and Site 4 values were comparable to each other and to the Upstream Control Site so no effects on water quality were obviously discernible from the BDEP project.

Table 2-2: 2019 BDEP Monitoring Summary of Water Quality Data

Site	Season	Temperature (°C)			Dissolved Oxygen (mg/L)			pH			Conductivity (uS/cm)		
		2017[1]	2019	2020	2017	2019	2020	2017	2019	2020	2017	2019	2020
Up-stream Control	Winter	--	0.6	0.5	--	11.9	12.4	--	8.3	8.8	--	413	403
	Spring	--	10.4	8.0	--	10.1	10.9	--	8.3	8.5	--	439	449
	Summer	--	16.0	15.5	--	9.5	9.3	--	8.7	8.8	--	332	331
	Fall	--	2.5	0.6	--	11.7	13.1	--	8.7	8.7	--	406	380
Site 1	Winter	0.04	0.3	0.5	12.8	12.1	13.0	8.2	8.5	8.8	192[2]	435[2]	399
	Spring	--	10.5	7.7	--	10.8	11.0	--	8.4	8.7	--	444	449
	Summer	--	16.4	15.4	--	9.1	9.3	--	8.7	8.8	--	306	316
	Fall	--	2.6	0.7	--	11.8	13.0	--	8.6	8.7	--	411	387
Site 4	Winter	0.04	1.0	0.01	12.8	12.1	12.8	8.2	8.5	8.7	192[2]	459[2]	404
	Spring	--	10.0	8.0	--	10.5	11.0	--	8.4	8.7	--	441	449
	Summer	--	16.7	15.8	--	9.4	9.2	--	8.5	8.7	--	331	317
	Fall	--	2.8	0.6	--	11.4	13.0	--	8.6	8.6	--	351	394

Notes:

1. 2017 was the baseline data collection year
2. Baseline and 2019/2020 values for conductivity are substantially different but are within the natural range of the Bow River where conductivity can range from 83 uS/cm to 662 uS/cm (City of Calgary unpublished data).

Fish Use

The baseline assessment of fish and fish habitat included a desktop review of historical documented fish presence in the project reach using Fisheries and Wildlife Management Information System (FWMIS) (Hemmera, 2017a). Based on the desktop assessment, 22 species of fish, including 11 sportfish species, were found to be likely to occur in proximity to the project as shown in Table 2-3 (ESRD, 2017). Fish sampling surveys were not conducted as part of the baseline assessment.

The 2020 fish observations and sampling included winter, spring, and summer assessments that were conducted at the locations, and according to the methods and timelines shown in Table 2-1. Fish data were collected to determine overall use of habitats within the study area, as well as species richness and abundance (i.e., CPUE) within the project sites.

A summary of the results of the fish use assessments are provided in Table 2-4 for Site 1, Table 2-5 for Site 2, and Table 2-6 for Site 4. Of the 22 species that have a probable potential of occurrence on the Bow River within the vicinity of the project, 10 were captured within the project area in 2019, including 6 sportfish and 4 non-sportfish species (KWL, 2020) and in 2020, 9 species were captured, including 5 sportfish and 4 non-sportfish species (Table 2-3). Total fish capture data is presented in Table 2-7; unprocessed fish data is presented in Appendix B – Attachment D. Representative photos of each fish species captured in 2020 are presented in Appendix B – Attachment A, photos 33 - 41.

Results for fish sampling are summarized below. More detail is provided in Appendix B.

- A total of 8 fish from 2 species (longnose sucker and white sucker) were captured using minnow trapping. Overall, white sucker had that the highest catch per unit effort (CPUE) for individual species captured by minnow trapping.
- A total of 112 fish from 9 species were captured using boat electrofishing, including longnose dace, longnose sucker, white sucker, trout perch, burbot, brown trout, rainbow trout, mountain whitefish and northern pike. The highest CPUE by fish species captured by electrofishing was longnose sucker followed by mountain whitefish.

- Site 1 minnow trapping catch per unit effort (CPUE) was 0.0120 fish/trap hour in 2020 compared to 2019 results of 0.0235 fish/trap hour. Site 1 electrofishing CPUE was 0.0868 fish/electrofishing-second in 2020 compared to 0.0167 fish/electrofishing-second in 2019. The highest electrofishing CPUE by species was rainbow trout at Site 1.
- Site 2 minnow trapping catch per unit effort (CPUE) was 0.0200 fish/trap hour in 2020 compared to 2019 results of 0.0235 fish/trap hour. Site 2 electrofishing CPUE was 0.0911 fish/electrofishing-second in 2020 compared to 0.0203 fish/electrofishing-second in 2019. The highest electrofishing CPUE by species was mountain whitefish at Site 2.
- There were no fish trapped at Site 4 by minnow trapping in 2020 compared to 2019 results of 0.0667 fish/trap hour. Site 4 electrofishing CPUE was 0.0716 fish/electrofishing-second in 2020 compared to 0.0473 fish/electrofishing-second in 2019. The highest electrofishing CPUE by species was longnose sucker at Site 4.

Table 2-3: 2020 BDEP Monitoring Fish Species Diversity

Common Name[1]	Scientific Name	Historic Presence in the Bow River[1]	BDEP Site		
			Site 1	Site 2	Site 4
SPORTFISH					
brook trout	*Salvelinus fontinalis*	X			
bull trout	*Salvelinus confluentus*	X			
brown trout	*Salmo trutta*	X	X	X	X
burbot	*Lota lota*	X	X	X	
cutthroat trout[2]	*Oncorhynchus clarki*	X			
lake whitefish	*Coregonus clupeaformis*	X			
mountain whitefish	*Prosopium williamsoni*	X		X	
northern pike	*Esox lucius*	X		X	
rainbow trout[3]	*Oncorhynchus mykiss*	X	X	X	X
yellow perch[4]	*Perca flavescens*	X			
walleye	*Sander vitreus*	X			
NON-SPORTFISH					
brook stickleback	*Culaea inconstans*	X			
fathead minnow	*Pimephales promelas*	X			
lake chub	*Couesius plumbeus*	X			
longnose dace	*Rhinichthys cataractae*	X	X		
longnose sucker	*Catostomus catostomus*	X	X	X	X
mountain sucker	*Catostomus platyrhynchus*	X			
Prussian carp	*Carissius gibclio*	X			
pearl dace	*Margariscus margarita*	X			
spoonhead sculpin	*Cottus ricei*	X			
trout-perch	*Percopsis omiscomaycus*	X		X	
white sucker	*Catostomus commersoni*	X	X	X	
Total		22			
2020 Species Richness			6	8	3
2019 Species Richness			7	2	6

Sources: List compiled from FWMIS, 2019; Nelson and Paetz, 1992.

Notes:

1. Cutthroat trout in the Bow River near the Project represent introduced stocks and are not considered native stocks of Westslope Cutthroat Trout (Onchorhynchus clarkii lewisi).
2. Rainbow trout in the Bow River near the Project represent introduced stocks and are not considered native stocks of Athabasca Rainbow Trout.
3. The historical range of yellow perch does not include the Bow River, however, numerous specimens have been captured in irrigation canals near the Project area.

Table 2-4: Site 1 Fish Use Assessment Results

Assessment	Observations
Winter – underwater photography and snorkel survey (January 7, 2020)	Similar to 2019 results, one fish was observed utilizing the Site 1 fish shelters during the winter assessment; the fish could not be identified to species due to high turbidity present at the time of the survey.
Spring – snorkel survey	Not completed due to high water levels and turbid water.
Summer – minnow trap sampling and electrofishing survey (September 17-18, 2020)	45 fish consisting of 6 species were captured as shown in Table 2-3. • 3 fish were captured by minnow trap (3 longnose sucker). • 42 fish were captured using boat electrofishing with species as shown in Table 2-7.

Table 2-5: Site 2 Fish Use Assessment Results

Assessment	Observations
Winter – underwater photography and snorkel survey (January 7, 2020)	The fish enhancement structures within Site 2 (i.e. box fascines) were dry at the time of the assessment, preventing overwintering use of the structures by fish.
Spring – snorkel survey	Not completed due to high water levels and turbid water.
Summer – minnow trap sampling and electrofishing survey (September 17-18, 2020)	42 fish consisting of 8 species were captured as shown in Table 2-3. • 5 fish were captured by minnow trap (2 longnose sucker and 3 white sucker). • 34 fish were captured using boat electrofishing with species as shown in Table 2-7.

Table 2-6: Site 4 Fish Use Assessment Results

Assessment	Observations
Winter – underwater photography and snorkel survey (January 7, 2020)	Site 4 was not surveyed as part of the winter assessment.
Spring – snorkel survey	Not completed due to high water levels and turbid water.
Summer – minnow trap sampling and electrofishing survey (September 17-18, 2020)	33 fish consisting of 3 species were captured as shown in Table 2-3. • 0 fish were captured by minnow trap. • 33 fish were captured using boat electrofishing with species as shown in Table 2-7.

Table 2-7 2020 BDEP Monitoring Total Fish Numbers Captured Per Species

Site	BNTR	BURB	LKCH	LNDC	LNSC	MNWH	NRPK	RNTR	TRPR	WHSC	YLPR	TOTAL
Site 1	2	1	0	1	12	0	0	26	0	3	0	45
Site 2	2	1	0	0	9	23	1	1	1	4	0	42
Site 4	5	0	0	0	25	0	0	3	0	0	0	33
2020 Total	9	2	0	1	46	23	1	30	1	7	0	120
2019 Total	2	1	1	1	18	1	1	4	0	10	9	48

Notes: BNTR – Brown Trout, BURB – Burbot, LKCH – Lake Chub, LNDC – Longnose Dace, LNSC – Longnose Sucker, MNWH – Mountain Whitefish, NRPK – Northern Pike, RNTR – Rainbow Trout, TRPR – Trout Perch, WHSC - White Sucker, YLPR – Yellow Perch

Fish Use Comparison

As discussed in Section 1.3, the baseline data and data collected in 2019 and 2020 for Site 1 and 2 are compared to the data collected for Site 4 in this section to meet the objectives of the BEMP.

Compared with historical fish capture data from the Bow River (ESRD, 2017), 9 of 22 species were captured during 2020 (Year 2) of monitoring, including 5 sportfish and 4 non-sportfish species. Abundance of fish species within the project area could not be compared with historical data, as fish sampling surveys were not previously conducted in similarly characterized Bow River habitat within proximity to the BDEP sites.

Although Site 1 had the second highest fish abundance measured by catch per unit effort (CPUE), it had the highest number of total fish captured and the single highest number of one species captured (rainbow trout) as shown in Table 2-7. Bioengineering enhancements were most diverse at Site 1, with boulder clusters, a riprap apron, crib wall fish shelters, and box fascines. The species abundance observed at Site 1 may have been supported by the variation in cover and microhabitats provided by the habitat enhancements.

Site 2 had the highest abundance and diversity of fish species, including five sportfish species (i.e., brown trout, burbot, mountain whitefish, northern pike, and rainbow trout). Site 2 had the highest CPUE for minnow trapping and electrofishing (0.0200 fish/trap hour; 0.0911 fish/electrofishing second respectively) with mountain whitefish being the most captured fish species.

Site 4 had the lowest CPUE of the three sites. Of the captured fish at Site 4, there was a higher abundance of forage fish, with longnose sucker being most prevalent. Site 4 had no habitat enhancements and has the least amount of variation in cover and microhabitats.

As expected, species composition and fish abundance observed during 2020 was higher than 2019 as the BDEP sites naturalize following the construction of the fish habitat enhancements. Fish use and population data collected in 2020 indicated a higher overall CPUE in 2020 of 0.2494 fish/electrofishing-second versus 2019 CPUE of 0.0844 fish/electrofishing-second.

Spawning Use

Field observations of spawning use were not conducted as part of the baseline assessment (Hemmera, 2017a).

In 2020, a spring spawning assessment could not be completed due to high flows and turbid water creating unsafe conditions. A fall spawning assessment was completed at the locations, and according to the methods and timelines shown in Table 2-1. A summary of the results is provided below.

- **Spring redd survey**: survey not completed.
- **Fall redd survey**: No redds or fish were identified in the surveyed reach.
- **Fall kick sampling survey**: Suitable mountain whitefish habitat was identified and kicked sampled for eggs. Six locations within the upstream extent of Site 1 (i.e., upstream of the Cushing Bridge) were sampled and mountain whitefish eggs were observed at each location (Appendix B – Attachment A, Photos 42 to 43).

2.3 Summary of Findings

For Year 2 (2020) of fish and fish habitat monitoring, fish were observed to be using the project area for migration, foraging, overwintering, rearing, and spawning purposes. In particular, monitoring results indicate that fish are utilizing the habitat enhancement structures included in the BDEP. Fish were observed using and were captured within the vicinity of the habitat structures throughout the project area at Site 1 and Site 2. Fish were observed in the fish shelters, boulder clusters, and surrounding habitats during winter, spring, and summer assessments. Although no fish were observed in the fall, mountain whitefish eggs were documented in the upstream section of Site 1.

Based on the fish use monitoring results, Sites 1 and 2 are providing high quality fish habitat in comparison to Site 4. Species composition and fish abundance observed during Year 2 are expected to vary in subsequent monitoring years as the BDEP sites naturalize following the construction of the fish habitat enhancements.

Photo 2-1: Timber crib wall and fish habitat enhancement boulders at Site 1-3.

3. Wildlife

Photo 3-1: Coyote photographed using the BDEP wildlife passage corridor

Baseline wildlife data was collected for Site 1, 2 and 4 in 2017 as described in the *Preliminary Natural Assessment Report* (Hemmera, 2017b) and summarized in the BEMP (Hemmera, 2018). As in 2019, wildlife monitoring was conducted again in 2020 at Sites 1, 2 and 4 to determine the effectiveness of post-construction conditions for wildlife use resulting from the habitat enhancements within each site. As discussed in Section 1.3, the baseline data and data collected in 2020 for Site 1 and 2 are compared to the data collected for Site 4 in this section to meet the objectives of the BEMP. Trend analysis will be completed following Year 3 (2021) monitoring and presented in the 2021 monitoring report.

Each of the three BDEP sites had different wildlife monitoring requirements related to the different scopes associated with each site, as described below.

- Site 1 was designed to have a wildlife corridor installed under the existing 17th Avenue Cushing Bridge and the new South East Bus Rapid Transit (SEBRT) bridge. The wildlife corridor was a 6 m wide vegetated soil area classified as “wildlife-friendly” riprap to allow for wildlife travel along the edge of the Bow River. Vegetation was planted to create a natural visual screen between the river and public pathway to promote wildlife movement between areas upstream and downstream of the 17th Avenue SE Bridge. The wildlife corridor location is shown on Figure 1-1.
- Site 2 was designed to have riparian vegetation and habitat restored and to provide suitable nesting habitat for breeding birds, including passerines, waterbirds and/or raptors.
- Site 4 has used conventional riprap, including large boulders placed along the bank and into the edge of the Bow River, as a bank restoration method. Site 4 was retrofitted with vegetation as part of BDEP; however, it was selected to represent a control site, where baseline conditions can be used to compare the effectiveness and trends observed in Sites 1 and 2, which are considered the treatment areas of the project.

3.1 Methods

Wildlife monitoring was completed in compliance with the BEMP (Hemmera, 2018). The Year 2 (2020) monitoring scope was comprised of trail camera monitoring at Site 1 to assess wildlife corridor usage by mammals along with breeding bird surveys and wildlife feature monitoring at all three Sites to assess habitat suitability and wildlife use. Wildlife features previously identified during the *Preliminary Natural Assessment Report* (Hemmera, 2017) and during Year 1 (2019) of the monitoring program, including two known bank swallow colonies were also monitored in Year 2 (2020).

Baseline Assessment

A summary of the baseline assessment wildlife assessment from 2017 is provided below (Hemmera, 2017b). No field monitoring or surveys were completed as part of the baseline wildlife assessment.

- A review of FWMIS resulted in 12 provincially or federally listed species that were identified as previously occurring within 1,000 m of the project (Table 3-1).
- A review of the Wildlife Sensitivity Maps indicated that Sites 1, 2, and 4 are located within the Sensitive Raptor Range for bald eagles, golden eagles and prairie falcon, and within the sharp-tailed grouse range (Hemmera, 2018; AEP, 2017a).
- Breeding habitat for bank swallows and nesting raptors were identified within the project area during the baseline assessment, with two bank swallow colonies identified in Site 2 (BANS01, Appendix B Figure 7) and Site 4 (BANS02, Appendix B Figure 7).
- There is suitable habitat present in and around the project for most of the species listed in Table 3-1. The Bow River provides foraging and breeding habitat for many waterbirds (e.g., sora, harlequin duck, western grebe, great blue heron, etc.) with a riparian zone of deciduous trees suitable for breeding raptors and passerines (e.g., bald eagle, least flycatcher). Bats would be able to forage over the Bow River and roost in the trees present in the riparian zones.

Table 3-1 Provincially or Federally Listed Species within 1 km of the Project area

Species	Scientific Name	AEP Ranking [a]	SARA Schedule [b]	COSEWIC Ranking [c]
Bald eagle	*Haliaeetus leucocephalus*	Sensitive	-	-
Baltimore oriole	*Icterus galbula*	Sensitive	-	-
Common nighthawk	*Chordeiles minor*	Sensitive	Schedule 1	Threatened
Eastern kingbird	*Tyrannus tyrannus*	Sensitive	-	-
Great blue heron	*Ardea herodias*	Sensitive	-	-
Harlequin duck	*Histrionicus histrionicus*	Sensitive	-	-
Least flycatcher	*Empidonax minimus*	Sensitive	-	-
Northern goshawk	*Accipiter gentilis*	Sensitive	-	-
Silver-haired bat	*Lasionycteris noctivagans*	Sensitive	-	-
Sora	*Porzana carolina*	Sensitive	-	-
Western grebe	*Aechmophorus occidentalis*	Sensitive	Schedule 1	Special Concern
Western wood-pewee	Contopus sordidulus	May be at Risk	-	-

[a] AEP 2017*b*; [b] Government of Canada 2016; [c] COSEWIC 2008

2020 Monitoring

Wildlife monitoring included breeding bird and nesting surveys at Sites 1, 2 and 4 and monitoring of four wildlife cameras at Site 1 (Camera 1, 2, 3 and 5). This represents one additional camera location (Camera 5) relative to Year 1 (2019) as described below and shown in Appendix B Figure 7. Trail cameras were installed on January 21, 2020 and removed on November 20, 2020 with data downloads and general camera condition checks completed on May 14, July 28 and September 25.

Breeding Bird and Nest Surveys

Year 2 (2020) breeding bird surveys and wildlife feature monitoring consisted of five breeding bird survey plots at the same locations as Year 1 (2019). Survey plots BBS03, BBS04 and BBS05 were located within Site 1, BBS02 located within Site 2, and BBS01 located within Site 4 (Appendix B Figure 7). Two rounds of breeding bird survey point counts were completed at each plot location on May 28 and June 16, 2020. These surveys follow the methods outlined in the *Sensitive Species Inventory Guidelines* (ESRD, 2013) for breeding birds and raptors.

Known wildlife features included active raptor nests and two known bank swallow colonies (Appendix B Figure 7) where monitoring and estimates of use were also completed on May 28 and June 16, 2020. Bank swallow colony use was assessed by recording the total number of bank swallows entering and exiting bank cavities over a five-minute period.

All surveys were conducted under appropriate conditions for the identification breeding birds (i.e., appropriate time of day, temperatures greater than 0°C, winds less than 20 km/hr, and no precipitation).

Wildlife Camera Monitoring

Three wildlife monitoring cameras were deployed within Site 1 at the same locations as 2019 (Appendix B Figure 7) and as described below.

- Camera 2 (11U 709370E 5658206N) was located 15 m downstream from the 17th Avenue SE Bridge on a storm drain outfall and was orientated downward at an approximately 45-degree angle towards the Bow River. Note that Camera 2 was referred to as Camera 3 in the 2019 report. Camera 2 was deployed on January 21, 2020 and was functional until August 8, 2020 (256 days) where the memory card in Camera 2 was observed to have reached capacity.
- Camera 3 (11U 709343E 5658206N) was located under the existing 17th Avenue SE Bridge facing east towards the Bow River. Note that Camera 3 was referred to as Camera 1 in the 2019 report. Camera 3 was deployed on January 21, 2020 and removed on November 20, 2020. It was functional for the full study period of 304 days.
- Camera 4 (11U 709370E 5658328N) was located approximately 126 m upstream from the 17th Avenue SE bridge on a storm drain outfall and orientated downward at an approximately 45-degree angle towards the Bow River. Note that Camera 4 was referred to as Camera 2 in the 2019 report. Camera 4 was deployed on January 21, 2020 and was found to have been knocked over by people on April 10, 2020. It was reinstalled on May 14, 2020 but was found to be knocked over again during the July 28, 2020 camera check. Camera 4 was functional for 195 days.

A fourth camera was installed at Site 1 in 2020 as shown in Appendix B Figure 7 and described below.

- Camera 5 was located approximately 148 m upstream from Camera 4, and approximately 277 m upstream from the 17th Avenue SE Bridge. It was oriented downwards facing east, horizontally, at an approximate 45-degree angle towards the Bow River. Camera 5 was vandalized and rendered non-functional on August 2, 2020 but it was not discovered until the September 25, 2020 camera check. It was not replaced as the monitoring period was nearly complete. Camera 5 was functional for 171 days.

Wildlife cameras were programmed to capture three images with a one second spacing between images when triggered by motion detection. All cameras were programmed not to trigger for five seconds following a motion triggered event, and camera sensitivity was set to the medium/high mode. Wildlife cameras were all aimed towards the Bow River, away from the adjacent pedestrian pathway to avoid abundant photographs of human activity on the pathway.

The placement of each wildlife trail camera in Site 1 was intended to track wildlife movement and determine the use of the treatment area by terrestrial mammals as a wildlife corridor. The Camera 5 location was new in 2020 and was added to provide coverage of the furthest upstream extent of Site 1. Similar to the Camera 4 location, the Camera 5 location captured the use of reference riparian habitat to compare wildlife usage with the treatment areas adjacent and beneath the 17th Avenue SE Bridge.

Wildlife camera monitoring was not conducted at Site 2 or Site 4 per the agreed study design described in the BEMP (Hemmera, 2018), as the focus was on wildlife movement at the Site 1 wildlife corridor. Also, no data collection on wildlife/vehicle interaction on Blackfoot Trail/17 AVE SE or Cushing Bridge was conducted as part of the study.

3.2 Results

The following outlines the results for wildlife monitoring at each site.

Breeding Bird and Nest Surveys

The observations from the breeding bird and nesting surveys are provided for Site 1 in Table 3-2, for Site 2 in Table 3-3, and for Site 4 in Table 3-4. The breeding bird surveys resulted in identifying 32 species over 2019 and 2020, including three listed species as shown in Table 3-5.

Table 3-2: Site 1 Breeding Bird and Nest Survey Results

Assessment	Observations
Species	A total of 50 individuals representing 20 different species were observed in Year 2 (2020), compared to 129 individuals representing 16 different species in Year 1 (2019) (Table 3-5). Bank swallow is considered a species of management concern – it is provincially listed as Sensitive (AEP, 2017b), and federally listed as Threatened under the Species at Risk Act (SARA) and by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (Government of Canada, 2016; COSEWIC, 2008).
Habitat	The habitat consists of deciduous trees, riparian area, and revegetated riparian (i.e., willow sp.) species. There is a large gravel area in Site 1 as the Bow River water levels drop exposing a large gravel bar. The habitat under the 17th Ave bridge is gravel/rocky substrate with some revegetation effort for willow species underway.
Nesting	No active songbird nests were observed at Site 1 in Year 2 (2020) in comparison to four stick nests that were observed in Year 1 (2019).

Table 3-3: Site 2 Breeding Bird and Nest Survey Results

Assessment	Observations
Species	A total of 29 individuals representing 10 different species were observed within Site 2 in Year 2 (2020), compared to 68 individuals representing 8 different species in Year 1 (2019) (Table 3-5). Of the species identified, bank swallow) is considered a species of management concern (see Table 3-2). Least flycatcher, which is considered a listed species (AEP, 2017b), was observed in Year 1 (2019), but not observed in Year 2 (2020).
Habitat	The habitat within Site 2 consists of grasses and shrubs with a city park habitat and pedestrian path adjacent to it.
Nesting	No active songbird nests were observed at Site 2 in Year 2 (2020) or in Year 1 (2019). The bank swallow colony identified in the baseline assessment and in Year 1 (2019) was observed at the site in Year 2 (2020).

Table 3-4: Site 4 Breeding Bird and Nest Survey Results

Assessment	Observations
Species	A total of 19 individuals representing 7 different species were observed within Site 4 in Year 2 (2020), compared to 24 individuals representing 6 different species in Year 1 (2019) (Table 3-5). Of the species identified, none were listed by AEP, SARA or COSEWIC (Government of Canada, 2016; COSEWIC, 2008; AEP, 2017b).
Habitat	The habitat within Site 4 consists of rock riprap, grasses and shrubs with an adjacent city park and pedestrian path adjacent to it.
Nesting	One bank swallow colony is located south of Site 4. A total of 18 bank swallows were identified at the colony in 2020 compared to 34 individuals in 2019. No other nesting features (i.e., raptor stick nests) were identified during the surveys.

In addition to the observations recorded during the standardized breeding bird plots, any additional wildlife observations made were recorded. These observations included blue-winged teal (*Anas discors*), Brewer's blackbird (*Euphagus cyanocephalus*), European starling, Franklin's gull, Lincoln's sparrow (*Melospiza lincolnii*), ring-billed gull (*Larus delawarensis*), rock pigeon (*Columba livia*), unidentified gull, and warbling vireo (*Vireo gilvus*). None of the incidental species observed are listed provincially or federally.

Table 3-5 Species Identified during the Breeding Bird Surveys at Site 1, Site 2 and Site 4

Common Name	Scientific Name	Number of Individuals					
		Site 1		Site 2		Site 4	
		2019	2020	2019	2020	2019	2020
American goldfinch	*Carduelis tristis*		1				
American robin	*Turdus migratorius*	5	4		1		
American wigeon	*Anas americana*			1			1
bank swallow[1]	*Riparia riparia*		1	43	7		
black-billed magpie	*Pica hudsonia*	2		2	1	5	1
black-capped chickadee	*Poecile atricapillus*	1	2		1		
brown-headed cowbird	*Molothrus ater*	4	1				
Canada goose	*Branta canadensis*	3	2			6	
gray catbird	*Dumetella carolinensis*						
cedar waxwing	*Bombycilla cedrorum*		4				
Chipping sparrow	*Spizella passerina*				1		
clay-colored sparrow	*Spizella pallida*		3			3	6
common goldeneye	*Bucephala clangula*	1					
common merganser	*Mergus merganser*	2	3				
common raven	*Corvus corax*		3				
double-crested cormorant	*Phalacrocorax auritus*	2	1				
European starling	*Sturnus vulgaris*	1					
Franklin's gull	*Leucophaeus pipixcan*	70		16			
Gadwall	*Anas strepera*	4					
house sparrow	*Passer domesticus*	2		3	12		6
house wren	*Troglodytes aedon*	6	1		1		
Killdeer	*Charadrius vociferus*	3	1				
least flycatcher[2]	*Empidonax minimus*	3		1			
Mallard	*Anas platyrhynchos*	2	1		2	8	
Northern flicker	*Colaptes auratus*		1				
red-winged blackbird	*Agelaius phoeniceus*	4	4	1	1		1
song sparrow	*Melospiza melodia*	3	7		2	1	1
spotted sandpiper	*Actitis macularius*	3	3	1			3
tree swallow	*Tachycineta bicolor*		1			1	
yellow warbler	*Dendroica petechia*	5	6				
western wood-pewee[3]	*Contopus sordidulus*	1					
warbling vireo	*Vireo gilvus*	2					
TOTAL		129	50	68	29	24	19

Notes:
1. Listed as “Sensitive” by AEP (AEP, 2017b), “Schedule 1” by SARA (Government of Canada, 2016), and “Threatened’ by COSEWIC (COSEWIC, 2008).
2. Listed as “Sensitive” by AEP (AEP, 2017b).
3. Listed as “May Be at Risk” by AEP (AEP, 2017b).

Year 2 (2020) surveys at Site 1 recorded 79 fewer individuals and two fewer species than the Year 1 (2019) surveys. This reduction in individuals observed is largely related to the 70 Franklin’s gulls observed in

2019, which were not observed in 2020. Franklin's gull is a gregarious species, so it is likely that they were foraging for food in the area, as nesting habitats consisting of shallow water and emergent vegetation are not present in the Project area. For Site 2, Year 2 (2020) surveys recorded 39 fewer individuals compared to Year 1 (2019) surveys, but these represented a slightly higher number of total species (10 species in 2020 compared to the 8 species observed in 2019). For Site 4, Year 2 (2020) surveys observed a similar number of individuals compared to Year 1 (2019) surveys, representing 7 different species compared to 6 different species observed in Year 1 (2019).

Two species of management concern identified in Year 1 (2019) (least flycatcher and western wood-pewee), were not observed in the Year 2 (2020) surveys. Of the species identified at Site 2 in Year 2 (2020), only one species (bank swallow) is considered a species of management concern. Least flycatcher, which is considered a listed species (AEP 2015), was observed in Year 1 (2019), but not observed in Year 2 (2020). None of the species identified at Site 4 in Year 2 (2020) were considered a species of management concern.

Similar to Year 1 (2019) surveys, Site 1 represented the highest number of individuals and species recorded compared to Site 2 and Site 4 in 2020. Site 2 represented half of the number of species observed in Site 1. Site 4 recorded approximately one third of the total species observed in Site 1. The increased activity at Site 1 and Site 2 over Site 4 may be the result of differences in vegetation between the sites, with Site 4 having lower density vegetation. Additionally, Site 1 was found to have the most diverse habitat conditions, followed by Site 2 and Site 4.

Wildlife Camera Monitoring (Site 1 only)

As discussed in Section 3.1 above, four wildlife monitoring cameras were installed at Site 1 in 2020 at the locations shown in (Appendix B Figure 7). Camera 2 produced 90 images, Camera 3 produced 88 images, Camera 4 produced 50 images, and Camera 5 produced 89 images for a total of 317 wildlife observations.

The species identified for each wildlife camera are presented in Table 3-6 for 2020 and Table 3-7 for 2019**.** A total of 7 wildlife species were identified in both 2020 and 2019; however there were 317 wildlife observations in 2020 compared to 212 observations in 2019. While Canada goose (*Branta canadensis*) were included in the 2019 analysis, this species was not included in the camera analysis. The analysis in 2020 has been limited to mammal species which rely on the corridor to pass through the Project area.

Cameras 2, 3, and 5 recorded similar total numbers of wildlife observations, at 90, 88, and 89, respectively. Camera 4 captured fewer individual observations and species, but this camera was only operational for 64% of the monitoring period. Camera 5 had high counts of individual wildlife observations, and the highest species diversity (five species), despite being operational for only 56% of the monitoring period. Camera 5 is directly adjacent to Pearce Estate Park and has greater tree cover compared to the other camera locations. This may, at least in part, explain the greater species diversity recorded at the Camera 5 location compared to the other camera locations with less diverse surrounding wildlife habitat.

White-tailed deer (*Odocoileus virginianus*) was the most common species observed across all cameras (153 individuals), with most observations occurring at Camera 3 (60 individuals). Mule deer (*Odocoileus hemionus*) by comparison was only observed twice at Camera 5. Coyote (*Canis latrans*) was the second most abundant species, with 100 individual observations across all camera locations. Eastern gray squirrel (*Sciurus carolinensis*) was commonly observed at the Camera 5 location (25 individuals) but was not recorded at any of the other camera locations. Both common raccoon (*Procyon lotor*) at Camera 3, and striped skunk (*Mephitis mephitis*) at Camera 2, were each only observed on one occasion.

The common raccoon and eastern gray squirrel were new species observations in Year 2 (2020), while all other species were observed in both monitoring years (Table 3-8). White-tailed deer and coyote mean use

increased from Year 1 (2019) to Year 2 (2020) as shown in Table 3-8. White-tailed jack rabbit (*Lepus townsendii*) mean use decreased in Year 2 (2020) as compared to Year 1 (2019).

Deer presence was recorded at all four of the cameras throughout Site 1, suggesting that wildlife corridor in the Project area is providing effective passage, and that deer are using all areas of Site 1 similarly. Coyote observations within Site 1 show a similar evenly distributed pattern of presence across all camera locations, suggesting that the wildlife corridor area provides effective passage for coyotes as well as deer. With the exception of the eastern gray squirrel discussed in relation to the proximity to the higher tree cover adjacent to Camera 5, it is difficult to draw conclusions about the presence or absence of the other species that had limited numbers of observations. White-tailed jackrabbits were found in relatively equal abundance at all locations, with the exception of Camera 4, where no individuals were recorded. As Camera 4 was intended to act as a reference habitat location, not restricted by the wildlife corridor, there is not an obvious reason why this species was found at both Camera 2 and Camera 3 on the other side of the limited width corridor, and at Camera 5 where corridor width is not limited.

Table 3-6 Total Sum of Species occurrences by Camera in Site 1 in 2020

Camera	Species[1]							Total
	Common racoon	Coyote	Eastern gray squirrel	Mule deer	Striped skunk	White-tailed deer	White-tailed jack rabbit	
Camera 2	-	39	-	-	1	39	11	90
Camera 3	1	16	-	-	-	60	11	88
Camera 4	-	14	-	-	-	36	-	50
Camera 5	-	31	25	2	-	18	13	89
Total[2]	1	100	25	2	1	153	35	317

Notes:
1. Species included in this table includes all observations of terrestrial mammals. 2020 data does not include Canada goose (*Branta canadensis*) as they are not limited to terrestrial movement like the mammal species. Canada goose has been observed to use the corridor habitat; however, they are also able to fly or swim through the Project area without relying on the movement corridor. Species such as house sparrow and rock dove were not included in the analysis since they were not using the wildlife corridor for passage but were likely nesting or roosting on the bridge structures.
2. Total is the number of individuals observed in pictures as "new individuals" to avoid any double counting of the same individual.

Table 3-7 Total Sum of Species occurrences by Camera in Site 1 in 2019

Camera	Species[1]								Total
	Canada goose	Coyote	Deer species[2]	Great blue heron	Mule deer	Striped skunk	White-tailed deer	White-tailed jack rabbit	
Camera 1	5	10	3		2		14	6	40
Camera 2	121	3	1	1	2	1	2	39	170
Camera 3	-	-	2	-		-	-	-	2
Total[3]	126	13	6	1	4	1	16	45	212
Frequency[4]	67	67	100	33	67	33	67	67	100

Notes:
1. Species included in this table includes all observations of terrestrial mammals and bird species using the terrestrial habitat as a wildlife passage corridor (i.e., on the substrate and not observed in the water, vegetation or anthropogenic structures). This included Canada goose (*Branta canadensis*) and great blue heron (*Ardea Herodias*). Species such as house sparrow and rock dove were not included in the analysis since they were not using the wildlife corridor for passage but were likely nesting or roosting on the bridge structures.
2. Deer species are individuals that could not be differentiated between white-tailed deer or mule deer.
3. Total is the number of individuals observed in pictures as "new individuals" to avoid any double counting of the same individual.
4. Frequency is the presence of each species captured on each camera compared to the total number of cameras. This was to show if any species was observed at all three cameras, or if a particular species was only observed at one camera

Table 3-8 Species Abundance, Mean Use, and Composition for Site Camera Monitoring Program

Species	Number of Individuals		Mean Use[1]		Composition of Total Species Occurrence[2] (%)	
	2019	2020	2019	2020	2019	2020
Canada goose[3]	126	n/a	0.21	n/a	59	n/a
Common racoon	-	1	-	-	-	0.3
coyote	13	100	0.02	0.11	6	32
deer species	6	-	0.01	-	3	-
Eastern gray squirrel	-	25	-	0.03	-	8
great blue heron	1	-	<0.01	-	0.5	-
mule deer	4	2	0.01	<0.01	2	0.7
striped skunk	1	1	<0.01	<0.01	0.5	0.3
white-tailed deer	16	153	0.03	0.17	8	48
white-tailed jack rabbit	45	35	0.07	0.04	21	11
Total	212	317	0.35	0.35	100	100

Notes:
1. Mean use was calculated based on the number of new individuals identified over the number of days the cameras functioned. It represents the use of the habitat overall during the monitoring period.
2. The composition of total species occurrence is the number of one species over the total number of individuals reported in percent.
3. While Canada goose (*Branta canadensis*) were included in the 2019 analysis, this species was not included in the 2020 camera analysis to limit the analysis to mammal species which rely on the corridor to pass through the Project area

While wildlife camera monitoring was not conducted at Site 4, it is expected that conditions at Site 1 are better for wildlife passage than Site 4 since the riprap surfaces such as found at Site 4 are difficult for many species to traverse, especially ungulates and amphibians (Ruediger & DiGiorgio, 2006; Chisholm, et al., 2010) and the filled-in riprap at Site 1 that is part of the wildlife corridor is clearly being used by a number of large mammals as documented by Camera 1. Also, it is expected that most of the large mammals will now be using the wildlife corridor instead of crossing Blackfoot Trail as research has shown that deer will go the long way under the bridge instead of taking the short way over the highway (Leete, 2016) and that the number of wildlife vehicle collisions reduces on average by 86 percent (Huijser, et al., 2008) when wildlife underpasses are provided. Because of the effectiveness of this technique, wildlife passage benches are standard practice in Minnesota to meet permitting requirements for the repair or reconstruction bridges impacting public waters (Leete, 2014; Leete, 2016).

3.3 Summary of Findings

The Year 2 (2020) breeding bird surveys resulted in the identification of 37 species including one listed species at the BDEP sites. The highest number of bird species and individuals identified was at Site 1, followed by Site 2 and Site 4. The bank swallow colony identified during the baseline assessment at Site 2 was observed again during the 2020 survey. No nests were observed at any of the sites in 2020. Site 1 (50 individuals from 20 species) and Site 2 (29 individuals from 10 species) showed increased bird activity relative to Site 4 (19 individuals from 7 species) based on the results of the breeding bird and nesting surveys. This increased activity may be the result of differences in vegetation between the sites, with Site 4 having lower density vegetation.

The wildlife camera monitoring program identified animals utilizing the wildlife corridor created under the Cushing/17th Avenue SE bridge. A total of 7 wildlife species were identified through observations of 317 individuals. The most abundant species identified during the monitoring program was white-tailed deer (48%)

followed by coyote (32%) and white-tailed jackrabbit (11%). Two new species were identified this year, common raccoon, and eastern gray squirrel.

Deer and coyote presence through all four of the cameras throughout Site 1 and the increased mean use from 2019 and 2020, suggests that the wildlife corridor in the Project area is providing effective passage for large mammals.

Year 2 (2020) of the wildlife monitoring program allowed for comparisons between the first two years of the program, including indications that some wildlife species are utilizing these habitats similarly to the reference habitats upstream and downstream.

Photo 3-2: Access trail at Site 1

4. Riparian Health

4.1 Methods

Baseline Riparian Health Assessments (RHAs) for Site 1, Site 2, and Site 4 were completed in 2016 according to the Large River Riparian Health Methodology (Cows and Fish, 2018) developed by the Alberta Riparian Habitat Management Society (Cows and Fish) (Hemmera, 2017c). Riparian health at Site 1, Site 2 and Site 4 was reassessed on September 16 and 17, 2019, and again on September 8 and 9, 2020 according to the same RHA methodology and assessment polygon boundaries used in the 2016 assessment. The polygon boundaries are shown in Figure 1-1.

To calculate RHA scores for the BDEP sites, 15 vegetation and soil/hydrology factors were assessed to give an overall rating of how well each particular reach was functioning ecologically (Table 4-1). Once a score is developed for each health indicator, reaches are then placed into one of three riparian health categories: Healthy, Healthy with Problems or Unhealthy (Table 4-2).

Table 4-1: Cows and Fish Large River Assessment Criteria

Parameter	Score
Vegetation	
1. Cottonwood and poplar regeneration from seed	/ 6
2. Regeneration of other native tree species	/ 3
3. Regeneration of preferred shrub species	/ 6
4. Standing decadent and dead woody material	/ 3
5a. Browsing/utilization of preferred tree and shrub species	/ 3
5b. Woody vegetation removal by beavers and/or humans	/ 3
6. Total canopy cover of trees and shrubs	/ 3
7a. Total canopy cover of invasive plant species	/ 3
7b. Density distribution pattern of invasive plant species	/ 3
8. Total canopy cover of disturbance-increaser plant species	/ 3
Soil / Hydrology	
9. Riverbank root mass protection	/ 6
10. Percent cover of human-caused bare ground	/ 6
11. Removal or addition of water to or from the river system[1]	/ 9
12. Control of flood peak and timing by upstream dam(s)[1]	/ 9
13. Percent of riverbank structurally altered by human activity[2]	/ 6
14. Percent of human alteration to the remainder of the polygon[2]	/ 3
15. Natural floodplain accessibility	/ 6
Total score	**/ 81**

Notes:
1. RHA parameters 11 and 12 cannot be influenced at a site-level scale through interventions such as a riverbank bioengineering site like the BDEP. Low or zeros scores are given on these parameters to RHA/RHI sites in Calgary due to irrigation withdrawals for parameter 11 (Western Irrigation District canal at Harvie Passage) and upstream dams on the Bow River for parameter 12.
2. Regardless of the improvement to other parameters that are a result of bioengineering projects with a structural component (e.g., vegetated crib walls), bioengineering riverbank projects are considered a bank structural alteration in the short term and they receive low scores for parameters 13 and 14.

Table 4-2: Riparian Health Scores and Ratings

Health Score (%)	Health Rating	Description
80-100	***Healthy***	Little to no impairment of riparian function.
60-79	***Healthy with Problems***	Some impairment of riparian function due to natural or human causes.
0-59	***Unhealthy***	Substantial impairment to riparian function due to natural or human causes.

Cows and Fish will be conducting a re-visit Riparian Health Inventory (RHI) in 2021 for RHI polygon BOW95 as described in the BEMP (Hemmera, 2018). Scores generated by RHI and RHA protocols are equivalent (i.e., the same parameters are scored), but additional data is collected to characterize the monitoring site when using the RHI protocol. The extent of BOW95 is slightly different than the assessed area described in this section. BOW95 includes Site 1 downstream of Cushing Bridge, Site 2 and Site 4 all in one assessment area.

4.2 Results

Results from the baseline, 2019, and 2020 RHAs for Site 1, Site 2, and Site 4 are summarized in Table 4-3. RHA field data sheets are provided in Appendix C All three sites are showing stable health trends between 2019 and 2020, with similar scores for the 2019 and 2020 RHAs. Significant improvements in riparian health have occurred from baseline assessments in 2016, where Site 1 has improved from 43% to 49%, Site 2 from 29% to 56%, and Site 4 from 29% to 58% as shown in Table 4-3 and as discussed below. The key factors that have led to improved RHA scores are increased tree regeneration of balsam poplar (*Populus balsamifera*) and aspen (*P. tremuloides*) (RHA parameters 1 and 2), increased regeneration of preferred shrub species (RHA parameter 3), and increased total canopy cover of woody species (RHA parameter 6). However, all three sites are rated as *Unhealthy*, which is the same result as 2016 and 2019 and which is explained in more detail below.

Table 4-3: 2020 BDEP Riparian Health Results Compared to Baseline and 2019

Rating	Site 1			Site 2			Site 4		
	2016[1]	2019	2020	2016[1]	2019	2020	2016[1]	2019	2020
Vegetation rating (%)	54	64	61	33	78	75	28	75	81
Soil / hydrology rating (%)	33	40	40	25	44	40	29	40	40
Overall rating (%)*	43	51	49	29	58	56	29	56	58
Trend[2]	Stable			Stable			Stable		
Health category[3]	*U*	*U*	*U*	*U*	*U*	*U*	*U*	*U*	*U*
	Note: 1. 2016 data are baseline RHAs ratings (Hemmera, 2017c) 2. Trend: Improving = >5% score increase, Degrading = >5% score decrease, and Stable = <5% score increase or decrease. 3. U = Unhealthy; UWP = Unhealth with Problems; and, H = Healthy								

Site 1 Riparian Health

Site 1 is shown in Figure 1-1 and Photo 4-1 and 4-2. Site 1 received a riparian health score of 49% in 2020, which is similar to the 2019 health score (i.e., 51%). Both the 2019 and 2020 health scores are higher than

the score of 43% received in 2016. The bioengineering work completed in Site 1 during the fall of 2018 / spring of 2019 as part of the BDEP has contributed to the improved health score over the 2016 baseline condition. The slight decrease in score from 2019 to 2020 is related to Parameter 3 (Table 4-1): many of the willow cuttings installed as part of the bioengineering work and considered regenerating preferred shrubs (i.e., less than 6 ft. tall) in 2019 are now becoming mature shrubs (i.e., greater than 6 ft. tall). Therefore, the ratio of immature to mature shrubs is decreasing, resulting in a lower score for this parameter. It should also be noted that overall woody canopy cover (Parameter 6) appeared to show a slight increase in 2020 compared to 2019.

Site 1 scored higher for vegetation parameters than soil / hydrology parameters (61% vs. 40%). Overall, Site 1 had high cover of woody plant species, no browsing of preferred shrubs, and no recent or major removal of woody vegetation. Tree regeneration was generally good as a result of balsam poplar and aspen cuttings and plantings. Although there is some natural regeneration of balsam poplar and sandbar willow (*Salix interior*) near the north end of the site, these regenerating woody species have relatively low cover compared to the previously mentioned planted willows that are now becoming mature shrubs.

Site 1 also had high cover of invasive (approximately 5%-15%) and disturbance-increaser (approximately 25%-50%) species. Eight invasive species were observed at Site 1 in 2020, as shown in Table 4-4. Of these eight species, common tansy (*Tanacetum vulgare*) was especially common and abundant, primarily north of Cushing Bridge. Disturbance-increaser species are common in Site 1, with approximately 25 different species observed. Of these, smooth brome (*Bromus inermis* spp. *inermis*) and quack grass (*Elymus repens*) were common under mature balsam poplar forest north of the bridge, while alfalfa (*Medicago sativa*) and sweet clovers (*Melilotus* spp.) were abundant where cuttings were installed.

With respect to soil / hydrology parameters, Site 1 generally had good floodplain accessibility, low cover of human-caused bare soil, and low amounts of water withdrawals from the river system. The reach bank still has relatively low root mass protection from trees and shrubs, although this has improved with the bioengineering work and it should continue to improve as the planted trees and shrubs mature. Human physical alteration has affected the entire bank and floodplain. Alterations include two bridges, the regional pathways, two stormwater outfalls, and the bank reconstruction work completed for the BDEP. Two of the hydrology indicators (i.e., water removal or addition from the river system and water levels controlled by upstream dams) are broad watershed indicators and cannot be improved by projects such as the BDEP. Bearspaw Dam, located upstream near the western City limits, controls flood peaks and timing of the Bow River, and impacts riparian health downstream, including at the BDEP.

Photo 4-1: View south of Site #1 from just south of Cushing Bridge (September 17, 2019) (E709336, N5658185)

Photo 4-2: View south of Site #1 from just south of Cushing Bridge (September 9, 2020) (E709336, N5658185)

Photo 4-3: View south-southeast from the north end of Site #2 (September 17, 2019) (E709346, N5657964)

Photo 4-4: View south-southeast from the north end of Site #2 (September 9, 2020) (E709346, N5657964)

Photo 4-5: View southeast from the north end of Site #4 (September 16, 2019) (E709402, N5657842)

Photo 4-6: View southeast from the north end of Site #4 (September 8, 2020) (E709402, N5657842)

Site 2 Riparian Health

Site 2 is shown in Figure 1-1 and Photo 4-3 and 4-4. Site 2 received a riparian health score of 56% in 2020, which is a significant improvement on the score of 29% received in 2016. The bioengineering work completed for the BDEP project is directly responsible for the health improvements observed in Site 2 since 2016. The 2020 riparian health score is similar to the score received in 2019 (i.e., 58%), meaning that the health of site appears to be stable or static. The reason for the slight decrease in score from 2019 to 2020 was due to increased cover of human-caused bare soil (Parameter 10). With the area now open to the public, it has become a popular spot to walk through. This increased human activity has led to the creation of a trail with high cover of exposed soil along the top of the bank. It should also be noted that this score decrease was partially offset by an apparent change in the cover of disturbance-increaser species, which were assessed to be lower in cover in 2020 compared to 2019.

Similar to Site 1, vegetation parameters were rated higher than soil / hydrology parameters for Site 2 (75% vs. 40%). Site 2 had excellent regeneration of trees and shrubs due to the bioengineering work

completed. There was also no browsing of preferred trees and shrubs, only minor amounts of dead or decadent woody material, and no woody vegetation removal.

The main reason for the below optimal vegetation rating for Site 2 was high cover of invasive species (approximately 5%-15%). As presented in Table 4-4, 10 invasive species were observed in Site 2. Also contributing to the reduced score at Site 2 were below optimal cover of woody species and increased cover of disturbance-increaser species. It should be noted that woody species were not planted in the north part of the site because the eroded bank there provides important swallow habitat. Twenty-two different disturbance-increaser species were recorded at Site 2 in 2020. Of these, alfalfa, black medick (*Medicago lupulina*), and smooth brome were the most common.

For soil / hydrology indicators, Site 2 generally had good floodplain accessibility, low cover of human-caused bare soil, and low amounts of water withdrawals from the river system. Riverbank root mass protection is still relatively low due to the aforementioned unplanted swallow habitat. Large portions of the bank and floodplain have been physically altered by human activities. Riprap has been installed along the bottom portion of the entire bank. As discussed for Site 1, Bearspaw Dam controls flood peaks and timing along this section of the Bow River, negatively impacting riparian health.

Site 4 Riparian Health

Site 4 is shown in Figure 1-1 and Photo 4-5 and 4-6. Site 4 received a riparian health score of 58% in 2020, which is significantly higher than the score of 29% from the baseline assessment in 2016. This improvement is attributable to the bioengineering work conducted for the BDEP. The 2020 riparian health score is similar to the score received in 2019 (i.e., 56%). The slight improvement in score is the result of an increase in cover of regenerating (immature) preferred shrubs (Parameter 3). In other words, cover from planted shrubs and cuttings appears to be increasing. All other riparian health parameters scored the same in 2019 and 2020.

Site 4 was similar to the other two sites in having a higher rating for vegetation-related parameters compared to soil / hydrology parameters (81% vs. 40%). The main reason for the slightly reduced vegetation score was due to invasive plant species. Six different invasive species were documented at Site 4, of which creeping (Canada) thistle was the most common (Table 4-4). Other minor health deductions were made for increased cover of disturbance-increaser species (approximately 5%-15%) and light browsing of preferred shrub species. Overall, Site 4 had high woody species cover, good tree and shrub regeneration, only minor amounts of dead and decadent woody species, and no removal of woody vegetation other than browsing.

Soil / hydrology parameters were rated similar for Site 4 as Sites 1 and 2. Riverbank root mass protection is improving as a result of the bioengineering work, but it is still below optimal levels. The entire Site 4 bank and floodplain has been physically altered by human activities. Approximately 20% of the bank is covered in unvegetated riprap. Bare soil cover is slightly above normal levels due to topsoil placement on site and a failure of the seed mix to establish in places, particularly the downstream one-third of the site. No embankments or other obstructions restrict natural floodplain accessibility. As discussed for Sites 1 and 2, Bearspaw Dam affects water levels in the Bow River, and some water is diverted into an irrigation canal approximately 850 m upstream from the BDEP, thereby impacting riparian health at Site 4.

BDEP RHA Scores

All three BDEP sites received a RHA score of *Unhealthy*; however, they are all showing significant improvement in vegetative riparian health parameters over the baseline condition as described above. Sites 2 and 4 are also very close to achieving the *Healthy with Problems* category. While the RHA/RHI is a powerful tool to describe riparian health, there are limitations in its use for urban riparian areas. The

RHA/RHI was designed as a tool to monitor riparian health against a natural, undisturbed potential 'reference' state. In doing so, it is very challenging to achieve either the *Healthy with Problems* or *Healthy* categories for sites in urban areas downstream from irrigation withdrawals and dams, and for sites that are located in highly used public spaces. These watershed-scale conditions that cannot be changed by site-level projects such as the BDEP but they all affect the RHA scores in a negative manner. While the BDEP has resulted in significant increases in the vegetation parameters of the RHA, the lower soil/hydrology parameter scores for each of the BDEP sites are a result of the sites being downstream of irrigation withdrawals and dams, and located in highly used public spaces, which ultimately results in the sites receiving an *Unhealthy* rating. The scores for the RHA soil/hydrology parameters will continue to be low in future assessments for the reasons listed below, and may never show improvement, or at least not within the 10-year monitoring program for the BDEP. This might possibly result in the BDEP sites remaining in the *Unhealthy* category despite the significant improvements that the BDEP has provided to local, vegetative riparian health conditions.

- It is not possible to achieve high scores (or scores above zero) for RHA soil / hydrology parameters 11 and 12 (Table 4-1) due to watershed-scale conditions such as upstream dams or irrigation withdrawals that cannot be influenced at a site-specific scale. These parameters are heavily weighted and strongly influence the overall riparian health score since upstream damming and artificial water withdrawals or diversions can significantly affect natural flood regimes, negatively affecting recruitment of keystone riparian species like balsam poplar (*Populus balsamifera*).
- Bioengineering projects with a structural component (e.g., vegetated crib walls, vegetated riprap) are considered human activities that alter the riverbank and they receive low marks for RHA parameter 13 (Table 4-1). The only exception to this (at least in the short term) are purely planting projects. If successful, in the long term, vegetated crib walls (and similar 'soft' bioengineering techniques) are expected to naturalize as the wood structures decompose and plantings take root. By comparison, riprap projects can have permanent structural alteration impacts.
- Highly used public spaces with urban infrastructure such as pathways, trails, roads, and bridges are considered human-caused structural alterations that alter the overall physical site integrity and they receive low marks for RHA parameter 14 (Table 4-1).

The RHAs limitations for assessing site-level riparian health improvements from bioengineering projects in an urban context was identified during the development of the overall RMP. A new indicator referred to as the Bank and Riparian Quality Index (BRQI) was developed for the RMP and is used for the RMP Bank Effectiveness component to monitor progress of a site towards a desired native plant community type. The BEMP approach approved by AEP and The City did not include the BRQI. The BRQI incorporates only pertinent, primarily vegetation riparian health indicators, and excludes others that cannot be directly influenced at a site-specific scale. The BRQI may be more suited to demonstrate the site-level riparian health improvements for projects like the BDEP and is included in the Recommendations section of this report.

Comparison to a Theoretical Conventional Riprap Design Site

As discussed in Section 1.3, the RHA ratings for Site 1, Site 2, and Site 4 were compared to the RHA ratings for a theoretical conventional riprap design site. The theoretical site was assigned a total RHA score of 38% with a vegetation component score of 33% and soil/hydrology component score of 40%. This leads to the corresponding *Unhealthy* condition based on the assumptions described in Table 4-2. While all BDEP sites and the theoretical conventional riprap design site were found to be *Unhealthy*, significant differences were identified that show marked improvements in riparian health at the BDEP sites over a theoretical conventional riprap design site as described below.

- Vegetation ratings are substantially higher for Sites 1, 2 and 4, ranging from 85% to 145% higher than the vegetation rating for a theoretical conventional riprap design site.
- Overall ratings for Sites 1, 2 and 4 range from 29% to 53% higher than the overall rating for a theoretical conventional riprap design site.

Note that soil / hydrology parameter ratings are essentially the same among the BDEP sites and the theoretical conventional riprap design site (i.e., 40%). This is due to several of the parameters in this category being broad watershed indicators that cannot be influenced by projects such as the BDEP (RHA parameters 11 and 12) and because most of the riparian areas in Calgary have been physically altered by human activities (RHA parameters 13 and 14) as discussed above. Thus, all projects on the Bow River in Calgary will have similar ratings for the soil / hydrology component of the RHA. Given the limitations of the soil / hydrology RHA ratings for sites on the Bow River in Calgary, other methods to assess improvements in riparian health such as the Bank and Riparian Quality Index (BRQI) that was developed as part of the RMP (KWL, 2018) will be investigated for this purpose in 2021, as mentioned above.

Table 4-4: Invasive Species Observed during the 2020 RHA Assessments

Invasive Species		Site Observed		
Common Name	**Scientific Name**	**Site 1**	**Site 2**	**Site 4**
black henbane	*Hyoscyamus niger*		X	X
common burdock	*Arctium minus*	X		
common mullein	*Verbascum thapsus*	X		
common tansy	*Tanacetum vulgare*	X	X	X
creeping bellflower	*Campanula rapunculoides*		X	
creeping (Canada) thistle	*Cirsium arvense*	X	X	X
scentless chamomile	*Tripleurospermum inodorum*	X	X	X
smooth perennial sow-thistle	*Sonchus arvensis ssp. uliginosus*	X	X	X
tufted vetch	*Vicia cracca*	X	X	
white cockle	*Silene latifolia*		X	
yellow clematis	*Clematis tangutica*	X	X	
yellow toadflax	*Linaria vulgaris*		X	X
Total number of species		8	10	6

4.3 Summary of Findings

Site 1, Site 2, and Site 4 have all improved in riparian health since the bioengineering work was completed. All three sites appear to be showing stable health trends, with only minor increases or decreases since 2019. Regardless, there has been a marked improvement at all three sites since the baseline assessment in 2016. This improvement is directly attributable to the bioengineering work completed for the BDEP. Due to factors beyond the control of this project, Sites 1, 2, and 4 may never be able to achieve a "*Healthy*" rating (i.e., greater than 80%). Despite that, there is room for improvement in terms of weed control and bank root mass protection that could push all three sites into the "*Healthy with Problems*" category with a little time and maintenance. All three BDEP sites currently still score higher than a theoretical conventional riprap site in terms of riparian health.

Photo 4-2: Willow stake establishment on BDEP site

5. Bioengineering Structural Integrity

Bioengineering structural integrity monitoring focuses on the long-term structural integrity, stability, and operational effectiveness of the bioengineering structures (i.e., long term performance of physical structures). The results of this monitoring component are intended to show how the BDEP has improved bank structural integrity and specifically how it has been improved over a conventional riprap design site.

5.1 Methods

As indicated in the BEMP (Hemmera, 2018), the methods used to monitor the BDEP bioengineering structures are the protocols developed as part of the RMP riverbank bioengineering effectiveness monitoring component (KWL, 2018). These protocols are separate and distinct from the monitoring of physical works that is required as part of the BDEP construction contract (i.e., warranty inspections) and are also not structural engineering assessments of the infrastructure. These protocols are also used to assess the effectiveness of all the riverbank bioengineering effectiveness sites monitored as part of the RMP, of which the BDEP sites are included.

Under RMP protocols, data for riverbank bioengineering effectiveness monitoring sites are collected through either desktop or field-based activities. Desktop activities include compiling general project information and planting design details. Field activities include a structural assessment, vegetation assessment, and failure assessment as described below. Detailed forms are completed for all monitoring activities.

Structural assessment: The RMP structural assessment includes a basic condition assessment of the materials used in the structure (e.g., rock, timber, erosion control matting, fencing), hydrologic observations (e.g., flow at time of survey, high water mark), site measurements (e.g., flow angle relative to the site, aspect, lengths, widths, slopes), a survey of vegetation elevations (native and planted), general observations of bed / bank erosion, sediment deposition, bank stability and geomorphological changes within the project area, an assessment of site conditions that might limit success, recommendations for repairs if needed, suggestions for alternative design options, observed success attributes, and photographic monitoring. A full RMP structural assessment is completed on the BDEP sites for each monitoring year. The results of the hydrologic observations, photographic monitoring, general observations of erosion and bank stability, and materials assessment are reported as part of the BDEP monitoring to meet the requirements of the BEMP. The full results of the structural assessment are also reported as part of the RMP reporting requirements.

Vegetation assessment: The RMP vegetation assessment includes three main components:

- 20 m long pinpoint transects at a representative section of each technique within the structure;
- quadrats along each transect at 5 m, 10 m, and 15 m for a total of 3 quadrats per transect; and
- assessments of plant health and survival for typically 50 cuttings and 20 plantings at each site.

These assessments allow a detailed statistical analysis of vegetation survivorship, leader growth, shoot length, vegetation cover, vegetation vigour, and species diversity. To comply with the requirements of the BEMP, only vegetation survivorship results are reported as part of the BDEP monitoring. The other data is reported through the RMP.

BOX 1: 2020 vs. 2019 Vegetation Parameter Assessment Methods

In 2020, vegetation survival at BDEP was measured by visual estimate at each bioengineering technique used, and cover and vigor assessments were measured by quadrat sampling at each bioengineering technique used. This was different than the methods used in 2019 where individual live cutting and planting counts were conducted at each transect location for each bioengineering technique, and cover and vigor were measured during the pinpoint transect surveys.

The change in method to assess survival was made because it is no longer possible to count individual stems after Year 1 due to site growth and state of decay of the dead cuttings. This is a normal process as the site ages where it becomes more challenging to identify surviving planted vegetation (live cuttings and container plants) versus either natural regrowth or dead planted vegetation. In the future it will become more useful to report on vegetation cover and vigor since survival percentages can become exaggerated when the only vegetation that is possible to identify and count is the living vegetation component as dead cuttings have decayed. An extreme example would be that a survival count of 100% might mistakenly be attributed to a 5-year-old site because only living vegetation could be found and counted where initially there was a 50% dieback of planted vegetation in year 1 but the dead live cuttings had all disappeared. Additionally, survival rates for live cuttings are expected to decrease over time due to natural competition for nutrients, space and sunlight where canopy cover is expected to increase as vegetation establishes and matures as illustrated in Figure 5-1 below.

Both transect and quadrat methods will be used in 2021 for comparison with 2019 and 2020 data for better data comparison between years.

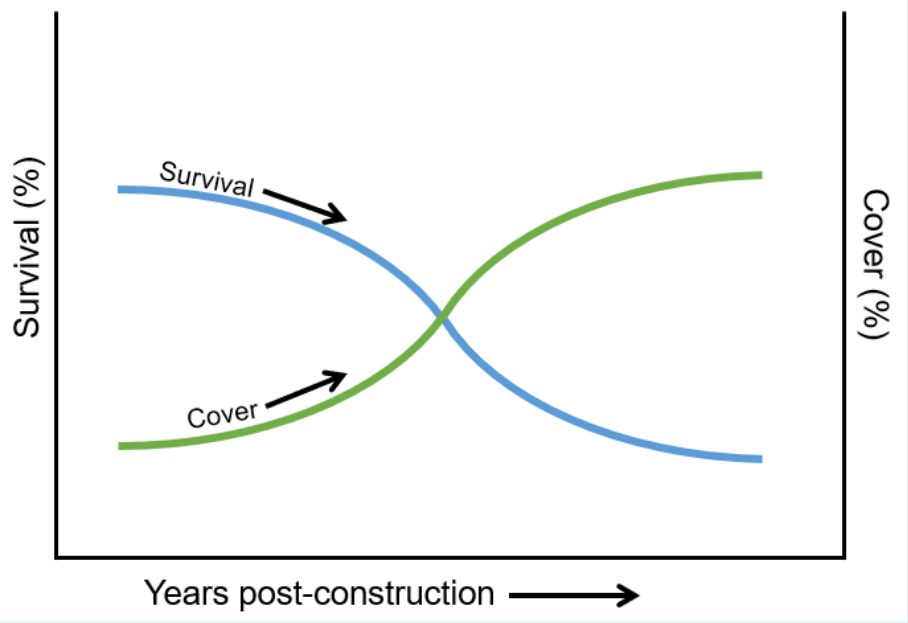


Figure 5-1: Idealized Illustration of the Relationship Between Live Cutting Survival and Cover Over Time

Failure assessment: An RMP failure assessment is completed on Year 1 post-construction sites that do not meet the woody vegetation survival threshold of 25% and / or if the structure is found to be missing, degraded or ineffective. An RMP failure assessment is completed on Year 3 or Year 5+ post-construction sites if the structure is found to be missing, degraded or ineffective. The results of failure assessments will be reported through both the RMP and BDEP monitoring if needed. This protocol was not used during the 2019 or 2020 assessments as the sites at the BDEP were all found to be successful.

A detailed description of the protocols developed for the RMP are described in the *Riparian Monitoring Program - Monitoring Plan* (KWL, 2018).

Photographic Monitoring

Baseline photographs of Sites 1, 2, and 4 were taken in 2016 and 2017. Photographic monitoring stations were then established in 2019 at Sites 1, 2, and 4. Photographs were taken again in 2020 from the established locations for comparison purposes and are provided in Appendix E.

Monitoring Sites and Dates

There are several different bioengineering techniques included in each BDEP site. For RMP monitoring purposes, Sites 1, 2 and 4 were divided into the ten sites shown in Figure 1-1, and described in Table 5-1 below. The RMP monitoring sites were defined according to the techniques that were used.

The RMP site code and design approach that correlates with each BDEP site number are also shown in Table 5-1. However, monitoring results in this report are provided only for Site 1, Site 2, and Site 4 in accordance with the BEMP. More detailed results are provided in the annual monitoring reports for the RMP.

Baseline assessments of the BDEP site occurred in 2016 and 2017 (Hemmera, 2016; Hemmera, 2017a; KWL, 2017). The 2020 structural assessments for the BDEP sites were competed on September 25, 2020 by M. Gallant and P. Raymond. A follow-up assessment the timber crib wall at Site 1 was completed by M. Gallant on October 27, 2020 to capture additional timber crib wall data. The 2020 vegetation assessment was completed on September 23, 24, and 28, 2021 by P. Raymond and A. Dodd. Summaries from these inspections can be found in Appendix D.

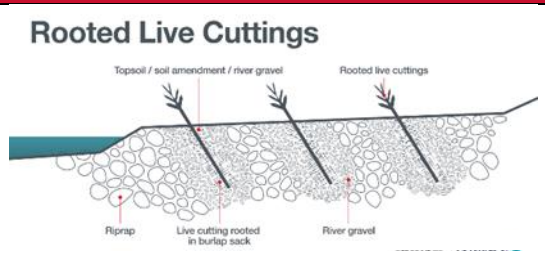
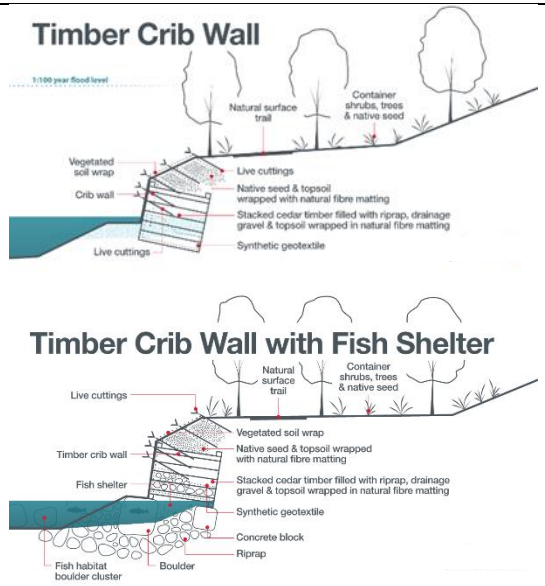
Warranty inspections as part of the construction contract were completed by J. Slaney from The City of Calgary on July 2, August 4, and September 8, 2020.

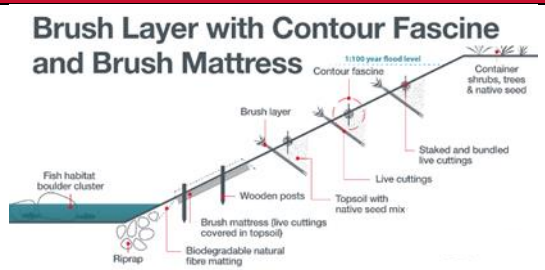
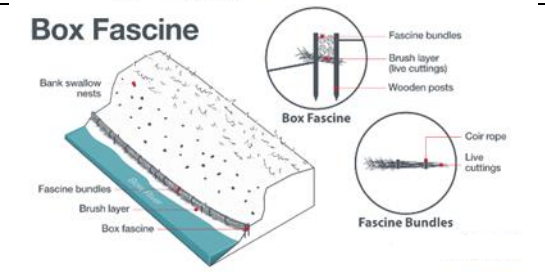
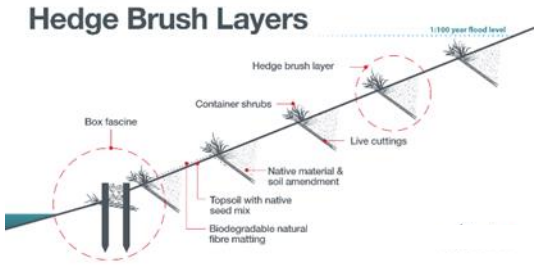
Hydrology and Shear Stress

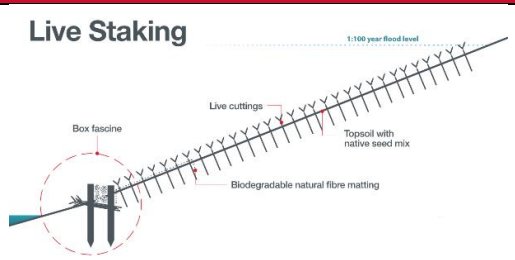
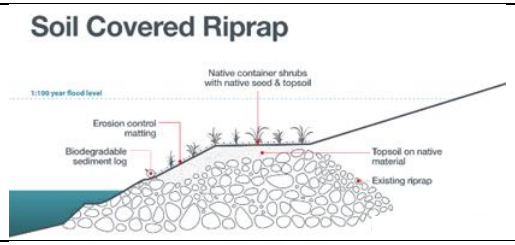
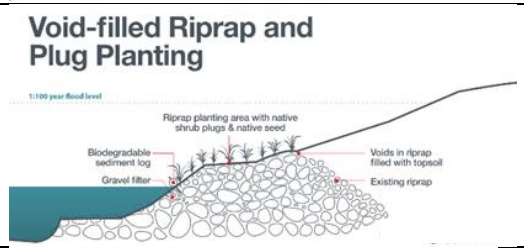
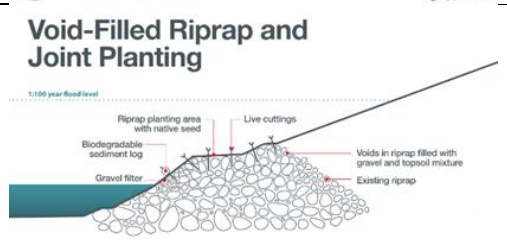
Baseline Bow River flow, velocity, and shear stress for each BDEP site were assumed to be the 100-year event to be consistent with the BDEP design basis. Bow River flow for the 100-year event was taken from the *Bow River and Elbow River Basin-Wide Hydrology Assessment and 2013 Flood Documentation* (Golder, 2014). Velocity and shear stress at each BDEP site was generated using the 100-year flow event in the *2015 Bow River and Elbow River Hydraulic Model* (Golder, 2015).

Maximum Bow River flow since construction for each BDEP site was obtained from the rivers.alberta.ca website. Flow data was obtained for the Water Survey Canada stations Bow River at Calgary (05BH004), Elbow River Below Glenmore Dam (05BJ001), and Western Irrigation District Canal near Headgates (05BM015). The maximum velocity and shear stress associated with the annual maximum flow event was generated at each BDEP site using the *2015 Bow River and Elbow River Hydraulic Model* (Golder, 2015).

Table 5-1: BDEP Site Numbers, Design Approaches, Fieldwork Dates and Vegetation Survival

BDEP Site No.	BDEP Sub-Site No. / RMP Site Code	BDEP Design Approaches	Vegetation Survival Results (%)[1] (refer to Section 5.2)		Estimated Permissible Shear Stress (N/m²)[2]
			2019	2020	
Site 1	Site 1-1 / BE-BOW-46A		Rooted Live Cuttings: 65%	Rooted Live Cuttings: 70%	Willow staking in placed riprap: 300[5]
	Site 1-2 / Not monitored	No bioengineering design applied; however, includes wildlife passage corridor	NA	NA	Class 2 riprap: 364[4]
	Site 1-3 / BE-BOW-46B		Live Cuttings: 50% Potted Plants: 100%	Live Cuttings: 48% Potted Plants: 97%	Timber crib wall with brush layers: 600[3]

BDEP Site No.	BDEP Sub-Site No. / RMP Site Code	BDEP Design Approaches	Vegetation Survival Results (%)[1] (refer to Section 5.2)		Estimated Permissible Shear Stress (N/m²)[2]
			2019	2020	
	Site 1-4 / BE-BOW-46C		Live Cuttings: 92% Potted Plants: 100%	Live Cuttings: 57% Potted Plants: 100%	Brush layer with contour fascine: 141[3] Brush mattress with rock toe: 244[3]
Site 2	Site 2-1 / BE-BOW-46D1		Live Cuttings: 96% Potted Plants: 100%	Live Cuttings: 15% Potted Plants: 100%	Box fascine: 141[3]
	Site 2-2 A / BE-BOW-46D2		Live Cuttings: 96% Potted Plants: 100%	Live Cuttings: 43% Potted Plants: 100%	Box fascine: 141[3] Brush mattress: 244[3] Contour fascine: 50[2]
	Site 2-2 B / BE-BOW-46D3		Live Cuttings: 68% Potted Plants: 100%	Live Cuttings: 57% Potted Plants: 100%	Box fascine: 141[3] Hedge brush layers: 141[3]

BDEP Site No.	BDEP Sub-Site No. / RMP Site Code	BDEP Design Approaches	Vegetation Survival Results (%)[1] (refer to Section 5.2)		Estimated Permissible Shear Stress (N/m²)[2]
			2019	2020	
	Site 2-2 C / BE-BOW-46D4		Live Cuttings: 82% Potted Plants: 100%	Live Cuttings: 62% Potted Plants: 100%	Box fascine: 141[3] Live staking: 150[3]
Site 4	Site 4-1 / BE-BOW-46E1		Potted Plants: 97%	Potted Plants: 100%	Class 2 riprap: 364[4] Plantings: 100[3]
	Site 4-2 / BE-BOW-46E2		Plugs: 96%	Plugs: 100%	Class 2 riprap: 364[4] Plantings: 100[3]
	Site 4-3 / BE-BOW-46E3		Live Cuttings: 60%	Live Cuttings: 54%	Willow staking in placed riprap: 300[5]
	Site 4-4 / Not monitored	No design applied as part of the BDEP – left as a control site	NA	NA	Class 2 riprap: 364[4]

Notes:
1. Survival is reduced slightly in 2020 in comparison to 2019 due to either the different methods that were used to measure survival between the 2 years and/or due to an expected reduction in survival as the site ages and natural competition occurs between the planted woody vegetation. Refer to Box 1 below.
2. Estimated shear stress resistance at the time of monitoring, i.e., 2-year post construction.
3. Source: Evette, A. et al (2018) *The limits of mechanical resistance in bioengineering for riverbank protection*
4. Source: Fischenich, C. (2001) *Stability Thresholds for Stream Restoration Materials - EMRRP Technical Notes Collection (ERDC TN EMRRP-SR-29)*
5. Source: Lachat, B. (1999). *Guide de protection des berges de cours d'eau en techniques vegetales*.

5.2 Results

Bow River Hydrology

Baseline Bow River flow, velocity and shear stress are shown in Table 5-2 and were taken to be the 100-year flood event per Section 5.1.

The maximum Bow River flow, velocity and shear stress for 2019 and 2020 are shown in Table 5-2. These represent the most extreme conditions that the monitored sites at the BDEP have experienced from construction to present. The maximum flow in 2020 was 388 m³/s on June 27, 2020. Maximum flows from construction to present have been less than the 2-year return period flow of 439 m³/s (Golder, 2014) and values of velocity and shear stress at the BDEP sites are all well below the baseline condition. Site 4 has experienced the highest maximum velocity and shear stress. Site 1 has experienced the lowest maximum velocity and shear stress.

Table 5-2: Baseline, 2019 and 2020 maximum values for Bow River Flow, Velocity and Shear Stress at the BDEP

Parameter	Baseline (100-Year Flood Event)			2019			2020		
	Site 1	Site 2	Site 4	Site 1	Site 2	Site 4	Site 1	Site 2	Site 4
Max. Flow (m/s³)[1]	2910			391			388		
Max. Velocity (m/s)[1]	3.5< to 3.9^	3.0	3.1	1.0*	1.1	1.7	0.9^ to 1.2<	1.0	1.5
Max. Shear Stress (N/m²)[1]	105> to 126^	79	95	10> to 13<	15	39	10> to 13<	15	35

Notes:
1. Maximum velocity and shear stress (channel) are calculated from the maximum flow shown in Table 5-2 using the *2015 Bow River and Elbow River Hydraulic Model* provided by The City.
2. The symbols shown represent the data from the following locations: < value upstream of Cushing Bridge; ^ value at Cushing Bridge; > value downstream of Cushing Bridge; and, * all values are equal.

2020 Precipitation and Wind

Total precipitation amounts in Calgary at the Calgary International Airport for the past three years are summarized in Table 5-3. With average total precipitation of 479 mm, 2020 was a wetter than average year. Average wind speed and direction were approximately 13 km/hr from the southwest for both 2018 to 2020.

Average precipitation and temperatures for 2018, 2019 and 2020 are shown in Figure 5-2. Precipitation was well above average in June and July 2020; however, it was very hot and dry in August and September.

Table 5-3: Climate data for Calgary Airport - 2018 - 2020

Parameter	2018	2019	2020
Rainfall (mm)[1]	425	416	479
Rainfall Relative to Average	Slightly above average	Above average	Above average
Wind speed (km/hr)	13	12.4	13.4
Wind Direction	SW	SW	SW

Notes:
1. Average precipitation at Calgary airport is 410 mm/year.

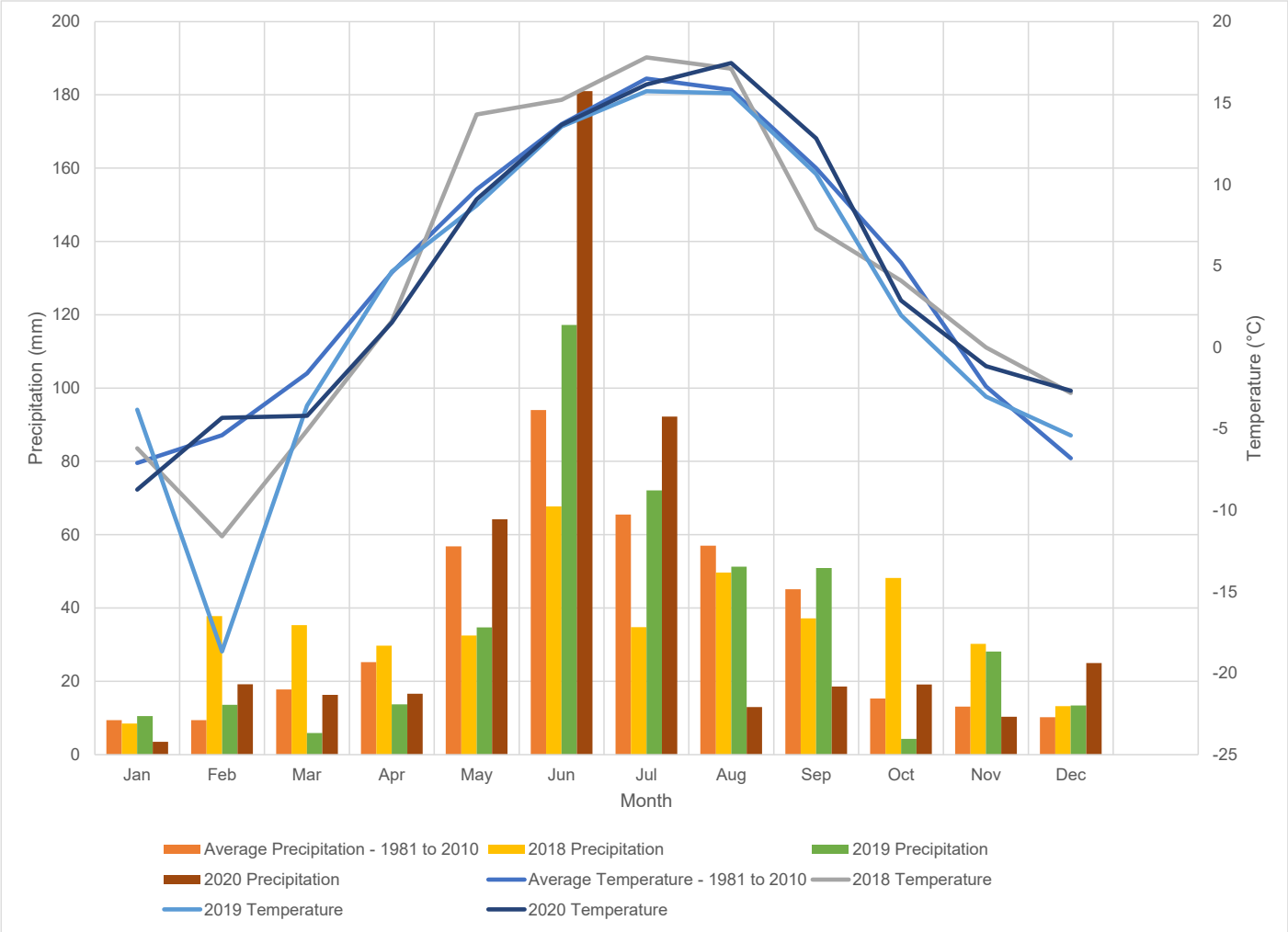


Figure 5-2: Calgary Precipitation and Temperature Data at Calgary International Airport - 2018, 2019 and 2020

Structural Assessment

The structural assessment consisted of a general observations of bank stability and erosion, and a materials assessment. Completed structural assessment field forms for each of the BDEP sites shown in Table 5-1 are provided in Appendix D.

Photographic Monitoring and General Observations

Visual assessments of the baseline conditions at Sites 1, 2 and 4 were conducted in 2016 and 2017 to document the physical condition and stability of the area. A visual assessment of the changes from the baseline and that physical condition of the bioengineering techniques at Sites 1, 2 and 4 was conducted during all four seasonal monitoring periods in 2020. Photographic data collected from the 2016/2017, 2019, and 2020 visual assessments at each of the established photo stations are presented in Appendix B – Attachment A, photos 1 - 32.

Results of the 2020 visual assessment and photographic data indicate that the physical condition of the treatments, including fish habitat structures (e.g., boulder clusters, fish shelters and box fascines), continue to be stable, with no signs of erosion, scour, or displacement.

Additional observations are listed below.

- Minor, local erosion that was observed in 2019 was no longer observed in 2020.

- Warranty replanting occurred at Site 1-1 (long rooted cuttings quantity unknown) and Site 1-3 (1000 live cuttings in the timber crib wall).
- No additional washout of placed material along the surface of bank toe at Site 4 in 2020 from what was observed in 2019.
- It appears that the settlement of the river gravels in the riprap at Site 1 was repaired.
- At Site 1, it was noted again that the non-woven geotextile used for backfill containment in the timber crib wall has a few gaps (see Photo 5-1). This was brought to the attention of the contractor in 2019 and it was relayed to the RMP team by The City in 2020 that the issue was being monitored.

Bank Stability

Baseline (2017), 2019, and 2020 observations of bank stability are provided below.

- **Site 1**: Observations for bank stability are as follows:
    - Upstream of Cushing Bridge: Baseline (2017) observations were that bank stability was relatively stable along the bank (Hemmera, 2017a). The same observations as baseline conditions for bank stability were observed in 2019 and 2020 where the bank was found to be stable.
    - At Cushing Bridge: Baseline (2017) observations were that bank stability was low along the bank immediately downstream of the Cushing Bridge (Hemmera, 2017a). Bank stability was considered stable along the bank immediately downstream of the Cushing Bridge in both 2019 and 2020.
    - Downstream of Cushing Bridge: Baseline (2017) observations were that bank stability was observed to be low along the bank immediately downstream of the Cushing Bridge and into the upstream extent of Site 2, with evidence of extensive erosion. There was existing debris in the form of broken concrete on the bank that was installed as an attempt to stabilize the bank in the past (Hemmera, 2017a). In contrast to the bank stability conditions observed in 2017, high bank stability and deciduous trees, shrubs and grasses along the bank were noted downstream of the Cushing Bridge in both 2019 and 2020.
- **Site 2:** Baseline (2017) observations were that bank stability was low through the site, with extensive erosion along the bank. High stability was only present within the immediate vicinity of the riprap groynes present at the upstream and downstream extents of the site (Hemmera, 2017a). In 2019 and 2020, bank stability was observed to be high along the bank in the site as a result of the BDEP.
- **Site 4**: Bank stability within Site 4 remains consistent with observations made during the baseline conditions assessment (Hemmera, 2017a). Bank stability is very high, with the entire bank composed of Class II riprap (d50 = 500 mm) and Class III riprap (d50 = 800 mm).

Materials Assessment

Materials used in the construction of the BDEP include rock riprap, wood, erosion control matting and geogrids, concrete, and steel. These materials were assessed for post-construction condition with observations as described below.

- **Rock Riprap:** Rock riprap used at the BDEP site remains in excellent condition and there are no concerns for long-term durability. No significant rock movement or displacement was observed.
- **Fill Materials:** Fill materials were observed to be in good condition and contained within the structures. Pea gravel washout from the box fascine at Site 2 and void-fill material washout from the

surface of the toe at Site 4 was noted during the 2019 assessment (occurred mostly in 2018) and was noted to be unchanged in 2020.

- **Wood Materials:** The wood materials used at the site consist of timber for the timber crib wall, posts for the box fascine, and posts for the brush mattress. In general, the condition of the posts used is very good with no concerns for long-term durability. Concern with the timber quality used in the crib wall at Site 1 was noted during the 2019 assessment. The timber crib wall was observed to be stable with no observable change in condition during the 2020 assessment (Photo 5-2).
- **Matting, Geogrids and Geotextiles:** Erosion control matting, coir geogrids, and non-woven geotextiles were installed at the BDEP to provide erosion control, material containment and material separation. The erosion control matting is installed at Site 4 to provide erosion control until vegetation established. It was observed in 2020 to be mostly biodegraded with no remaining useful life. Both woody and herbaceous vegetation have established at Site 4, so the matting performed its function within its expected product longevity. The coir geogrid was used at Site 1 in the timber crib wall for material containment, and at Site 1 and Site 2 for erosion control until vegetation establishes. It was observed to be in good condition and there are no concerns with the coir geogrid continuing to provide erosion control until vegetation fully establishes at those sites (Photo 5-3). The non-woven geotextile is used at Site 1 in the timber crib wall for material containment and separation. It is in very good condition with no concerns for long-term durability.
- **Wattles**: Curlex sediment logs were installed at Site 4 to provide erosion control and material containment along the toe of the bank. The logs were noted to be in fair condition in 2019 and they remain in roughly the same condition in 2020 (Photo 5-4). There is some concern that since they are supported by the rodent fence in many locations (e.g., Site 4-1), when the rodent fence is removed at the end of the warranty period, the logs will be no longer be stable. The logs also support some of the soil cover material, so it they are removed, it might also disturb the soil and establishing vegetation above. It might be advisable to install some wooden stakes to support the curlex log when the rodent fence is removed.
- **Hydromulch and Seeding**: Hydromulch was installed at Site 1, Site 2, and Site 4 for erosion control and seeding. The hydromulch was washed away at the upstream end of Site 1; however natural regeneration is occurring at this location as shown in Photo 5-5. Herbaceous establishment was very high at all sites with high invasive weed cover.
- **Concrete**: Concrete blocks were incorporated into the construction timber crib wall at Site 1 in the fish shelters to support the landside of the wall. It was not possible to inspect the blocks this year due to high water levels.
- **Steel**: Steel products were used at several locations at the BDEP site: at Site 1, stainless steel plates and bolts were used to secure neighbouring timber cribs together in the timber crib wall, galvanized spiral shank spikes were used to fasten the timber together in the timber crib wall, and steel jacks were used to support the timber crib wall in the fish shelters; at Site 1 and Site 2, steel wire was used to tie down the box fascine and the brush mattress; and, at Site 4, candy cane rebar were used to secure the wattles. All steel products were observed to be in good to excellent condition with no concerns for long-term durability. The steel supports that were placed under the spanning members in the fish shelters are in very good condition with one loose support at the south end of the crib wall Photo 5-6. It is recommended to tighten the loose support.

- **Temporary Fencing**: Temporary fencing was placed around the planting areas to limit access to wildlife and the public while the vegetation establishes. The fencing was found to be in very good condition except for a few areas that have been identified to the contractor for repair.
- **Fish Shelters**: The fish shelters were inspected on September 25, 2020 and October 27, 2020. Fine sediment was observed to have deposited along the bottom of 9 of the 12 shelters in a layer ranging from 0.05 m to 0.2 m depth and average of 0.1 m depth of but were otherwise clear and providing good fish habitat as shown in Photo 5-7. The large woody debris that was observed on the fish boulders in 2019 was observed again in 2020. No significant change in the condition of the timber crib wall was observed from as-constructed conditions per Photo 5-8, and there was no measured change in the deflection of the spanning members that are supported by the steel supports.

Photo 5-1: Gaps in non-woven geotextile used for material containment in the timber crib wall at Site 1 Credit: Terra Erosion Control Ltd.

Photo 5-2: Typical vegetated timber crib wall section (shown with rodent fencing attached) (Sept 25, 2020)

Photo 5-3: Coir geogrid at Site 2 (Sept 25, 2020)

Photo 5-4: Degraded curlex log at Site 4 (Sept 25, 2020)

Photo 5-5: Natural regeneration at Site 1 upstream of Cushing Bridge (September 25, 2020)

Photo 5-6: Measuring sediment depth in fish shelters and timber crib wall supports (September 25, 2020)

Photo 5-7: Fish Shelter at Site 1

Photo 5-8: Timber crib wall at Site 1

Vegetation Assessment

The results of vegetation survival for Sites 1, 2, and 4 are provided in Table 5-4. In 2020, overall survival of planted vegetation was highest at Site 4, followed by Site 1 and 2 in contrast to 2019 where overall survival of planted vegetation was highest at Site 2, followed by Site 1 and 4. Overall vegetation survival for all sites in 2020 was estimated to be 76% in comparison to 2019 survival of 80%. A reduction in survival rates for live cuttings is expected over time due to natural competition for nutrients, space and sunlight as mentioned in Box 1. Additionally, as has been observed through the RMP at almost all bioengineering sites in Calgary, potted plant survival is higher than live cutting survival at Sites 1, 2 and 4 (KWL, 2019).

Table 5-4: 2019-2020 vegetation survival by Site

Site No.	Overall Vegetation Survival (%)		Live Cutting Survival (%)		Potted Plant Survival (%)	
	2019	2020	2019	2020	2019	2020
1	77	74	65	56	100	98
2	83	68	80	36	100	100
4	77	85	60	54	96	100
Total	**80**	**76**	**74**	**50**	**99**	**99**

Planted vegetation survival for the 10 treatment areas that roughly correspond to the different bioengineering techniques used at the BDEP site are listed in Table 5-1. Key results and observations from the vegetation assessment of the different bioengineering techniques are listed below.

- Survival of rooted live cuttings at Site 1 was 70% in 2020 which is higher than 2019 and is assumed to be due to replanting efforts (Photo 5-9). The survival of rooted live cuttings demonstrates that they can successfully be used as an option to conventional live cuttings. They have now been used in at least 4 other sites in Calgary likely to facilitate summer construction.
- At Site 1, the combined survival of live cuttings in the timber crib wall and the vegetated soil wrap was 48% in 2020, which was slightly less than observed in 2019. Survival was expected to be higher in 2020 as live cuttings were replanted into the lower rows of the timber crib wall. Unfortunately, many of the replanted cuttings were dead at the time of the inspection. It is understood that the contractor elected to remove the dedicated sprinkler too early, and the replanted live cuttings desiccated in the hot and dry late summer period. It is recommended to replant the previously replanted areas in 2021. Nevertheless, the establishing vegetation is providing very good overhanging cover to enhance fish habitat as shown in Photo 5-8.
- The brush mattress, brush layer and contour fascine survival at Site 1 is lower in 2020 than 2019; however, there is overall good and vigorous growth establishment in this portion of Site 1 per Photo 5-10.
- At Site 2, the box fascine survival was found to be much lower in 2020 versus 2019. This is due to the different methods used to estimate survival between the two monitoring years. The survival for the live staking technique was found to be higher than the brush mattress, contour fascine, and the hedge brush layers techniques in 2020. Survival for all of the techniques was found to be lower in 2020 compared to 2019. Despite the lower survival values in 2020 compared to 2019, these techniques demonstrate overall good and vigorous growth establishment in 2020 per Photo 5-11 and Photo 5-12.
- At Site 2, there was observed to be an approximately 11 m long section of contour fascine that is recommended to be replaced on the upper northwest corner of the site.
- At Site 4, vegetation survival was highest for the soil covered riprap with container plants, and void-filled riprap and plug planting techniques. However, woody vegetation vigour (a measure of vegetation health (KWL, 2020b)), was observed to be low due to herbaceous vegetation competition for both of these techniques Photo 5-13. A comparison of the riprap void-fill techniques to retrofit existing riprap leads to the result that void-fill with topsoil and plug planting with an overall survival of 100% in 2020 and 96% in 2019 is more successful than void-fill with pitrun and live staking with a survival of 54% in 2020 and 60% in 2019. Woody vegetation vigour was also observed to be low due to herbaceous vegetation competition for the void-fill with pitrun and live staking technique.
- It is recommended to replant Site 4 in areas where the survival target of 75% was not achieved.
- In general, herbaceous vegetation at all BDEP sites is thick and is competing with the planted woody vegetation. It is recommended to weed the herbaceous vegetation in fall 2020 to avoid woody vegetation mortality caused by snow press over winter.
- While the FAC is expected to be issued in 2021, any replanting conducted in 2021 should be subject to an additional 1-year warranty and maintenance period to ensure that establishment occurs. It is also recommended that The City staff perform annual post-flood inspections to monitor the structural condition of the site and later in August / September to monitor continued vegetation establishment

and success after the FAC has been issued and on years when the BDEP is not being monitored by the RMP team (inspections will occur in 2023 and 2028). It would also be prudent for The City to consider setting aside a budget to address possible maintenance concerns that are identified by the BDEP monitoring team during the remaining monitoring years in 2023 and 2028 as the FAC will likely have been issued and the contractor will no longer be under contractual obligations to address any possible issues.

Photo 5-9: Replanted cuttings in the upstream end of Site 1 (September 23, 2020) Credit: Terra Erosion Control Ltd.

Photo 5-10: Vigorous growth at the downstream end of Site 1 (September 25, 2020)

Photo 5-11: Box fascine growth at Site 2 (September 25, 2020) Credit: Terra Erosion Control Ltd.

Photo 5-12: Good and vigorous growth in Hedge Brush Layer at Site 2 (September 25, 2020) Credit: Terra Erosion Control Ltd.

Photo 5-13: Herbaceous vegetation competition and shrubs with low vigour at Site 4 (September 24, 2020) Credit: Terra Erosion Control Ltd.

Photo 5-14: Live cutting at Site 4 (September 24, 2020) Credit: Terra Erosion Control Ltd.

Comparison with Theoretical Conventional Riprap Design Site

As discussed in Section 1.3, the shear stress resistance of the bioengineering techniques used at BDEP Sites 1, 2, and 4 were compared to the shear stress resistance for a theoretical conventional riprap design site. The theoretical conventional riprap design site was assigned a permissible shear stress of 364 N/m² based on the assumption of Class 2 riprap (d50 = ±500 mm) (Fischenich, 2001).

The estimated permissible shear stresses for Year 2 (2020) post-construction of the various bioengineering techniques used at Sites 1, 2, and 4 are shown in Table 5-1. Techniques that provide comparable or better shear stress resistance than Class 2 riprap are those that also include Class 2 riprap in the overall technique such as Site 4. However, the vegetated timber crib wall at Site 1 provides greater shear stress resistance than Class 2 riprap. The remaining techniques range in permissible shear stress from 141 N/m² to 244 N/m² are less than the resistance provided by Class 2 riprap, but all meet the requirement to withstand the 100-year design flood event and 2020 peak annual flow event shear stresses shown in Table 5-2.

5.3 Summary of Findings

Key findings from the bioengineering structural integrity assessment are listed below.

- Flows in the Bow River at the site were below the 2-year flood flow and shear stresses ranged from 10 to 35 N/m². Rainfall in Calgary in 2020 was above average at 479 mm. In particular, June and July rainfall were well above average; however, August and September were very hot and dry.
- The structural assessment identified that the physical condition of the bioengineering techniques, including fish habitat structures appears to be stable, with no signs of major erosion, scour, or displacement.
- Materials used in the construction of the bioengineering techniques at Sites 1, 2, and 4 include rock riprap, wood, erosion control matting and geogrids, concrete and steel and were generally found to be in good to excellent condition. Biodegradable erosion control matting is either at the end of its useful life or will be within the next ±5 years; however, it has served its purpose of stabilizing soils to allow for vegetation to establish.
- The fish shelters were observed to have some fine sediment deposited along the bottom but were otherwise clear and providing good fish habitat. No significant change in the condition of the timber crib wall was observed from as-constructed conditions, and there was no observed change in the deflection of the spanning members that are supported by the steel supports.

- Overall vegetation survival at the BDEP sites was 76% in 2020, with Site 1 vegetation survival of 74%, Site 2 vegetation survival of 68%, and Site 4 vegetation survival of 85%. Differences in 2020 and 2019 vegetation survival results are due to either the different methods that were used to measure survival between the 2 years (visual estimate in 2020 versus actual count in 2019) and/or due to an expected reduction in survival as the site ages and natural competition occurs between the planted woody vegetation as discussed in Box 1 above.
- The shear stress resistance of Class 2 riprap is higher than the bioengineering techniques used except for the vegetated timber crib wall at Site 1 and where existing riprap was retrofitted at Site 4. However, the shear stress resistance for the bioengineering techniques is all higher than the baseline case (100-year flood event) and the maximum shear stress from 2019 and 2020 Bow River flows.

6. Conclusions and Recommendations

Photo 6-1: Site 1 looking downstream towards the wildlife corridor under Cushing Bridge on September 25, 2020

The key conclusions listed below were noted in this report.

Monitoring Approaches

The goals of the monitoring activities are to assess how the bioengineering techniques used in the BDEP have affected fish habitat, wildlife habitat, riparian health, and bank structural integrity compared to a conventional riprap design site. The specific approaches for comparing the monitoring data collected at the BDEP to a conventional riprap design site are as follows:

- Fish habitat and wildlife habitat monitoring results from Site 1 and Site 2 are compared to monitoring results at Site 4 as the conventional riprap design control site.
- Riparian health and bioengineering structural integrity results for Sites 1, 2, and 4 are compared to riparian health and shear stress parameters for a theoretical conventional riprap design site.

Fish and Fish Habitat

- Year 2 (2020) fish and fish habitat monitoring activities occurred in the spring, summer, fall and winter.
- All water quality parameters measured in Site 1, Site 4, and the Upstream Control Site were within federal guidelines (CCME, 1999). Results from water quality measurements in 2020 were similar to measurements recorded in 2019, with similar seasonal variability in temperature, dissolved oxygen and conductivity. Site 1 and Site 4 values were also within the natural seasonal variation of the Bow

River as determined by comparison to the Upstream Control Site. In addition, Site 1 and Site 4 values were comparable to each other and to the Upstream Control Site so no effects on water quality were obviously discernible from the BDEP project.

- Fish are continuing to use the habitat enhancement structures provided by the BDEP as first observed in Year 1 (2019). Fish were observed using and were captured within the vicinity of the habitat structures throughout the project area; and fish were observed in the fish shelters, boulder clusters, and surrounding habitats during winter, spring and summer assessments.
- Compared with the baseline desktop assessment of historic fish capture data from the Bow River, of the 22 species that have a probable potential of occurrence on the Bow River within the vicinity of the project, in 2020, 9 species were captured, including 5 sportfish and 4 non-sportfish species. In 2019, 10 were captured within the project area, including 6 sportfish and 4 non-sportfish species. Abundance of fish species within the project area could not be compared with baseline data, as fish sampling surveys were not previously conducted in similarly characterized Bow River habitat within proximity to the BDEP sites, so comparison was limited to the baseline desktop assessment, as noted above.
- A total of 45 fish from 6 species were captured at Site 1, 42 fish from 8 species were captured at Site 2, and 33 fish from 3 species were captured at Site 4 using a single boat electrofishing pass in 2020. In comparison, in 2019 a total of 16 fish from 7 species were captured at Site 1, 8 fish from 2 species were captured at Site 2, and 24 fish from 6 species were captured from Site 4.
- Both minnow trapping and electrofishing Catch per Unit Effort (CPUE) was greatest at Site 2, followed by Site 1, with Site 4 having the lowest in 2020. In 2019, minnow trapping and electrofishing CPUE was highest at Site 4, followed by Site 2, then Site 1 (Site 1 and Site 2 had equal minnow trapping CPUE). In 2020, the highest electrofishing CPUE by species was rainbow trout at Site 1, mountain whitefish at Site 2, and longnose sucker at Site 4. In 2019, the highest CPUE was rainbow trout and perch at Site 1 (equal CPUE), white sucker at Site 2, and longnose sucker at Site 4.
- Site 2 had the highest abundance and diversity of fish species in 2020, including five sportfish species (i.e., brown trout, burbot, mountain whitefish, northern pike, and rainbow trout). This is a change from 2019 results where only forage fish were captured at Site 2. Although Site 1 had the second highest fish abundance, it had the highest total number of fish captured, and the single highest number of one species captured (rainbow trout). This is also a change from 2019 where Site 1 had the lowest fish abundance, but the highest species richness, and highest abundance and diversity of sportfish. Of the captured fish at Site 4, there was a higher abundance of forage fish, with longnose sucker being most prevalent, which is consistent with 2019 results.
- As expected, species composition and fish abundance observed during 2020 was higher than 2019 as the BDEP sites naturalize following the construction of the fish habitat enhancements.
- In 2020, a spring spawning assessment could not be completed due to high flows and turbid water creating unsafe conditions. No redds or fish were identified in the surveyed reach during the fall redd survey. Six locations within the upstream extent of Site 1 (i.e., upstream of the Cushing Bridge) were sampled during the fall kick sampling survey and mountain whitefish eggs were observed at each location.
- Based on the fish use monitoring results, Sites 1 and 2 are providing higher quality fish habitat in comparison to Site 4. Species distribution and fish abundance observed during Year 2 are expected

to vary in subsequent monitoring years as the BDEP sites naturalize following the construction of the fish habitat enhancements.

Wildlife

- The Year 2 (2020) breeding bird surveys resulted in the identification of 37 species including one listed species at the BDEP sites (bank swallow) compared to 31 species including three listed species in 2019 (least flycatcher, western wood-pewee, and bank swallow). The highest number of bird species and individuals identified in 2020 was at Site 1, followed by Site 2 and Site 4, which was consistent with 2019 results.
- The bank swallow colony identified in the baseline assessment at Site 2 was observed during 2019 and again in 2020 monitoring, indicating that construction did not result in fewer breeding colonies in the project area. No nests were observed at any of the sites in 2020 where stick nests were observed at Site 1 in 2019.
- Site 1 (50 individuals from 20 species) and Site 2 (29 individuals from 10 species) showed increased bird activity relative to Site 4 (19 individuals from 7 species) based on the results of the breeding bird and nesting surveys in 2020. This is consistent with 2019 bird activity results where Site 1 had 129 individuals from 22 species, Site 2 had 68 individuals from 8 species and Site 4 had 24 individuals from 6 species. This increased activity may be the result of differences in vegetation between the sites, with Site 4 having lower density vegetation.
- The wildlife camera monitoring program included four cameras that identified animals using the wildlife corridor created as part of the BDEP under the Cushing Bridge/17th Avenue SE bridge.
- A total of 7 wildlife species were identified through observations of 317 individuals. The most abundant species identified during the monitoring program was white-tailed deer (48%) followed by coyote (32%) and white-tailed jackrabbit (11%). This compares to a total of 212 individuals from 8 species that were observed in 2019, the most common of which was the white-tailed jackrabbit (21%), white-tailed deer (8%) and coyote (6%). Two new species were identified in 2020: common raccoon, and eastern gray squirrel.
- Deer and coyote presence observed on all four of the cameras throughout Site 1 and the increased mean use from 2019 and 2020, suggests that the wildlife corridor in the Project area is providing effective passage for large mammals. Thus, Site 1 is presumably providing better wildlife passage than Site 4, the conventional riprap design site, based on the findings in the reviewed literature that the riprap surfaces such as found at Site 4 are difficult for many species to traverse, especially ungulates and amphibians.

Riparian Health

- All three BDEP sites show significantly improved riparian health in comparison to the baseline condition (2016). The 2020 Riparian Health Assessment (RHA) rating for Site 1 was 49% compared to 43% in 2016, for Site 2 was 56% compared to 29% in 2016, and for Site 4 was 58% compared to 29% in 2016.
- There was a slight increase in RHA scores between 2019 and 2020 assessments for Site 4 and a slight reduction for Site 1 and Site 2. The main reason for the slightly increased RHA score for Site 4 was an increase in regeneration of preferred shrub species (increase in 2 points overall). The main reasons for the slightly reduced RHA scores were slightly lower cover of preferred shrub

species at Site 1 (decrease in 1 point overall from 2019), and slightly more human-caused bare ground at Site 2 (decrease in 1 point overall from 2019).

- The 2020 RHA scores for Sites 1, 2, and 4 result in the sites being categorized as *Unhealthy* (same category as the baseline and 2019 assessments); however, the limitations in the RHA method, particularly the low scores for the larger-scale parameters that are not influenced by site-level projects like the BDEP and lower scores due to site-level disturbances typical of urban areas are limiting a change in the riparian health category, despite the significant improvements in riparian health that are a direct result of the BDEP. It is possible that the riparian *Healthy* rating category may never be achieved due to these limitations in the RHA scoring.
- Increases in the vegetation component of the RHA scores was the key factor in the increased 2020 RHA ratings compared to baseline (2016) results. At Site 1 the vegetation rating has increased by 13% over the 2016 rating, at Site 2 the vegetation rating has increased by 127% over the 2016 rating, and at Site 4 the vegetation rating has increased by 189% over the 2016 ratings. The key vegetation parameters that have led to improved RHA scores are increased tree regeneration of balsam poplar (*Populus balsamifera*) and aspen (*P. tremuloides*) (RHA parameters 1 and 2), increased regeneration of preferred shrub species (RHA parameter 3), and increased total canopy cover of woody species (RHA parameter 6). These increases in the vegetation rating parameters is directly attributable to the bioengineering work completed for the BDEP.
- Overall 2020 RHA ratings for Sites 1, 2, and 4 range from 29% to 53% higher than the RHA rating for a theoretical conventional riprap design site. The main reason for increased RHA scores for the BDEP sites is that vegetation ratings are 85% to 145% higher for Sites 1, 2 and 4 than a theoretical conventional riprap design site
- The improving health trends are attributable to the successful BDEP bioengineering.

Bioengineering Structural Integrity

- Flows in the Bow River at the site were below the 2-year flood flow and shear stresses ranged from 10 to 35 N/m². Rainfall in Calgary in 2020 was above average at 479 mm.
- In general, the physical condition of the bioengineering techniques, including fish habitat structures appears to be stable, with no signs of major erosion, scour, or displacement.
- Materials used in the construction of the BDEP include rock riprap, wood, erosion control matting and geogrids, concrete, and steel and were generally found to be in good to excellent condition. Biodegradable erosion control matting is either at the end of their useful life or will be within the next ±5 years; however, they have served their purpose of stabilizing soils to allow for vegetation to establish.
- The fish shelters were observed to have some fine sediment deposited along the bottom but were otherwise clear and providing good fish habitat. No significant change in the condition of the timber crib wall was observed from as-constructed conditions, and there was no observed change in the deflection of the spanning members that are supported by the steel supports.
- Overall vegetation survival at the BDEP sites was 76% in 2020, with Site 1 vegetation survival of 74%, Site 2 vegetation survival of 68%, and Site 4 vegetation survival of 85%. This is slightly lower than the survival in 2019, where overall survival was 80%, Site 1 vegetation survival was 77%, Site 2 vegetation survival was 83%, and Site 4 vegetation survival was 77%.

- Differences in 2020 and 2019 vegetation survival results are due to either the different methods that were used to measure survival between the 2 years or due to an expected reduction in survival as the site ages and natural competition occurs between the planted woody vegetation.
- Survival of rooted live cuttings at Site 1-1 is approximately the same in 2020 compared to 2019. The increased survival at Site 1-1 in 2020 is likely due to the replanting efforts. The survival of rooted live cuttings demonstrates that they can successfully be used as an option to conventional live cuttings. They have now been used in at least four other sites in Calgary likely to facilitate summer construction.
- At Site 1, the combined survival of live cuttings in the timber crib wall and the vegetated soil wrap was 48% in 2020, which was slightly less than observed in 2019. Live cuttings were replanted in 2020 at Site 1 in the area upstream from Cushing Bridge and in the vegetated timber crib wall. Survival was expected to be higher in 2020 due to replanting efforts; however, many of the replanted cuttings were dead at the time of the inspection. It is understood that the contractor elected to remove the dedicated sprinkler too early, and the replanted live cuttings desiccated in the hot and dry late summer period. Nevertheless, the establishing vegetation in the timber crib wall is providing very good overhanging cover to enhance fish habitat.
- The brush mattress, brush layer and contour fascine survival at Site 1 is lower in 2020 than 2019; however, there is overall good and vigorous growth establishment in this portion of Site 1.
- At Site 2, the survival for the live staking technique was found to be higher than the brush mattress, contour fascine, and the hedge brush layers techniques in 2020. Survival for all of the techniques was found to be lower in 2020 compared to 2019. Despite the lower survival values in 2020 compared to 2019, these techniques demonstrate overall good and vigorous growth establishment in 2020.
- At Site 4, vegetation survival was highest for the soil covered riprap with container plants, and void-filled riprap and plug planting techniques; however, woody vegetation vigour (a measure of vegetation health), was observed to be low over the whole site due to herbaceous vegetation competition. A comparison of the existing riprap retrofit void-fill techniques finds that void-fill with topsoil and plug planting (with an overall survival of 100% in 2020 and 96% in 2019) is more successful than void-fill with pitrun and live staking (with a survival of 54% in 2020 and 60% in 2019).
- The shear stress resistance of Class 2 riprap is higher than the bioengineering techniques used except for the vegetated timber crib wall at Site 1 and where existing riprap was retrofitted at Site 4. However, the shear stress resistance for the bioengineering techniques are all higher than the baseline case (100-year flood event) and the maximum shear stress from 2019 and 2020 Bow River flows.

6.1 Recommendations

Recommendations for future monitoring years are listed below.

Fish and Fish Habitat

- Use the fish use and population data collected in 2019 and 2020 to make comparisons and trends with data collected in subsequent monitoring years to meet the requirements of the BEMP (Hemmera, 2018). Any remedial actions needed to meet the BEMP requirements that are identified for the site by the monitoring team should be considered for implementation by The City.

- Recommendations for monitoring in 2021 related to the timing and equipment of the monitoring program are as follows:
    - the crew will monitor the ice conditions of the Bow River beginning in January to determine safe conditions for completing the winter and spring assessment (i.e., stable and thick ice for on-ice survey or ice-free open water conditions for snorkel survey); and,
    - during the summer assessment, the crew will continue to use a smaller boat for more effective sampling of near shore habitats adjacent to Sites 1 and 2.

Wildlife

- More frequent camera checks to assess technical issues such as remaining memory card capacity and vandalism.
- Based on the perceived success of the wildlife corridor at Site 1, it is recommended to consider creating a City-wide design standard to infill riprap void-spaces with smaller sized gravels or topsoil. This would improve wildlife passage under bridges in Calgary (as is standard in Minnesota per Section 3.2), but also at all locations where riprap is used on the riverbank as a means to improve wildlife passage and habitat on riverbanks.

Riparian Health Assessment

- Future monitoring should be continued to confirm findings to date that BDEP has contributed to long-term improvements in riparian health.
- The results of the 2021 revisit RHI of BOW95 should be compared against the RHA scores collected for Sites 1, 2 and 4 to provide an independent confirmation of the impact that the BDEP has had on riparian health.
- Given the limitations of the soil / hydrology component of the RHA ratings for sites on the Bow River in Calgary, other methods to assess improvements in riparian health should be investigated. The Bank and Riparian Quality Index (BRQI) that was developed as part of the RMP (KWL, 2018) is recommended in 2021 to achieve this purpose. AEP approval will be required as this method was not included in the BEMP.
- Better control of weeds should occur at the BDEP sites as many species of invasive weeds and disturbance increaser species were documented. With better maintenance focused on weed control and some additional growth time, it might be possible for all three sites to obtain the "*Healthy with Problems*" category.

Bioengineering Structural Integrity

- Based on the success of the rooted live cuttings at Site 1, they appear to be a viable approach for constructing bioengineering projects. They are recommended to be used within various bioengineering structure types when timing constraints result in construction outside of the recommended period for using dormant live cuttings.
- The contractor should carefully consider the impact of early removal of irrigation at the Site since live cuttings replanted in the timber crib wall in 2020 mostly died due to early irrigation removal. It is recommended to replace the dead replanted live cuttings in 2021 and provide on-going irrigation throughout the summer.

- If the timber crib wall with fish shelters technique is used in the future, it is recommended to construct the spanning members using structural timber with dimensions larger than the timber used in the BDEP timber crib wall or use shorter spans.
- More detailed monitoring of the timber in the timber crib wall should be conducted using non-destructive methods such as a Resistograph to provide more detailed understanding of the remaining useful life of the timber.
- For future box fascine installations on the Bow River, it is recommended that the fill placed in the box fascine be larger sized material than pea gravels that were used at Site 2. A good option could be native river gravels excavated during site construction. Also, placing erodible void-fill material on the surface of exposed steep riprap slopes per the conditions observed at Site 4 should be avoided.
- It is recommended to replace an approximately 11 m long section of contour fascine on the upper northwest corner of Site 2.
- It is recommended to use hedge brush layers where brush layers are being considered despite the additional cost. In a hedge brush layer, potted plants are used in combination with conventional live cuttings which improves overall biodiversity and habitat for wildlife.
- It is recommended to continue detailed monitoring of the three techniques used to retrofit existing riprap at Site 4 to determine the preferred approach. If live cuttings are used in future applications of this type, they should be placed in the openings in the riprap prior to backfilling with growing substrate versus installation after void-filling.
- It is recommended to replant Site 4 in areas where the survival target of 75% was not achieved.
- It is recommended to measure vegetation parameters (e.g., cover and vigor) in 2021 and following years using both the transect and quadrat methods to facilitate better data comparison and consistent data.

Final Acceptance Certificate

- Because FAC is expected to be issued in 2021, any replanting that occurs in 2021 should be subject to an additional 1-year warranty period to ensure that establishment occurs.
- It is recommended that The City consider setting aside a budget to address maintenance concerns that are identified by the BDEP monitoring team after FAC has been issued but during the remaining monitoring years in 2023 and 2028.
- It is also recommended that The City staff perform annual inspections post freshet to monitor the structural condition of the site and later in August / September to assess vegetation establishment and success on non-monitoring years.

7. References

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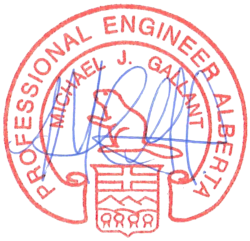
8. Report Submission

This report has been prepared and reviewed by the personnel listed below.

KERR WOOD LEIDAL ASSOCIATES LTD.

Prepared by:



2021-06-24

Mike Gallant, MScE, P.Eng., CPESC
Senior Water Resources Engineer

Reviewed by:

Craig Kipkie, M.Sc., P.Eng.
Principal, Project Manager, KWL

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Senior Water Resources Engineer

PERMIT TO PRACTICE
KERR WOOD LEIDAL ASSOCIATES LTD
RM SIGNATURE: _____
RM APEGA ID #: 90096
DATE: 2021-06-24
PERMIT NUMBER: P007929
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

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Revision History

Revision #	Date	Status	Revision	Author
0	June 23, 2021	FINAL	Issued for Use	MG

APEGA Permit # P07929

KERR WOOD LEIDAL
consulting engineers

Appendix A

Bioengineering Efficacy Monitoring Plan

Prepared by: Hemmera Envirochem Inc.

August 29, 2018

Mr. David DePape
Senior Manager, FISHES Program
Alberta Environment and Parks
South Saskatchewan Region
1st Floor, Suite 100, 3115 – 12th St. N.E.
Calgary, Alberta
T2E 7J2

Dear Mr. DePape, DAVE

Re: Final Bioefficacy Monitoring Plan (May, 2018)

Thank you for submitting the final Bioefficacy Monitoring Plan (BEMP) for the Bioengineering Demonstration and Education Project. Please consider this letter The City of Calgary's official acceptance of the final plan.

The City of Calgary (The City) is pleased to be part of the Bioengineering Demonstration and Education Project and is committed to fulfilling the financial and project obligations outlined in the *Memorandum of Understanding* and *Project Charter* including the implementation of the BEMP. The City recognizes the importance of this project in achieving fish habitat and riparian restoration and enhancing the knowledge of bioengineering techniques.

The BEMP will be an important component of The City's Riparian Monitoring Program and will contribute to improving our understanding of the efficiency of bioengineering restoration practices. This knowledge will support our ongoing work to protect riparian areas in Calgary.

We look forward to initiating the implementation of the BEMP in 2019 and continuing to work with you and the Province on this valuable project.

Sincerely,

Trevor Rhodes, M.Sc., P. Biol.
Leader, Watershed Strategy
Watershed Planning Division| Water Resources
The City of Calgary

Cc: Carolyn Bowen, Manager, Watershed Planning, Water Resources
Harpreet Sandhu, Team Lead, Resource Strategy, Water Resources

Bioengineering Demonstration and Education Project
Bioengineering Efficacy Monitoring Plan

May 2018

Prepared for:

Alberta Environment and Parks
Suite 100, 3115 12 St. NE
Calgary, Alberta T2E 7J2

Prepared by:

Hemmera
An Ausenco Company

THURBER ENGINEERING LTD.

KERR WOOD LEIDAL
consulting engineers

Terra Erosion Control Ltd.

Polster Environmental Services Ltd.

O2 PLANNING + DESIGN

ACKNOWLEDGEMENT

The Bioengineering Efficacy Monitoring Plan (BEMP) is an important component of the Bioengineering Demonstration and Education Project (BDEP). It will provide data to support the use of bioengineering techniques as ecologically valuable and cost-effective alternatives to conventional engineering practices for bank erosion protection and riparian restoration.

The need for a longer term (10 year) monitoring plan to assess the BDEP was always envisioned as an integral part of BDEP. Development of the plan was supported and funded by Alberta Environment and Parks (AEP) as part of the design contract scope of work. Implementation of the Plan is the responsibility of the City of Calgary. Given the partnership between Alberta Environment and Parks and The City of Calgary in the development and implementation of BDEP, the BEMP could not have been developed without the input and guidance of a large number of individuals.

Greg Eisler (Hemmera) and Lisa Rear (Hemmera) were principal authors of the Plan, and supporting budget and schedule, which was informed by input from staff within The City of Calgary and Alberta Environment and Parks. Members of the Technical Team supporting AEP in the delivery of the BDEP also contributed to the Plan.

The following individuals and organizations provided technical input, to ensure the effectiveness of long-term monitoring activities, as well as institutional knowledge to ensure the effective integration of the BEMP and complimentary riparian restoration and monitoring initiatives within the City of Calgary:

- Trevor Rhodes (City of Calgary Water Resources)
- Jon Slaney (City of Calgary Water Resources)
- George Roman (City of Calgary Water Resources)
- Norma Posada (City of Calgary Water Resources)
- Sarah Marshall (City of Calgary Water Resources)
- Tim Walls (City of Calgary Parks)
- Kathryn Hull (Cows and Fish)
- David DePape (Alberta Environment and Parks)
- Kevin Brayford (Alberta Environment and Parks)
- Mike Gallant (Kerr Wood Leidal Associates Ltd.)
- Andrew Szojka (Kerr Wood Leidal Associates Ltd.)
- Pierre Raymond (Tera Erosion Control)
- Mike Magnan (02 Planning + Design)
- Mark Piciacchia (Hemmera)
- Mike Peckford (Hemmera)

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1.0 INTRODUCTION

Hemmera Envirochem Inc. (Hemmera) has prepared a *Bioengineering Efficacy Monitoring Plan* (BEMP) for Alberta Environment and Parks (AEP) Fisheries Habitat Enhancement and Sustainability (FISHES) Program, in partial fulfillment of the requirements of the Bioengineering Demonstration and Education project (the Project). The Project is being delivered under a formal partnership agreement between AEP and the City of Calgary (The City). As part of the partnership understanding, development of the BEMP is the responsibility of AEP, while implementation of the BEMP is the responsibility of The City. This report outlines the details of the proposed BEMP for Sites 1, 2, and 4 (**Figure 1**). It is understood that final refinements to this BEMP may be necessary, pending further discussions between The City and the FISHES Program and/or any changes to the Project's intended footprint occurring at construction.

Hemmera's team understands that AEP's primary goal is to achieve fish habitat enhancement and riparian restoration at flood affected and impacted sites using bioengineering techniques. Integrating education opportunities and objectives during project development will facilitate increased understanding of bioengineering techniques, as effective and ecologically valuable alternatives to hard engineering practices (i.e. controlled disruption of natural processes by using man-made structures) for bank erosion protection and associated riparian restoration, with a range of identified audiences.

The goals for the Project, as per the *Project Charter*, are to meet the following criteria:

- Effectively stabilize an area of unstable, steep bank.
- Initiate measurable restoration of flood affected habitat or creation of new fish habitat (e.g. bank overhangs, in-stream refugia, boulder clusters, large woody debris, shade/cover by riparian plantings, etc.).
- Design and construct methods to facilitate increased awareness and understanding of flood recovery processes, development of new educational programming targeting bioengineering techniques, and related design success factors.
- Improve riverbank aesthetics in the area.

Building on the Project goals, key objectives of the Bioengineering Demonstration and Education Project (BDEP) are:

- To monitor the overall effectiveness and cost of the Project, specifically in relation to a more conventional rip rap bank protection project.
- To evaluate the overall effectiveness and cost of the Project, specifically in relation to a more conventional rip rap bank protection project.
- To report on the overall effectiveness and cost of the Project, specifically in relation to a more conventional rip rap bank protection project.

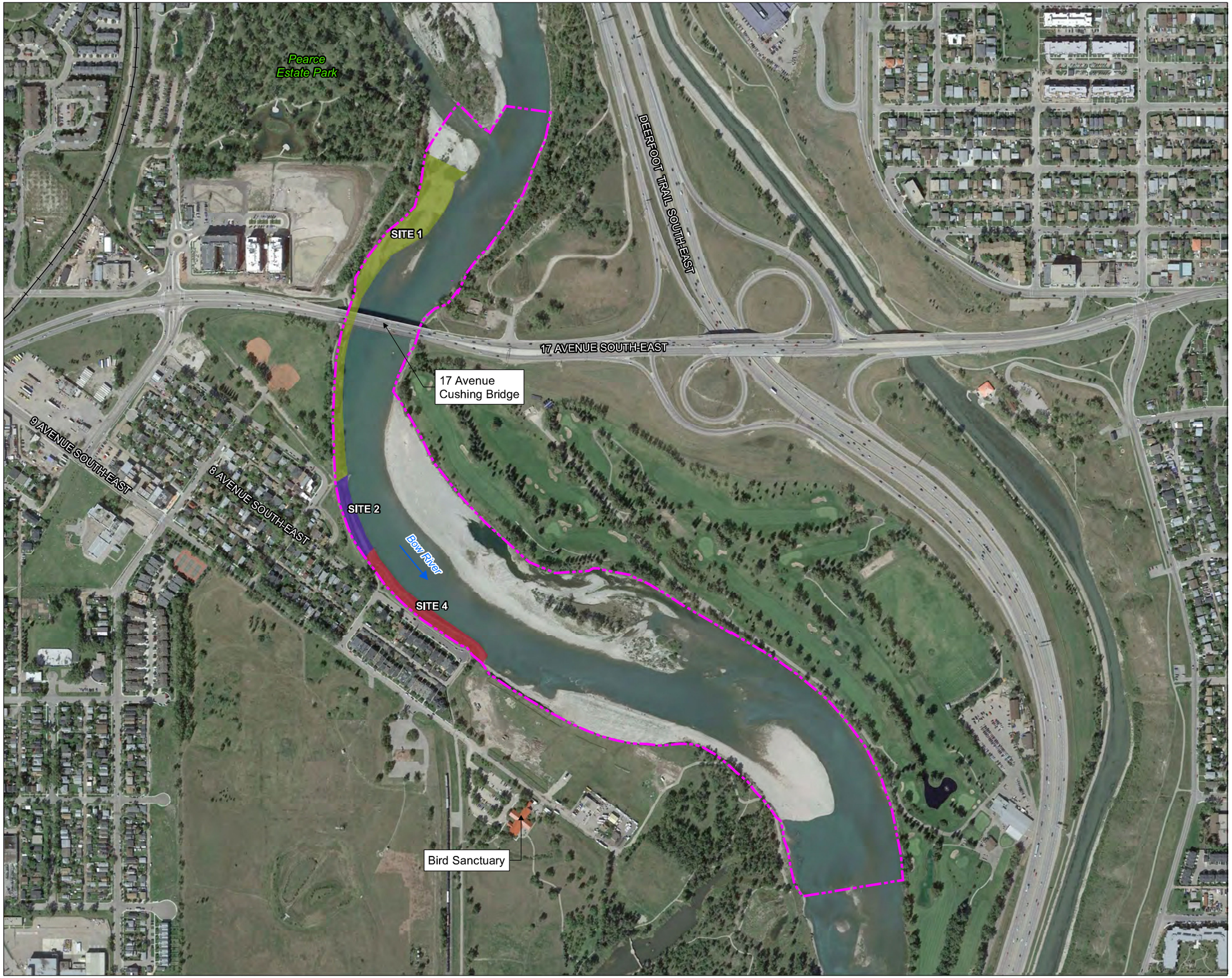
In this context, the BEMP is a critical tool to providing information to support understanding of the effectiveness of the physical works undertaken through the Project, with respect to the goals noted above, and support a comparison with conventional approaches to bank protection. However, an actual cost benefit analysis of the Project in relation to a more conventional riprap bank protection project is outside the scope of the BEMP.

The scope of work for the BEMP involves post-construction monitoring over multiple years, with the first year of monitoring commencing in 2019, after anticipated Project construction is complete in December 2018. Subsequent monitoring will occur in 2020, 2021, 2023, and 2028. It is recommended that a visual inspection of the works be completed following any return event greater than 1:10, given this is the flood level on the Bow River where significant sediment transport will likely be realized. The BEMP also includes a contingency budget to support monitoring immediately following a significant flood event(s) that occurs post-construction and results in significant damage to Project works. A significant flood event is defined as 'a return event that causes enough damage to the works to require major repairs or re-construction'. Should this occur, the monitoring schedule would be reset to include monitoring in years 1, 2, and 4, post-reconstruction. Monitoring will include surveys for fish and fish habitat, riparian health, wildlife, and integrity of the bioengineering structures/installments. Monitoring visits will be conducted during select (and in some cases multiple) seasons in each monitoring year to capture the range of environmental conditions that may exist at the sites, and to ensure that sampling of biotic and abiotic elements occurs with appropriate timing. Details of each component are presented in subsequent sections. A summary of survey timing and level of effort is provided in **Section 4.0**, **Table 6.**

In support of The City's *Riparian Action Program*, The City is currently undertaking a 5-year Riparian Monitoring Program (RMP). An opportunity was identified for The City to undertake implementation of the BEMP, in concert with implementation of the RMP, as both initiatives have overlapping objectives, similar implementation timelines, and draw on similar monitoring activities. Additional detail on how implementation of the BEMP will be undertaken in an integrated manner with the RMP is included in **Section 2.0** (BEMP Implementation).

Bioengineering Efficacy Monitoring Plan
Bow River, Calgary, Alberta

Site Map



Legend

- Assessed Reach
- Site 1
- Site 2
- Site 4
- Direction of Flow
- Railway

Notes

1. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Basedata: Government of Alberta
- Aerial Image: Google Earth (imagery date: 8/22/2015)
- Inset Basemap: ESRI World Topographic Map

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Hemmera
An Ausenco Company

Alberta Environment and Parks

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2.0 BEMP IMPLEMENTATION

In support of The City's *Riparian Action Program*, The City is currently undertaking a 5-year Riparian Monitoring Program (RMP). During the planning phase of BDEP, an opportunity was identified for The City to undertake implementation of the BEMP in concert with implementation of the RMP. While both initiatives have overlapping objectives, similar implementation timelines and draw on similar monitoring activities, there are also differences in the objectives of the two initiatives, which result, in some cases, in different monitoring activities. This section of the BEMP provides an overview of the overlaps and differences in monitoring approaches between the two programs.

The City's RMP focuses on bioengineering and riparian planting projects implemented by The City in the last ten years, as well as baseline Riparian Health Inventory (RHI) sites assessed since 2007.

The RMP involves two components: *Effectiveness Monitoring* and *Trend Monitoring*.

- **Effectiveness Monitoring** – Effectiveness monitoring will assess post-construction conditions to evaluate changes resulting from implemented restoration projects.
- **Trend Monitoring** – Trend monitoring will be used to establish the nature and direction of riparian health. The table below shows the overlap between the two programs.

A main deliverable of the RMP Phase 1 is a program *Monitoring Plan*, which will include the BDEP as a special project.

Table 1 Comparison of BEMP and RMP Monitoring Approaches: provides an overview of where the monitoring approaches in The City's RMP overlap with the BEMP, and where the objectives of the BEMP require a different approach or frequency of monitoring, relative to that employed in The City's RMP.

Table 1 Comparison of BEMP and RMP Monitoring Approaches

Monitoring Focus	BEMP	RMP
Fish and Fish Habitat	This component is part of the BEMP. The BEMP describes methods for monitoring of fish and fish habitat.	This component is currently not part of the overall RMP. The BEMP methods will be followed as part of the RMP for the BDEP sites.
Riparian Health	This component is part of the BEMP. The monitoring method for riparian health described in the BEMP includes a Riparian Health Assessment (RHA).	Riparian Health is a component of the overall RMP, and BEMP monitoring methods, including frequencies, will be part of the RMP monitoring. There are two monitoring procedures that will be included in the RMP to support the BEMP: • Completion of a revisit Riparian Health Inventory (RHI) in 2021 for the BOW95 Site (Cows and Fish 2016b). • The RMP includes a riparian/top-of-bank assessment component as part of its Bank Effectiveness Monitoring that will be integrated with Riparian Health Assessments (RHA). RHAs were not originally part of the RMP but will be undertaken to be consistent with the BEMP methods. The BEMP monitoring frequencies will be followed for RHAs.
Wildlife	This component is part of the BEMP. The BEMP describes methods for monitoring of wildlife.	This component is currently not part of the overall RMP. The BEMP methods will be followed as part of the RMP for BDEP sites.
Bioengineering Structural Integrity	This component is included in the BEMP. The BEMP describes timelines for monitoring that are more frequent than the RMP.	This component is part of the overall RMP. The BEMP monitoring frequencies will be followed for RMP implementation at BDEP sites. The RMP will define specific methods and analysis that align with the BEMP.
Reporting	BEMP implementation assumes one reporting of results will take place in every year in which monitoring activities are undertaken. A final report, summarizing the conclusions and findings of the overall monitoring programs, as well findings related to the individual components (e.g. fish, wildlife, structural integrity etc.), will be completed and provided to AEP within 6 months of the final monitoring event.	This component is part of the overall RMP, The BEMP monitoring findings will be integrated with the RMP reporting scope. Annual reports will be prepared as part of the RMP.

It should be noted that the RMP is currently structured as a 5-yr program, and the BEMP is a 10-yr monitoring program. However, the RMP is expected to continue beyond 5 years and will provide for the longer term monitoring and reporting requirements of the BEMP.

The City's RMP is intended to be a dynamic program that can be adapted, and modified, in response to the findings of the monitoring activities. As such, specific RMP monitoring requirements and methods may change in the future. The City will engage AEP, prior to making changes to monitoring approaches that apply to the BDEP sites, to ensure new approaches support the long-term objectives of BDEP.

In addition to sharing common monitoring objectives, as noted above, both the RMP and BEMP are aligned with, and supportive of, the goals and objectives of the Bioengineering Demonstration and Education Project Education Plan[1].

[1] Hemmera Envirochem Ltd., "Education Plan", *Bioengineering Demonstration and Education Project* (Prepared for Alberta Environment and Parks, 2017).

3.0 BASELINE DATA

The purpose of the Project's baseline data collection was to assess pre-construction environmental conditions for Sites 1, 2, and 4 (**Figure 1**). These baseline data form a reference condition, upon which project effects (bioengineering structures/installments), on the identified components, will be monitored and documented throughout the BEMP.

In addition to monitoring potential changes at each site, the BEMP is also planning to provide an analysis of the efficacy of the remediation methods, comparing Sites 1 and 2, where intensive bioengineering remediation is intended (e.g. fish shelters, rock clusters, box fascines), to Site 4, where less intensive elements are intended (e.g. vegetating existing riprap armouring). For comparative purposes, Site 4 has been selected to represent baseline conditions, from which anticipated successes at Sites 1 and/or 2 can be benchmarked. In this comparison, Site 4 represents a proxy to the traditional method of flood mitigation (hard armouring), albeit with some minor bioengineering enhancements, whereas Sites 1 and 2 are identified as the treatment reaches. It is expected that only a comparison of overall fish habitat suitability among the three sites will be possible, given the difference between treatments (i.e. the scope of bioengineering elements) designed for Sites 1, 2, and 4.

Hemmera led an on-site reconnaissance, by its Project team on July 18, 2016, to assess the conditions and identify bioengineering design, fish habitat, and education opportunities at each site. Prior to this site reconnaissance meeting, Skymatics Ltd. provided drone technology to document the existing baseline conditions of the Project area, particularly to facilitate the performance evaluation of each site regarding riparian vegetation, riverbank and slope stability, and fish and wildlife habitat. During this drone reconnaissance, aerial imagery of the riverbank and a video of the river's morphological features were obtained. A georeferenced flight path was documented for use in long-term monitoring of the Project. This electronic information is available upon request. While the sampling protocols and budget presented in the BEMP do not provide for visual monitoring of site conditions, the aerial imagery of pre-construction site conditions, collected during drone flights, could be used to support future monitoring of changes in site conditions post-construction.

3.1 FISH AND FISH HABITAT

Hemmera completed a baseline fish habitat assessment of riverine areas encompassing each of the three Project sites on March 27, 2017. Historical documentation of fish presence was determined using FWMIS[2] and aerial imagery from 2002 to 2016 was reviewed[3] to supplement field observations. Due to the existing database of previously documented fish species in the Bow River within the vicinity of the Project, fish

[2] Fisheries and Wildlife Management Information System (FWMIS), "Area-Specific Search Request (2017)", at *Fish and Wildlife Division: Alberta Environment and Sustainable Resource Development,* https://maps.srd.alberta.ca/FWIMT_Pub/Viewer/?TermsOfUseRequired=true&Viewer=FWIMT_Pub (accessed April, 2017).

[3] Google Earth 7.1.5.1557. (2015), "Calgary, Alberta. 50°58'50.17"N 114°01'42.46"W. 3406 ft." *Digital Globe Imagery* (accessed March 2017)

sampling was not conducted. Supplemental information was reviewed, including morphological mapping conducted in 2014 by Klohn Crippen Berger[4], and a bathymetry survey conducted in July 2016 by Kerr Wood Leidal[5]. Detailed descriptions of habitat characteristics and potential, for each Site, are provided in the *Project's Fish and Fish Habitat Assessment Report*[6].

During the baseline fish habitat assessment, data were collected and assessed following Hemmera's protocols for fish habitat assessments[7], which will enable replicative, post-construction monitoring during the BEMP. However, should alternate analytics be preferred during the implementation of the BEMP (e.g. direct reference to Habitat Suitability Indices, or weighted habitat unit values), retroactive concordance of data may be required.

Habitat

In summary, the assessed reach of the Bow River (including Sites 1, 2, and 4) is characterized as a low gradient (2%) and a regular meander pattern that is frequently confined by its valley walls. The entire assessed reach is dominated by Class 1 run habitat (R1) (>1.0 m), alternating with various pool habitats (P1-deep, P2-moderate, and P3-shallow) along the right downstream bank (RDB). Habitat features in the assessed reach also include riffles, a Class 2 run habitat (R2) (0.75-1.0 m), and a backwater pool (BW) habitat. A snye habitat (backwater or side channel) is located along the left downstream bank (LDB), adjacent to the Inglewood Golf and Curling Club (**Figure 1**). The snye habitat likely has connectivity at its upstream extent, during high flow periods (e.g. during spring freshet). P1 habitat is present at the downstream extent of the assessed reach.

Substrate throughout the assessed reach is dominated by boulder and cobble in run habitats (R1 And R2), and cobble and large gravel in riffle habitats. Substrates within pool habitats (P1, P2, and P3) consist primarily of boulder, cobble, and fines. Gravel and fines dominate the snye habitat located along the LDB.. Throughout the assessed reach, maximum water depth ranges from 0.54m to 7.10m, with an average water depth of 1.54m[8].

Bankfull width in the assessed reach ranges from 105m to 230m, with an average width of approximately 163m. Wetted width ranges from 80m to 174m, with an average width of 116m. Bank stability throughout the assessed reach ranges from stable slopes, in areas armoured with riprap, to near vertical and unstable, along the RDB immediately downstream of the 17 Avenue Cushing Bridge. Additionally, some banks consist primarily of fines and cobble.

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4 Klohn Crippen Berger, "Calgary Rivers Morphology and Fish Habitat Study – Draft", *Technical Memo F-1: Existing Fish Habitat*. Draft report prepared for The City of Calgary, (April 2015).

5 Kerr Wood Leidal, "Project Site Topography" for the *Bioengineering Demonstration and Education Project*. Prepared for Hemmera Envirochem Inc., (2016).

6 Hemmera Envirochem Ltd., "Fish and Fish Habitat Assessment: Bow River, Alberta", *Bioengineering Demonstration and Education Project*, (2017).

7 Hemmera Envirochem Ltd., "fish Habitat Assessment".

8 Hemmera Envirochem Ltd., "fish Habitat Assessment".

The concentration of dissolved oxygen and pH were within, or exceeded, the Canadian Council of Ministers of the Environment (CCME) *Guidelines for the Protection of Freshwater Life*[9]. Conductivity and water temperature were within anticipated levels, based on time of year. Detailed water quality measurements were collected at Site 2[10].

Fish

The Bow River, from its headwaters to the confluence with the Oldman River, is known to support 35 fish species[11]. However, within the vicinity of the Project (i.e. between Bearspaw and Carseland Dams), only 22 of these species are likely to occur, including 11 sportfish species (Table 1).

Categorization of fish habitat potential focused on brown trout, rainbow trout, and mountain whitefish. These species were chosen for fish habitat potential ratings based upon presumed relative species abundance[12], being part of a CRA (commercial, recreational, or aboriginal) fishery, and construction effects on spawning season. These species are representative of all spawning seasons that will be affected by construction (both spring and fall). Habitat potential was graded based on the ability to provide spawning, rearing, adult feeding, and overwintering habitat. The fish habitat potentials were rated as:

- Essential: habitat that is rare, highly productive, sensitive, or vital in sustaining commercial, recreational or Aboriginal fisheries, or any species at risk, or is of management concern.
- Important: habitat that is important to the fish population for spawning, feeding, rearing, wintering, and migration and is not deemed to be critical to a specific population.
- Marginal: habitat characterized by low productive capacity that contributes marginally to fish production; includes habitat that is not available to fish due to natural permanent barriers.
- Unsuitable: no suitable habitat present for a specific fish species life history stage.

Ratings were based upon the professional judgement of the QAES, using an adaptation of habitat descriptions from the *BC Oil and Gas Commission*[13] and *BC Ministry of Forests, Lands, and Natural Resource Operations*[14], as well as various known habitat suitability characteristics for each species.

Important fish habitat potential was observed throughout the assessed reach for numerous sportfish species. Overall, wintering, migration, and rearing habitat was rated 'Important' for the species assessed (mountain whitefish, rainbow trout, and brown trout). Moderate depth and deep run habitats (R2 and R1),

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9 Canadian Council of Ministers of the Environment (CCME), "Canadian Water Quality Guidelines for the Protection of Aquatic Life: Summary Table", *Canadian Environmental Quality Guidelines*, revised 2007 (Winnipeg: Canadian Council of Ministers of the Environment, 1999).

10 Hemmera Envirochem Ltd., "fish Habitat Assessment".

11 FWMIS, "Area-Specific Search Request".

12 FWMIS, "Area-Specific Search Request".

13 British Columbia Oil and Gas Commission*, Environmental Protection and Management Guide, Version 1.9,* Fort St. (John: Oil and Gas Commission, 2017).

14 British Columbia Ministry of Forests, Lands, and Natural Resource Operations [FLNRO], BC Ministry of Environment, and Fisheries and Oceans Canada, *Fish-stream Crossing Guidebook, revised ed*. (Victoria: Prac. Invest. Br., 2012).

observed along the entire reach, are likely to provide deep, slow habitat that is suitable for overwintering. Migration was rated 'Important', as no known barriers to fish migration exist between the Bearspaw and Carseland dams. Stream margins and low velocity habitat features, including snyes and backwater areas, offer rearing habitat for multiple species. The spawning potential for mountain whitefish and brown trout was rated 'Important', due to the abundance of suitable substrates, habitat types, and cover availability. Spawning activity by mountain whitefish and brown trout has been documented downstream of the Project area[15]. The spawning potential for rainbow trout was rated 'Marginal', as most of the lower Bow River watershed population spawns in tributaries located downstream of the Project, in the Highwood and Sheep River headwaters. Historically, low levels of spawning have been documented in the Project reach[16].

Table 2 Fish Species Documented in the Bow River near the Project

Common Name[17]	Scientific Name	Spawning Season[18]	Provincial Status[19]	Federal Status[20]
SPORTFISH				
Brook trout	*Salvelinus fontinalis*	Fall	Exotic/Alien	Not Listed
Bull trout	*Salvelinus confluentus*	Fall	At Risk	No Status
Brown trout	*Salmo trutta*	Fall	Exotic/Alien	Not Listed
Burbot	*Lota lota*	Winter	Secure	Not Listed
Cutthroat trout[a]	*Oncorhynchus clarki*	Spring	Exotic/Alien	Not Listed
Lake whitefish	*Coregonus clupeaformis*	Fall / Winter	Secure	Not Listed
Mountain whitefish	*Prosopium williamsoni*	Fall	Secure	Not Listed
Northern pike	*Esox Lucius*	Spring	Secure	Not Listed
Rainbow trout[b]	*Oncorhynchus mykiss*	Spring	Secure	Not Listed
Yellow perch[c]	*Perca flavescens*	Spring	Secure	Not Listed
Walleye	*Sander vitreus*	Spring	Secure	Not Listed

15 FWMIS, "Area-Specific Search Request", 2017; Golder Associates, *Fish Habitat inventory and habitat use assessment for the Bow River from Bearspaw dam to WID weir, volumes I and II.* (Prepared for Fisheries Management Division, Alberta Sust. Res. Dev., Calgary, AB. 2001).

16 Alberta Environment (AE) and Alberta Sustainable Resource Development (ASRD), "Appendix A: Fisheries Management Objectives" *Instream Flow Needs Determinations for the South Saskatchewan River Basin, Alberta, Canada*. http://aep.alberta.ca/water/programs-and-services/south-saskatchewan-river-basin-water-information/studies/instream-flows-needs.aspx (2003).

17 FWMIS, "Area-Specific Search Request"; Joseph S Nelson and Martin J. Paetz, *The Fishes of Alberta* (Edmonton: University of Alberta press, 1992).

18 Amanda Joynt and Michael Gary Sullivan, *Fish of Alberta* (Edmonton: Lone Pine Publishing, 2003); Nelson and Paetz, *The Fishes of Alberta*.

19 Government of Alberta, *Alberta Wild Species General Status Listing -2015, (Government of Alberta, 2017)*. http://aep.alberta.ca/fish-wildlife/species-at-risk/albertas-species-at-risk-strategy/general-status-of-alberta-wild-species/documents/SAR-2015WildSpeciesGeneralStatusList-Mar2017.pdf. (Accessed: March 2017).

20 Government of Canada, *Species at Risk Public Registry, A to Z Species Index,* 2017. https://www.registrelep-sararegistry.gc.ca/sar/index/default_e.cfm (Accessed: March, 2017).

Common Name[17]	Scientific Name	Spawning Season[18]	Provincial Status[19]	Federal Status[20]
NON-SPORTFISH				
Brook stickleback	*Culaea inconstans*	Spring / Summer	Secure	Not Listed
Fathead minnow	*Pimephales promelas*	Summer	Secure	Not Listed
Lake chub	*Couesius plumbeus*	Spring	Secure	Not Listed
Longnose dace	*Rhinichthys cataractae*	Spring / Summer	Secure	Not Listed
Longnose sucker	*Catostomus catostomus*	Spring	Secure	Not Listed
Mountain sucker	*Catostomus platyrhynchus*	Summer	Secure	Not at Risk
Prussian carp	*Carissius gibclio*	Spring / Summer	Exotic/Alien	Not Listed
Pearl dace	*Margariscus margarita*	Spring / Summer	Undetermined	Not Listed
Spoonhead sculpin	*Cottus ricei*	Spring	May be at Risk	Not at Risk
Trout-perch	*Percopsis omiscomaycus*	Spring / Summer	Secure	Not Listed
White sucker	*Catostomus commersoni*	Spring	Secure	Not Listed

Notes:
a Cutthroat trout in the Bow River near the Project represent introduced stocks and are not considered native stocks of Westslope Cutthroat Trout (*Onchorhynchus clarkii lewisi*).
b Rainbow trout in the Bow River near the Project represent introduced stocks and are not considered native stocks of Athabasca Rainbow Trout.
c The historical range of yellow perch does not include the Bow River. However, numerous specimens have been captured in irrigation canals near the Project area.

3.2 RIPARIAN HEALTH

Hemmera conducted a Riparian Health Assessment (RHA) for Sites 1, 2, and 4 on October 2, 2016[21], using the 'Alberta Wetland Health Assessment for Large River Systems methodology'[22]. A summary of the goals and objectives for the riparian component of the Bioengineering Demonstration and Education Project include the following:

- Monitor presence and abundance of invasive species to control their establishment and spread.
- Introduce native plant and shrub species to promote natural regeneration of the sites.
- Monitor the survivorship of riparian plantings.
- Install educational signage to convey key riparian and river health messages and project benefits.

The polygons or assessment boundaries identified for each site are described in **Table 3**.

21 Hemmera Envirochem Ltd., "Riparian Health Assessment: Bow River, Alberta", *Bioengineering Demonstration and Education Project* (2016).
22 Cows and Fish, *Alberta Lotic Wetland Health Assessment for Large River Systems (Survey) User Manual* (2016). http://cowsandfish.org/riparian/documents/AlbertaRiverSurveyManual.pdf

Table 3 Riparian Health Assessment Polygon Characteristics

Polygon	Assessment Boundary	Length (m)	Area (ha)
Site 1	Downstream of Harvie Passage, to upstream of The City of Calgary storm water outfall B-9; approximately 250 m downstream of the Cushing Bridge	591	2.75
Site 2	Adjacent to the downstream boundary of Site 1, at outfall B-9	128	0.44
Site 4	Boundary begins at the upstream edge of the riprap rock groyne and extends to the downstream riprap rock groyne	251	0.36

SITE 1

The overall rating of the riparian health in this polygon is 'degraded', given the presence of invasive weed species throughout the area. The species diversity and richness is greater upstream of Cushing Bridge, where a mature riparian forest with a well-developed canopy and understory is present on the west side of the Bow River, adjacent to the regional pathway. Approximately half of the riverbank length in the polygon (upstream of the Cushing Bridge) is accessible to animals (e.g. deer) for browsing. Historic erosion and unstable banks characterize the half of the site that is downstream of Cushing Bridge. The area continues to be extremely susceptible to erosion, given the nearly vertical banks and lack of stabilizing riparian vegetation. Most of the Site 1 polygon is classified as no land-use apparent (85%), with development and recreation (15%), for the boat launch ramp and the regional pathway, comprising the remainder of land use in the polygon. Hemmera[23] provides a full list of native and invasive plant species.

SITE 2

The overall rating of the riparian health in this polygon is 'static', given the top of bank and upland areas of the polygon are maintained as green spaces by The City of Calgary. There is limited regeneration of balsam poplar along the toe of the riverbank, and the riparian species present are reflective of species that quickly colonize disturbed areas. No land use is apparent for the majority (70%) of the polygon, with the rest of the land use designated as turf grass (mowed lawn) (20%) and recreation (regional pathway) (10%). Adjacent land use is primarily residential development (50%), roads (30%) and turf (lawns) (20%). Hemmera provides a full list of native and invasive plant species[24].

SITE 4

The overall rating of the riparian health in this polygon is 'improving', due to the extensive riparian planting program conducted in 2014 by Golder Associates Ltd. As part of The City of Calgary's 2013 flood remediation and bank stabilization works. Some natural (i.e. not planted) regeneration of sandbar willow was observed among the planted species. The entire polygon is categorized as no land use apparent and

[23] Hemmera Envirochem Ltd. "Riparian Health Assessment".
[24] Hemmera Envirochem Ltd. "Riparian Health Assessment".

serves primarily as green space along the regional pathway. Adjacent land use is comprised of turf lawns (50%), residential development (30%), recreation (regional pathway) (10%) and roads (10%). Hemmera provides a full list of native and invasive plant species[25].

Riparian health was scored based on parameters from the vegetation and soil/hydrology categories, as stated in the referenced methods[26]. Scores are summarized in Table 4. The health ratings are categorized as follows:

- Healthy (80 – 100%): Little or no impairment to riparian functions.
- Healthy but with Problems (60 – 79%): Some impairment to riparian functions due to human or natural causes.
- Unhealthy (<60%): Impairment to many riparian functions due to human or natural causes.

Table 4 Riparian Health Assessment Scores for Project Sites

Parameter	Site		
	1	2	4
Vegetation			
Vegetation Health Rating (%)	54%	33%	28%
Soil / Hydrology			
Soil / Hydrology Health Rating (%)	33%	25%	29%
Overall			
Overall Health Rating (%)	43%	29%	29%
Overall Health Rating Category	Unhealthy	Unhealthy	Unhealthy

The health rating category results of the RHA were compared to the results of the Cows and Fish *Riparian Health Inventory Summary Report* for the BOW95 Site[27], which overlaps with the Project locations. The overall 'Unhealthy' rating of Site 1, Site 2 and Site 4, was consistent with the conclusions of the Cows and Fish *Riparian Assessment* for those areas.

Overall, the riparian health of the current Project area is considered 'Unhealthy' due to the heavily disturbed condition, which resluted from severe bank erosion, historical bank protection efforts, and human use. Site 4 is 'improving' given the riparian planting that was part of stream bank restoration and stabilization work after the 2013 flood. The Project's bioengineering designs and landscape planting plans are intended to improve the riparian health of the Project lands, and contribute to fish and terrestrial wildlife habitat value, ultimately increasing biodiversity in the Project area.

25 Hemmera Envirochem Ltd. "Riparian Health Assessment".
26 Cows and Fish, *Wetland Health Assessment*.
27 Cows and Fish, "Riparian Health Inventory Summary Report: BOW95" Inglewood Bioengineering Demo Proposed Site, Calgary (2016).

3.3 BENTHIC MACROINVERTEBRATES

Background information related to the benthic invertebrate community in Project area, collected in 2017, has been provided below for context only. While it is acknowledged that benthic invertebrates provide an indicator of stream health, monitoring of trends related to benthic invertebrates will not form part of the scope of the BEMP. Studies have shown[28] that benthic invertebrates recover quickly from short-term disturbances, suggesting that there is limited value in monitoring this parameter as part of the BEMP's proposed 10 year monitoring period. Additionally, significant in-stream disturbance has already occurred in this reach of the Bow River from other flood mitigation works (e.g. Harvey Passage), making it very difficult to establish a baseline for benthic macroinvertebrate assessment.

The general aquatic environment for Sites 1, 2, and 4 consist of riffles and Class 1 runs (1.0 m), with boulder, cobble, gravel, and fines[29]. Based on these characteristics, it is expected that a benthic community would be composed largely of benthic invertebrates associated with larger particle size and swift water, such as orders Ephemeroptera (Mayflies), Plecoptera (Stoneflies), and Trichoptera (Caddisflies) (EPT), with some Chironomidae and burrowing species. In general, a higher percentage of EPT in a stream suggests a healthier aquatic ecosystem, as EPT have lower tolerance for environmental changes and pollution, compared to others such as the Chironomidae family, which can survive in areas with a higher fine sediment load and pollutant concentration[30].

A report prepared for Alberta Environment (AENV)[31] on the Bow River, classified the aquatic ecosystem health of primary producers in the upper reaches of this watershed as 'good', and 'marginal' in the middle reach downstream of The City of Calgary. In general, there are limited data for benthic invertebrates in the Bow River at the site locations.

While not required to support BEMP implementation, as part of Phase 1 of The City's RMP, baseline sampling of the benthic invertebrate community at the Project location was conducted in 2017.

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28 Anderson et al. "Impacts and Recovery in a Coldwater Stream Following a Natural Gas Pipeline Crossing Installation" Proceedings of the International Pipeline Conference 1998: American Society of Mechanical Engineers. (1998); Collier et al. "Stream Ecology. Bouncing Back: How fast can stream invertebrates recolonize?" *Water and Atmosphere* 10.2 (2002); Reid, S.M. and P.G. Anderson. "Effects of Sediment Released During Open cut Pipeline Water Crossings". *Canadian Water Resources Journal* 24.3 (1999); Reid, S.M. et al. "Effects of natural gas pipeline water crossing replacement on the benthic invertebrates and fish communities of Big Darby Creek, OH". 7th International Symposium on Environmental Concerns in Right of Way Management, Calgary, AB (2002).

29 Hemmera Envirochem Ltd., "fish Habitat Assessment".

30 Benoit, C. et al. "Aquatic Insects as Water Quality Indicators in the Elbow River Watershed, Alberta".*ENSC 502*. University of Calgary (2016).

31 North/South Consultants, *Summary Report of the Initial Assessment of Ecological Health of Aquatic Ecosystems in Alberta: Water Quality, Sediment Quality and Non-Fish Biota*. Prepared for Alberta Environment (Edmonton, 2007).

3.4 WILDLIFE

A desktop review of available wildlife information was completed using the Fisheries and Wildlife Management Information System[32]. The results are summarized in **Table 5,** and provided in **Appendix A**. This species summary report identified several listed species within 1km of the Project site. A search of the Wildlife Sensitivity Maps indicated that Sites 1, 2, and 4 overlap with key range layers for bald eagles, golden eagles, prairie falcons, and sharp-tailed grouses[33].

Table 5 Provincially or Federally Listed Species with Documented Occurrences within 1 km of Project Sites

Species	Scientific Name	Provincial Ranking[34]	SARA Schedule[35]	COSEWIC Ranking[36]
Bald eagle	*Haliaeetus leucocephalus*	Sensitive	-	-
Baltimore oriole	*Icterus galbula*	Sensitive	-	-
Eastern kingbird	*Tyrannus tyrannus*	Sensitive	-	-
Common nighthawk	*Chordeiles minor*	Sensitive	Schedule 1	Threatened
Great blue heron	*Ardea herodias*	Sensitive	-	-
Harlequin duck	*Histrionicus histrionicus*	Sensitive	-	-
Least flycatcher	*Empidonax minimus*	Sensitive	-	-
Northern goshawk	*Accipiter gentilis*	Sensitive	-	-
Silver-haired bat	*Lasionycteris noctivagans*	Sensitive	-	-
Sora	*Porzana carolina*	Sensitive	-	-
Western grebe	*Aechmophorus occidentalis*	Sensitive	No Schedule	No Status
Western wood-pewee	*Contopus sordidulus*	Sensitive	-	-

A terrestrial assessment,, including wildlife species, was conducted in 2016[37]. This assessment is described in the Project's *Preliminary Natural Assessment Report*[38]. It is notable that wildlife habitat observed at the three sites contained riparian habitat that could provide nesting sites for various breeding bird species, including bank swallows and raptors, such as bald eagles.

32 FWMIS, "Area-Specific Search Request".
33 Alberta Environment and Parks. *Wildlife Sensitivity Maps* (2017). http://aep.alberta.ca/forms-maps-services/maps/wildlife-sensitivity-maps/default.aspx. (accessed on 13 April 2017)
34 Alberta Environment and Parks. *Wild Species Status Search* (2017). http://aep.alberta.ca/fish-wildlife/species-at-risk/wild-species-status-search.aspx. (accessed on 13 April 2017)
35 Environment and Climate Change Canada (ECCC). *Species at Risk Public Registry Species Index* (2017). http://www.registrelep-sararegistry.gc.ca/sar/index/default_e.cfm
36 ECCC, *Species at Risk*.
37 Hemmera Envirochem Ltd. "Riparian Health Assessment".
38 Hemmera Envirochem Ltd.. "Preliminary Natural Site Assessment, Bow River, Alberta". *Bioengineering Demonstration and Education Project*, 2017.

Riparian habitat with exposed banks can provide areas for nesting bank swallow colonies. The *Final Design Report*[39] identified a bank swallow colony near Site 2. This bank swallow colony was also observed during site reconnaissance, along with another bank swallow colony near Site 4[40]. Bank swallows are listed by AEP as Sensitive in Alberta[41] . They are listed as Threatened by COSEWIC, and have no status under SARA[42].

Site 1 contains several mature trees that have the potential to support breeding for some of the avifauna species in **Table 5**. These trees will be removed, as part of Project activities, outside of the nesting season for breeding birds in nesting zone B4 (April 22 - August 17)[43] There are no mature trees in Sites 2 and 4 that would support breeding. No great blue heron rookeries were observed at any of the sites during the site visits. Surrounding habitat at Peace Estate Park and adjacent neighbourhoods to the Sites contained forested areas that may also provide nesting habitat for raptors.

3.5 BIOENGINEERING STRUCTURES/INSTALMENTS

The designed bioengineering bank protection and fish habitat enhancement measures are based on the information, design basis, and analysis presented by KWL[44], and are designed to withstand the assumed river and ice forces described in this report. They are also meant to be relatively resilient and self-healing, as rock riprap shifts and self-launches in response to river and ice forces. In this manner, the proposed works are meant to avoid a catastrophic loss of integrity, but are otherwise categorized as perpetual maintenance structures.

Drone reconnaissance conducted by Skymatics Ltd. documented the existing baseline conditions of the Project area, by collecting photos of the riverbank along a georeferenced flight path. While the sampling protocols and budget presented in the BEMP do not provide for visual monitoring of site conditions, these aerial images of pre-construction conditions could be used to support future monitoring of changes post-cinstruction. This electronic information is available from Skymatics upon request.

The success of the Project depends significantly on quality of installation, quality of live material used (e.g. dormancy of live cuttings, stock handling until placement) and maintenance, including weeding, watering, mulching, mowing, and monitoring. Inspection of these works is important to identify any damage to the works as early as possible, to ensure the structures are repaired in a timely manner. Permanent photo locations should be set when structures are installed. Monitoring and maintenance costs will be included in annual budgets to guarantee lengthy service life of these structures.

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39 Kerr Wood Leidal Associates Ltd., *Final Design Report Bioengineering Demonstration and Education Project (BDEP), Technical Memorandum*. Prepared for Alberta Environment and Parks (2017).

40 Hemmera Envirochem Ltd., “Preliminary Natural Site Assessment”; Hemmera Envirochem Ltd., »Technical Memorandum : Summary of Terrestrial Assessments” *Bioengineering Demonstration and Education Project*. Prepared for Alberta Environment and Parks, 2017.

41 Alberta Environment and Parks. *Wild Species Status.*

42 ECCC, *Species at Risk*

43 Environment and Climate Change Canada (ECCC), *General Nesting Periods of Migratory Birds in Canada* (2016). http://www.ec.gc.ca/paom-itmb/default.asp?lang=En&n=4f39a78f-1#_fig01

44 Kerr Wood Leidal Associsates Ltd., *Final Design Report.*

4.0 BIOENGINEERING EFFICACY MONITORING PLAN

The detailed description of proposed bioengineering treatments for Sites 1, 2, and 4 are provided in the *Final Design Report*[45] and summarized in **Table 5**. All data and site details obtained from the BEMP outlined below will be reported each year in which monitoring occurs, as well as discussed cumulatively and comparatively at either the five or ten year post-construction monitoring interval. Annual monitoring reports will be made available to all stakeholders involved in the educational component of the Project.

The BEMP will focus on evaluating potential enhancement values at and among all of the sites over a ten-year period. Elements that will be included during the BEMP are fish and fish habitat, riparian heath, wildlife, and structural integrity considerations. The scope, frequency and timing of efficacy monitoring visits are unique for each of these elements, and are defined independently below.

Although a total of five monitoring years (2019, 2020, 2021, 2023, and 2028), over a 10-year period, have been scheduled for BEMP activities, it is anticipated that in the event of significant flood event(s) contingency monitoring may be required to assess potential damage to the Project's works. In this instance, a resetting of the BEMP monitoring frequency will be needed and will be dependant on the timing of the flood event(s). Although the timing of this contingency monitoring is not confirmed in the BEMP, a contingency budget is included for this purpose in the Project budget (Appendix B).

4.1 FISH AND FISH HABITAT

All assessments of fish habitat use and potential will be completed by a crew of either two or three, depending on the potential use of a boat, and led by a Qualified Aquatic Environment Specialist (QAES). Assessments for Sites 1, 2, and 4 will be completed in multiple seasons (spring, summer, fall, and winter), in each of 2019, 2020, 2021, 2023, and 2028.

SPRING

A spring assessment of fish use, occurring post-ice-off, but pre-freshet (late April to May), will be completed for all sites. The goal is to document fish presence during the potential spawning period of rainbow trout and to best observe the condition, functionality, and use of underwater elements by fish (e.g. boulder cluster, riprap apron, crib wall fish shelters). Fish sampling (e.g. electrofishing) during the spring period is unlikely, given its concurrence to a presumed spawning period of rainbow trout; all fish observations will be completed by underwater camera or via snorkelling surveys. This assessment will include a spawning survey (redd survey) focussing on rainbow trout, which will extend from 500m upstream of Site 1, through all riverine habitat adjacent to Sites 2 and 4, to 500m downstream of the downstream extent of Site 4. Given the comparatively subjective nature of underwater observations and potential for limited rainbow trout spawning, comparative analysis of pre and post-construction observations will yield limited value. Rather, observations made during these assessments are intended exclusively to provide validation of fish use of the Project's enhancement structures.

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45 Kerr Wood Leidal Associsates Ltd., *Final Design Report.*

SUMMER

A more comprehensive fish habitat assessment, including quantification of in-stream and near-stream characteristics of value to fish, will be completed post-freshet (July – August) in each sampling year (summer assessment). The timing is intended to coincide with declining water levels, increasing water clarity, and the growing season for riparian vegetation. Based on this timing, it is anticipated that permission to sample fish communities will be granted by AEP Fisheries Management staff, since rainbow trout fry emergence (if spawning occurs in the area) will have occurred and that spawning by other species of management concern will not have begun. The same timing (or as near as possible) will be used in each subsequent summer sampling season.

During the summer assessment, habitat data will be collected to quantify in-stream and near-stream conditions and document habitat enhancement values. Enhancement values will be compared to those predicted by the Project's DFO Self Assessment Analysis[46]. Habitat assessment data will be collected at the site location, as well as upstream to 100m and downstream to 600m from the site location, and will include:

- Transect data approximately every 100m in the assessed reach, including measurements of bankfull width, wetted width, and bank height, recorded to the nearest 0.1m.
- A photographic assessment of fish habitat enhancements (e.g. boulder clusters) and bank stabilization features (e.g. bank riprap) installed at the site locations (Site 1-1 to Site 1-4) to support visual assessments of physical habitat quality and stability.
- Collection of water quality data (e.g. dissolved oxygen, temperature, conductivity, and pH) from site locations and reference location. A reference water quality sampling location will be established upstream of the Project area, at the same location used for the benthic invertebrate assessment (**Section 3.1.3**). Water quality parameters (dissolved oxygen, conductivity, pH, and water temperature) can be collected using a handheld water quality meter, such as a YSI 556. and CHEMets Kit (Dissolved Oxygen K-7512). Water quality data will be compared against standards identified in the Canadian Council of Ministers of the Environment (CCME) *Guidelines for the Protection of Freshwater Organisms*[47].
- Channel pattern, substrate type, confinement, embeddedness, stream shading, stage, in-stream and near-stream cover (e.g. overhanging vegetation, woody debris, in-stream vegetation, boulder, undercut banks, and depth), and other water body characteristics. Refer to the Project's QAES report for a complete listing of characteristics to be reported on.

46 Hemmera Envirochem Ltd., "fish Habitat Assessment".
47 CCME, "Canadian Water Quality Guidelines".

Based on data collected, and observations made, during the summer assessment, fish habitat potential ratings will be assigned, using the same qualification as defined in the Project's QAES report, as 'essential', 'important', 'marginal', or 'unsuitable'. Alternatively, habitat data collected during the BEMP can be translated to accommodate other sampling/analytic protocols, particularly if there is a preference to enable evaluation of enhancement values according to HSI indices and weighted habitat unit (WHU) values.

The presence and relative abundance of fish will be assessed during the summer assessment, potentially with a proxy baseline evaluation against values from AEP Resource Management index sampling results from nearby and similarly characterized habitat. Single pass electrofishing and passive trapping methods will be used in each sampling year and will be replicated using equipment and effort as near identical between years as possible (e.g. placement of traps will occur at the same locations and electrofishing effort will be maintained among years). All water quality and fisheries work will follow applicable regulatory guidelines, as cited in the Fish and Fish Habitat Assessment Report[48]. Note that if a motorized boat is used for potential assessments, a Vessel Operation Restriction Regulations Permit approval will be required from the of the Navigation Protection Program (Transport Canada). Fish sampling will use the following methods:

- A portable electrofisher (e.g.,Smith Root™ Type VI-A or 2.5 GPP) mounted on zodiac inflatable boat will be used over the entire length of the site locations.
- G-type minnow traps, placed at site locations as determined by a QAES and at bioengineering instalments (e.g. Site 1-3 and Site 1-4).

Captured fish will be recorded by species, length, and weight, and returned unharmed to the capture location. Catch per Unit Effort (CPUE) by species will be recorded as an indirect measure of fish abundance at the site location and reference site. Location of fish relative to habitat unit types (e.g. riffle, run, back water), and fish habitat enhancements (e.g. boulder clusters) will be documented to determine fish use of differing habitat types and enhancements. Fish species composition and abundance data will be compared with historical data (if available), as well as between the sites.

FALL

Like the spring assessment, observations of the use of Project enhanced elements will be completed in each sampling year, in late October or early November (fall assessment). Using an underwater camera, observations will be collected via boat, shore, or snorkel surveys. The assessment will be used to observe the potential use of habitat within, and adjacent to, in-stream enhancement features (e.g. boulder cluster, riprap apron, crib wall fish shelters), particularly by fall spawning species (e.g. brown trout). The fall assessment will include a spawning survey (redd survey) focussing on brown trout, which will extend from 500m upstream of Site 1, through all riverine habitat adjacent to Sites 2 and 4, to 500m downstream of the downstream extent of Site 4. Sampling of mountain whitefish eggs will also be completed using kick nets or water propulsion pumps at transects downstream from suitable mountain whitefish spawning habitat.

[48] Hemmera Envirochem Ltd., "fish Habitat Assessment".

Transect locations and sampling efforts will be established in the first sampling event and replicated in each subsequent year. As with the spring survey, resulting spawning data is only to provide validation of fish use of the Project's enhancement structures during critical life stages.

WINTER

A shore-based winter assessment (January) will be conducted at Sites 1-3 and Site 1-4, conditions and safety permitting, to confirm or refute the potential of overwinter use of the fish shelter constructed under the vegetated timber crib wall[49]. An assessment will also be conducted at Site 2-1 and Site 2-2 to confirm or refute the potential of overwintering use of near-bank habitat, adjacent to the box fascines. Sampling will likely require the use of underwater camera(s), or opportunistic snorkel observations, ice cover and flow conditions permitting.

4.2 RIPARIAN HEALTH

The RHA for the sites will be conducted in the late summer/early fall of 2019, 2020, 2021, 2023, and 2028 by an ecologist and/or a vegetation/wetland specialist. Given the expected concurrence of The City's RMP (at least over the first five years, post-construction), BEMP methods and analysis of the RHA will be as defined as those employed in The City's RMP. The RHA methods that will be used as part of The City's RMP include:

- RHAs for Sites 1, 2, and 4 are concurrent with the Bank Effectiveness Monitoring of these sites as part of the RMP. This will follow the *Alberta Wetland Health Assessment for Large River Systems* methodology[50]. As the sites are part of a Large River RHA, 15 parameters will be assessed, from which an overall health rating will be determined.
- As part of the Trend Monitoring component of the RMP, a revisit of the 2016 BOW95 RHI Polygon will be conducted at 5-year intervals. This polygon extends from the 17 Avenue SW Bridge to the downstream extent of Site 4. This will entail completion of a detailed Riparian Inventory following the Cows and Fish *Alberta Lotic Wetland Inventory* protocol[51]. A Riparian Health Assessment Score is derived from the detailed vegetation and physical RHI data. Health score ratings for RHI and RHA sites are based on the same scoring convention for the same 15 parameters, but more in-depth monitoring data on plant community composition and structure is collected for RHIs.

49 Kerr Wood Leidal Associsates Ltd., *Final Design Report.*
50 Cows and Fish, *Wetland Health Assessment*.
51 Cows and Fish. *Alberta Lotic Wetland Inventory Form User Manual* (2017). *http://cowsandfish.org/riparian/documents/2017AlbertaLoticInventoryManualCowsandFish.pdf*

4.3 WILDLIFE

Wildlife surveys will occur in the monitoring years 2019, 2020, 2021, 2023, and 2028, during the month of June, to assess breeding bird activity. This assessment will be completed in accordance with the Sensitive Species Inventory Guidelines[52] for breeding bird surveys on each affected site. Other surveys specific to each site include:

SITE 1

- A nest search will be conducted during monitoring years, from Site 1-1 to Site 1-4, to identify any nesting species, including raptors.
- While not provided for in the sampling protocols or budget presented in the BEMP, remote camera installation and/or track counts could be an ancillary wildlife monitoring activity, to determine if wildlife corridors proposed at Site 1-1 and Site 1-2 are actively being used. This would likely require four visits/year to change data cards and batteries. Track counts might be an opportunity for citizen science.

SITE 2

- A nest search will be conducted during monitoring years, from Site 2-1 to Site 2-2, to identify any nesting species, including raptors and bank swallows. Bank swallow colonies will be monitored to determine the number of breeding adults present.

SITE 4

- A nest search will be conducted during monitoring years, from Site 4-1 to Site 4-3, to identify any nesting species, including raptors and bank swallows. Bank swallow colonies will be monitored to determine the number of breeding adults present.

4.4 BIOENGINEERING STRUCTURAL INTEGRITY

The bioengineering structures and instalments are intended to provide long-term bank protection. Bioengineering structures and instalments at Sites 1, 2, and 4 summarized in **Table 6**[53] will be inspected during monitoring years 2019, 2020, 2021, 2023, and 2028 at key intervals, including:

- A high-water inspection during annual freshet events (June/July);
- A summer inspection, during the growing season in late August, will enable vegetation survivorship evaluations.

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52 Environment and Sustainable Resource Development (ESRD), *Wildlife Management: Sensitive Species Inventory Guidelines* (Government of Alberta, 2013) http://aep.alberta.ca/fish-wildlife/wildlife-management/documents/SensitiveSpeciesInventoryGuidelines-Apr18-2019.pdf

53 Kerr Wood Leidal Associsates Ltd., *Final Design Report.*

Monitoring of the structural integrity, stability and operational effectiveness of the bioengineering features will be the priority during these site visits, and remedial needs will be reported immediately so that corrective actions can be implemented. BEMP structural integrity monitoring will focus on the long-term structural integrity of bioengineering structures (i.e. long term performance of physical structures) including identifying typical ongoing maintenance that may be required, such as after the annual freshet.

BEMP structural integrity monitoring will be provided by the RMP, which includes detailed structural integrity monitoring protocols, as part of its Bank Effectiveness Monitoring component, which overlaps with the BEMP Bioengineering Structural Integrity component. BEMP timelines will be followed for the Project as part of the RMP, but the RMP will define specific monitoring methods, analysis, and reporting.

Protocols for monitoring the structural integrity of bioengineering structures, as described above, are separate and distinct from the monitoring of physical works that is required and will be undertaken as part of the BDEP construction contract (i.e. quality monitoring relative to design specifications).

Drone reconnaissance conducted by Skymatics Ltd. documented the existing baseline conditions of the Project area, by collecting photos of the riverbank along a georeferenced flight path. While the sampling protocols and budget presented in the BEMP do not provide for visual monitoring of site conditions, these aerial images of pre-construction conditions could be used to support future monitoring of changes post-cinstruction. This electronic information is available from Skymatics upon request.

Table 6 Summary of Bioengineering Techniques Proposed by the Project

Technique Name	Description	Proposed Location
Box Fascine	Fascine bundles placed at the toe of an eroding bank and secured between wooden poles[54].	Site 2-1, Site 2-2
Brush Layer	Row(s) of live cuttings placed in a crisscrossed or overlapping manner between layers of soil, with tips protruding beyond the face of the fill[55].	Site 1-3, Site 1-4 Site 2-1, Site 2-2
Brush Mattress	A layer of interlaced/adjacent live cuttings placed on the face of the riverbank[56].	Site 1-4 Site 2-2
Container Shrub Planting	Planting container stock seedling species that are selected for beneficial attributes, such as being fast growing, a natural colonizer, deep rooting, a nitrogen fixer, and a food producer[57].	Site 1-2, Site 1-3, Site 1-4 Site 2-2 Site 4-1, Site 4-2

54 AMEC, "Streambank Erosion and Potential Remedial Measures", *Design Guidelines for Erosion and Flood Control Projects Streambank and Riparian Stability Restoration.* Report submitted to The City of Calgary (2012), Guideline A.

55 D. H. Gray and R. Sotir, *Biotechnical & Soil Bioengineering Slope Stabilization: A Practical Guide for Erosion Control* (New York: John Wiley and Sons, 1996); AMEC, "Streambank Erosion", Guideline I1.

56 AMEC, "Streambank Erosion", Guideline I5.

57 AMEC, "Streambank Erosion", Guideline H; AMEC, "Streambank Erosion", Guideline L.

Technique Name	Description	Proposed Location
Contour Fascine	Fascines are live cuttings that are tied together in long bundles. Contour fascines are installed in shallow trenches constructed with a contour, and anchored in the trench using stakes[58].	Site 1-3, Site 1-4 Site 2-2
Live Staking	Insertion of live cuttings into the ground, to promote root growth and leaf-out[59].	Site 1-1, Site 1-2 Site 2-2 Site 4-3
Hedge Brush Layer	Layers of interlaced/adjacent live cuttings and rooted stock placed on the face of the riverbank[60].	Site 1-3, Site 1-4
Joint Planting	Live staking existing riprap to improve riparian, aquatic, and terrestrial habitats, while also improving aesthetics[61].	Site 4-3
Native Species Seeding	Planting of native stream bank and riparian species that are selected for beneficial attributes, such as being fast growing, a natural colonizer, deep rooting, a nitrogen fixer, and food producer[62].	Site 1-2, Site 1-3, Site 1-4 Site 2-2 Site 4-1, Site 4-2, Site 4-3
Soil-Covered Riprap	Covering existing riprap bank protection with soil and vegetation to improve riparian, aquatic, and terrestrial habitats, while also improving aesthetics[63].	Site 4-1
Vegetated Soil Wraps	Consists of brush layers interspersed between layers of soil, wrapped in natural geotextile materials that provide reinforcement[64].	Site 1-3, Site 1-4
Vegetated Timber Crib Wall	Consists of a hollow, box-like, interlocking arrangement of structural timber, filled with suitable backfill material, and layers of live cuttings[65].	Site 1-3, Site 1-4
Void-filled Riprap	Planting material inserted into void-spaces in existing riprap bank protection and planted with live cuttings or container shrub plantings, to improve riparian, aquatic, and terrestrial habitats, while also improving aesthetics[66].	Site 4-2, Site 4-3

58 AMEC, “Streambank Erosion”, Guideline I2.

59 Gray and Sotir, *Bioengineering Slope Stabilization*; AMEC, “Streambank Erosion”, Guideline H.

60 H.M. Schiechtl and R. Stern, *Water Bioengineering Techniques for Watercourse Bank and Shoreline Protection* (Boston: Wiley-Blackwell, 1997); Gay Muhlberg and Nancy Moore, *Streambank Revegetation and Protection: A Guide for Alaska*, revised by Jeanne Walter and Dean Hughes (Juneau: Alaska Department of Fish and Game, 2005).

61 AMEC, “Streambank Erosion”, Guideline F.

62 AMEC, “Streambank Erosion”, Guideline L.

63 John McCullah and Donald Gray, *NCHRP Report 544*: *Environmentally Sensitive Channel- and Bank-Protection Measures* (Washington: Transportation Research Board, 2005).

64 Gray and Sotir, *Bioengineering Slope Stabilization*; McCullah and Gray, *Environmentally Sensitive.*

65 Gray and Sotir, *Bioengineering Slope Stabilization*; AMEC, “Streambank Erosion”, Guideline E.

66 Wulliman J. and D. Johns, *Demonstration Projects Illustrating Void-Filled Riprap Applications in Stream Restoration* (Lakewood: Prepared by Muller Engineering Company, Inc. for Urban Drainage and Flood Control District, 2011).

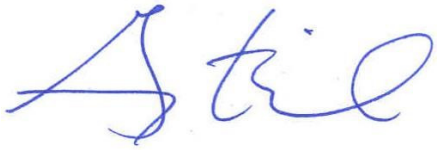
5.0 MONITORING SCHEDULE

The BEMP schedule for the Project Sites is presented in **Appendix C**. The schedule presented does not take into account potentially catastrophic flood events (such as the 2013 flood event), which could impact the ecological features and physical structures constructed as part of BDEP. However, the BEMP budget presented in **Appendix B** does include a contingency for undertaking additional 'baseline' data collection, following a potentially catastrophic flood event. In the case of such an event, and depending on the specific circumstances, the assumed monitoring schedule presented in **Appendix C** could be modified as required to provide for the most effective approach to monitor the long-term bio-efficacy of BDEP.

6.0 CLOSURE

We sincerely appreciate the opportunity to have assisted with this project. If there are any questions regarding the scope of work, or the preliminary budget anticipated to complete the work, please do not hesitate to contact the undersigned by phone.

Report was prepared by:
Hemmera Envirochem Inc.



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7.0 REFERENCES

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APPENDIX A

Fish and Wildlife Species Summary Report

Alberta Environment and Parks

Fish and Wildlife Internet Mapping Tool (FWIMT)

(source database: Fish and Wildlife Management Information System (FWMIS))

Species Summary Report

Report Created: 13-Apr-2017 09:51

Species present within the current extent :

Fish Inventory	Wildlife Inventory	Stocked Inventory
BROWN TROUT	BALD EAGLE	RAINBOW TROUT
LONGNOSE DACE	BALTIMORE ORIOLE	
MOUNTAIN WHITEFISH	COMMON NIGHTHAWK	
RAINBOW TROUT	EASTERN KINGBIRD	
	GREAT BLUE HERON	
	HARLEQUIN DUCK	
	LEAST FLYCATCHER	
	NORTHERN GOSHAWK	
	SILVER-HAIRED BAT	
	SORA	
	WESTERN GREBE	
	WESTERN WOOD-PEWEE	

Buffer Extent

Centroid (X,Y):	Projection	Centroid: (Qtr Sec Twp Rng Mer)	Buffer Radius:
569118, 5651980	10-TM AEP Forest	NW 12 24 1 5	1 kilometers

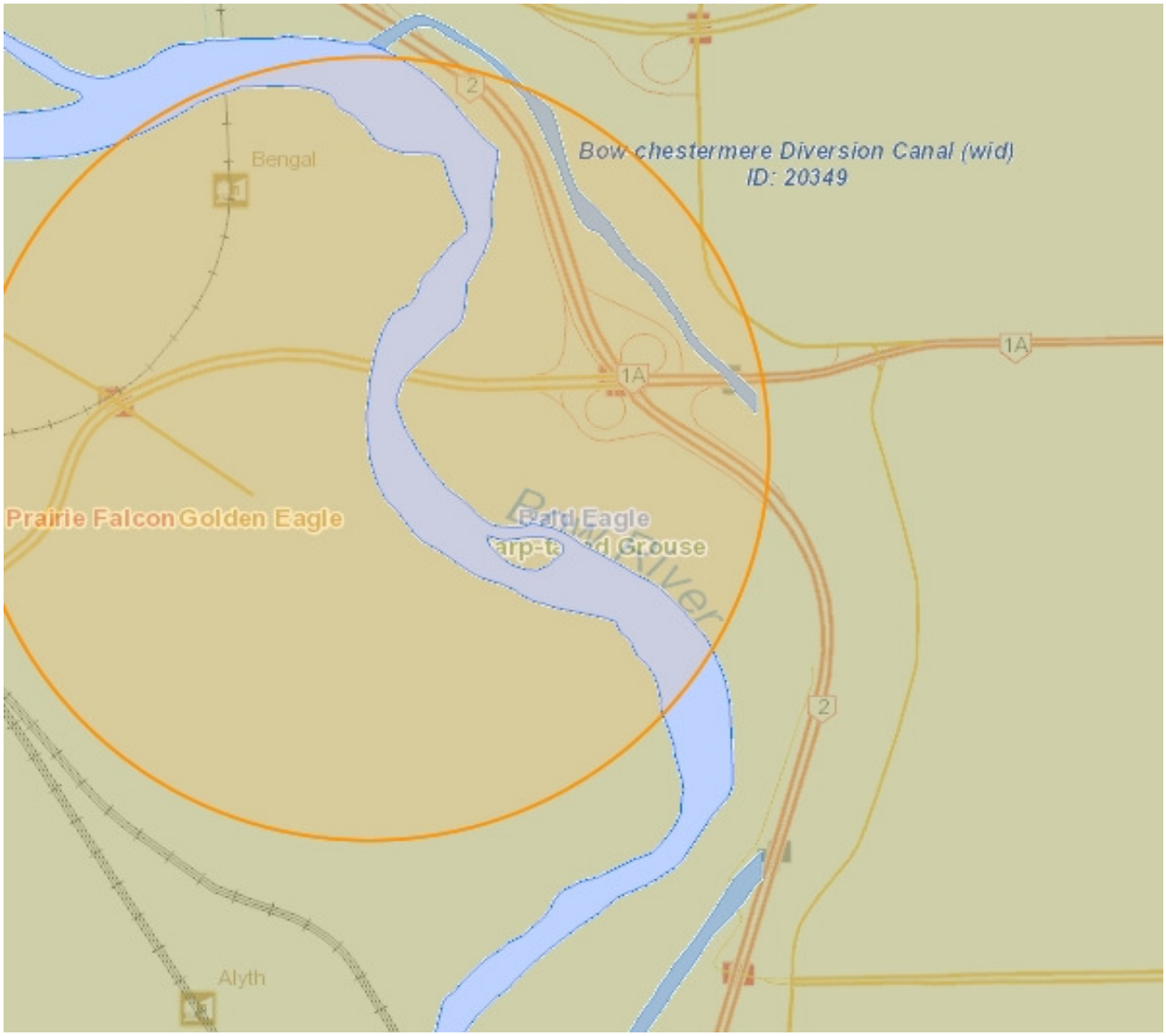
Contact Information

For contact information, please visit:

http://aep.alberta.ca/about-us/contact-us/fisheries-wildlife-management-area-contacts.aspx

13-Apr-2017 09:51

Map Results



APPENDIX B

Bio-Efficacy Monitoring Plan Projected Cost Estimate (December 12, 2017) - Summary

Appendix B: Bio-Efficacy Monitoring Plan Projected Cost Estimate (December 12, 2017) - Summary

Service Description	Details/Amount	TOTAL LABOUR HOURS	TOTAL LABOUR COST	Disbursements (exclusive of markup and GST)				TOTAL DISBURSEMENTS	SERVICE TOTAL
				Field Equipment, Supplies and Sample Shipping	Vehicle Rental	Laboratory Analytical[1]	Utility Locate and Surveying Subcontractor		
2019 Year 1									
Fish Habitat	4 times/year (included management of all other tasks over scope of project)	414	$55,959.75	$11,715.00	$1,250.00			$12,965.00	$68,924.75
Riparian Health	Annual	77	$9,822.75	$60.00	$250.00			$310.00	$10,132.75
Wildlife	Annual	75	$9,591.75	$380.00	$250.00			$630.00	$10,221.75
Bioengineering Structures	2 times/year	70	$9,943.50	$80.00	$500.00			$580.00	$10,523.50
2020 Year 2									$99,802.75
Fish Habitat	4 times/year	414	$55,959.75	$11,715.00	$1,250.00			$12,965.00	$68,924.75
Riparian Health	Annual	77	$9,822.75	$60.00	$250.00			$310.00	$10,132.75
Wildlife	Annual	75	$9,591.75	$380.00	$250.00			$630.00	$10,221.75
Bioengineering Structures	2 times/year	70	$9,943.50	$80.00	$500.00			$580.00	$10,523.50
2021 Year 3									$99,802.75
Fish Habitat	4 times/year	414	$55,959.75	$11,715.00	$1,250.00			$12,965.00	$68,924.75
Riparian Health	Annual	77	$9,822.75	$60.00	$250.00			$310.00	$10,132.75
Wildlife	Annual	75	$9,591.75	$380.00	$250.00			$630.00	$10,221.75
Bioengineering Structures	2 times/year	70	$9,943.50	$80.00	$500.00			$580.00	$10,523.50
2023 Year 5									$99,802.75
Fish Habitat	4 times/year	414	$55,959.75	$11,715.00	$1,250.00			$12,965.00	$68,924.75
Riparian Health	Annual	77	$9,822.75	$60.00	$250.00			$310.00	$10,132.75
Wildlife	Annual	75	$9,591.75	$380.00	$250.00			$630.00	$10,221.75
Bioengineering Structures	2 times/year	70	$9,943.50	$80.00	$500.00			$580.00	$10,523.50
2028 Year 10									$99,802.75
Fish Habitat	4 times/year	414	$55,959.75	$11,715.00	$1,250.00			$12,965.00	$68,924.75
Riparian Health	Annual	77	$9,822.75	$60.00	$250.00			$310.00	$10,132.75
Wildlife	Annual	75	$9,591.75	$380.00	$250.00			$630.00	$10,221.75
Bioengineering Structures	2 times/year	70	$9,943.50	$80.00	$500.00			$580.00	$10,523.50
2028 Cumulative Reporting									$99,802.75
Cumulative Report	Fisheries	140	$16,401.00					$0.00	$16,401.00
Cumulative Report	Riparian	53	$6,210.75					$0.00	$6,210.75
Cumulative Report	Wildlife	53	$6,210.75					$0.00	$6,210.75
Cumulative Report	Bioengineering	53	$6,210.75					$0.00	$6,210.75
									$35,033.25
Contingency Planning (in the event of a flood event at a TBD level)									
Assuming a scenario of a significant flood event (at a level to be determined) in spring 2020 requiring a re-sequencing of the monitoring program while retaining the sunset date of 2027 (tens years post-construction), monitoring would occur as orginally intended in 2020, 2022 and 2027, with the addition of replicated monitoring in 2021. This would enable a 'reset' for trend analysis and result in monitoring in the year of the flood as well as years 1, 2 and 6 post-flood .		636	$85,317.75	$12,235.00	$2,250.00	$0.00	$0.00	$14,485.00	$99,802.75
	TOTAL ESTIMATE	4115	$546,939.75	$61,175.00	$11,250.00	$0.00	$0.00	$72,425.00	$633,849.75
								GST	$31,692.49
	PROJECT TOTAL								$665,542.24

APPENDIX C

Bioengineering Efficacy Monitoring Plan Schedule

Appendix C: Bioengineering Efficacy Monitoring Plan Schedule

Monitoring Component	Season	2019												2020												2021												2023												2028											
		J	F	MA		MJ	J	A	S		ON	D		J	F	MA		MJ	J	A	S		ON	D		J	F	MA		MJ	J	A	S		ON	D		J	F	MA		MJ	J	A	S		ON	D		J	F	MA		MJ	J	A	S		ON	D	
Fish and Fish Habitat	Spring				■												■												■												■												■										
	Summer						■												■												■												■												■								
	Fall								■												■												■												■												■				
	Winter	■												■												■												■												■										
Riparian Health	Fall								■												■												■												■												■				
Wildlife	Summer					■												■												■												■												■								
Bioengineering Structural Stability	Spring					■												■												■												■												■								
	Summer							■												■												■												■												■								

KERR WOOD LEIDAL
consulting engineers

Appendix B

2020 Monitoring Report Bioengineering Demonstration and Education Project

Including:

- **Attachment A: Fish Assessment Photo Log**
- **Attachment B: Fish Assessment - Bow River Site Atlas**
- **Attachment C: Bow River Fish Habitat Map**
- **Attachment D: Raw Fish Data**
- **Attachment E: Wildlife Photo Log**

Prepared by: Hemmera Envirochem Inc.

2020 Monitoring Report Bioengineering Demonstration and Education Project

Prepared for:

City of Calgary

Project No. 103530-02

Prepared by:

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December 16, 2020

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ATTACHMENTS

1.0 FISH AND FISH HABITAT

1.1 Introduction

Hemmera Envirochem Inc's (Hemmera) has been retained by Kerr Wood Leidal Consulting Engineers (KWL) to implement the aquatics monitoring section of the Bio-efficacy Monitoring Program for the Bioengineering Demonstration and Education Project (BDEP) (**Figure 1**). Bio-efficacy monitoring at the BDEP site is being commissioned by the City of Calgary, as part of their larger Riparian Monitoring Program (a component of a Riparian Action Program), which is evaluating riparian habitat recovery at numerous sites within the city limits.

The following fish habitat enhancement and bioengineering structures were constructed at the BDEP site in Site 1, Site 2 and Site 4, and are presented in **Table 1** and **Figure 1**.

Bio-efficacy monitoring at the BDEP site by Hemmera is to include evaluation of fish habitat use and potential of the fish habitat enhancements at Sites 1, 2 and 4 as defined by the Bioengineering Demonstration and Education Project Efficacy Monitoring Plan (Hemmera 2018). 2020 was the second year of a multi year program (2019, 2020, 2021, 2023, and 2028), monitoring and reporting in 2020 will be limited to effectiveness monitoring for 2019 and 2020 and comparison to baseline conditions. Limited trend analysis from 2019 and 2020 will be reported in this year's report, and trend analysis over multiple years post-construction will be presented in subsequent reports.

Hemmera's team understands that the primary goal of BDEP is to achieve fish habitat enhancement and riparian restoration at flood affected and impacted sites using bioengineering techniques.

The goals for the Project, as per the Project Charter (Hemmera 2018), are to meet the following criteria:

- Effectively stabilize an area of unstable, steep bank.
- Initiate measurable restoration of flood-affected habitat or creation of new fish habitat (e.g. bank overhangs, in-stream refugia, boulder clusters, large woody debris, shade/cover by riparian plantings, etc.).
- Design and construct methods to facilitate increased awareness and understanding of flood recovery processes, development of new educational programming targeting bioengineering techniques, and related design success factors.
- Improve riverbank aesthetics in the area.

Table 1 Summary of Bioengineering Techniques used in the Project

Technical Name	Description	Proposed Location
Box Fascine	Fascine bundles placed at the toe of an eroding bank and secured between wooden poles.	Site 2
Brush Layer	Row(s) of live cuttings placed in a criss-cross or overlapping manner between layers of soil, with tips protruding beyond the face of the fill.	Site 1, Site 2
Brush Mattress	A layer of interlaced/adjacent live cuttings placed on the face of the riverbank.	Site 1, Site 2
Container Shrub Planting	Planting of container stock seedling species that are selected for beneficial attributes such as fast-growing, natural colonizer, deep rooting, nitrogen fixing, and food production.	Site 1, Site 2, Site 4
Contour Fascine	Fascines are live cuttings that are tied together in long bundles. Contour fascines are installed in shallow trenches constructed on contour, and anchored in the trench using stakes	Site 1, Site 2
Live Staking	Insertion of live cuttings into the ground in such a manner as to promote root growth and leaf-out.	Site 1, Site 2, Site 4
Hedge Brush Layer	Row(s) of live cuttings mixed with rooted stock placed in a crisscross or overlapping manner between layers of soil, with tips protruding beyond the face of the fill.	, Site 2
Joint Planting	Live staking of existing riprap to improve riparian, aquatic and terrestrial habitats while also improving aesthetics.	Site 4
Native Species Seeding	Planting of native streambank/riparian species that are selected for beneficial attributes such as fast-growing, natural colonizer, deep rooting, nitrogen fixing, and food production.	Site 1, Site 2, Site 4
Soil-Covered Riprap	Covering existing riprap bank protection with soil and vegetation to improve riparian, aquatic and terrestrial habitats while also improving aesthetics.	Site 4
Vegetated Soil Wraps	Consists of brush layers interspersed between layers of soil wrapped in natural geotextile materials that provides reinforcement.	Site 1
Vegetated Timber Crib Wall	Consists of a hollow, box-like interlocking arrangement of structural timber, filled with suitable backfill material and layers of live cuttings.	Site 1
Void-filled Riprap	Planting material inserted into void-spaces in existing riprap bank protection and planted with live cuttings or container shrub plantings to improve riparian, aquatic and terrestrial habitats while also improving aesthetics.	Site 4

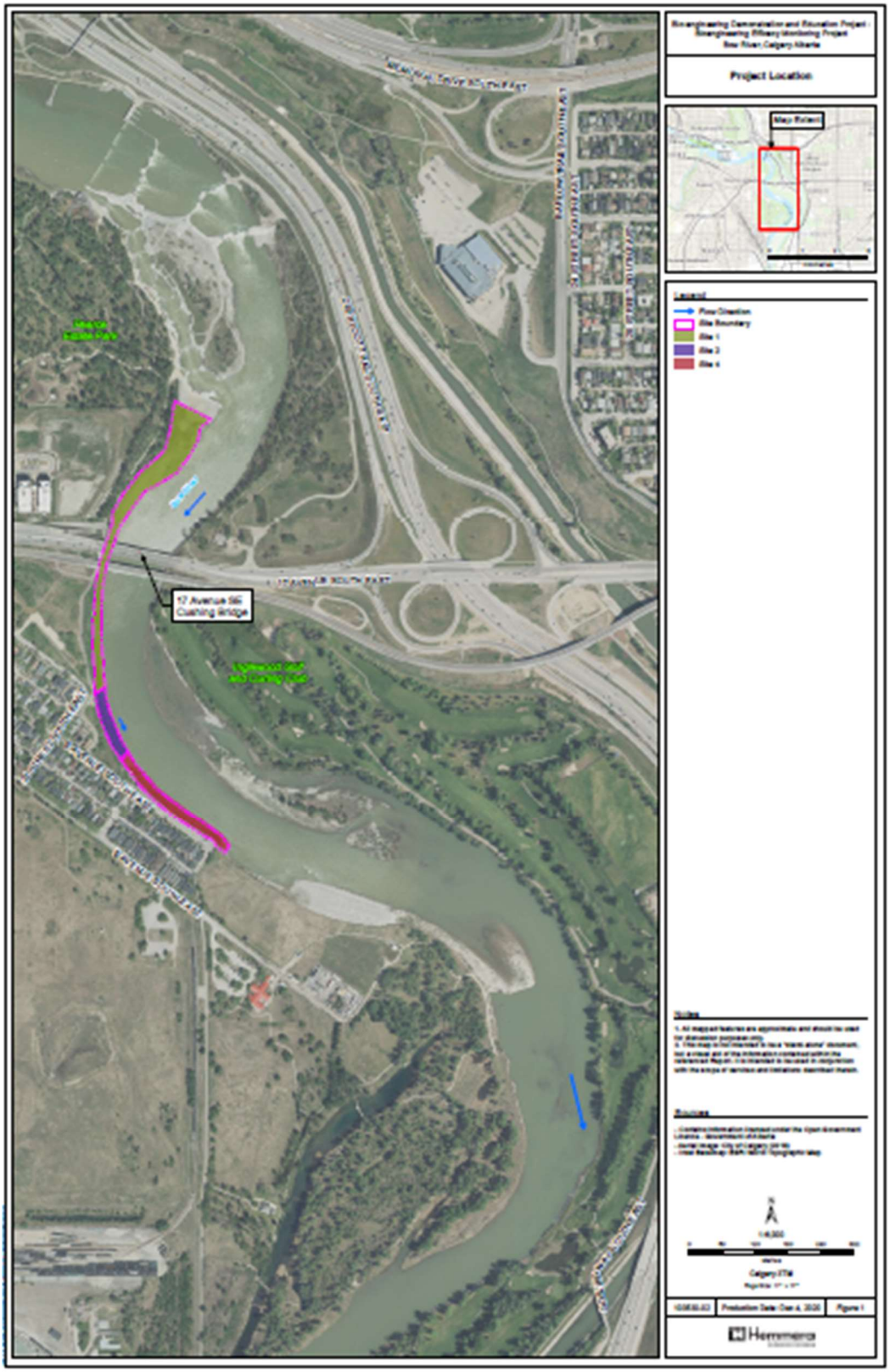

Figure 1 Project Location

1.2 Methods

All assessments of fish habitat and fish use were completed by a crew of two and led by a Qualified Aquatic Environment Specialist (QAES). Assessments for Sites 1, 2, and 4 were completed in multiple seasons (spring, summer, fall, and winter) in 2020 as shown in **Table 2**. Sampling locations are provided in **Figure 2**.

Table 2 Schedule of Field Assessments

Field Assessment	Details	Timing			
		Winter	Spring	Summer	Fall
Fish Use	Visual assessment of fish use of near bank habitat via underwater photography and snorkel survey	x	-	-	-
Fish Spawning Use	Visual surveys conducted from bank for rainbow trout (Spring) and brown trout (Fall) redds	-	x	-	x
	Sampling of mountain whitefish eggs via kick sampling	-	-	-	x
Fish Habitat Assessment	Collection of in-stream and near stream condition, documentation of fish habitat enhancements	-	-	x	-
Water Quality	Collection of water quality parameters from Site 1 and Site 4 and the upstream control location	x	x	x	x
Fish Sampling	Fish capture via single pass boat electrofishing and overnight set gee-style minnow traps	-	-	x	-
Photographic assessment of physical condition and stability	Establishment and assessment of photo monitoring stations	-	-	x	-

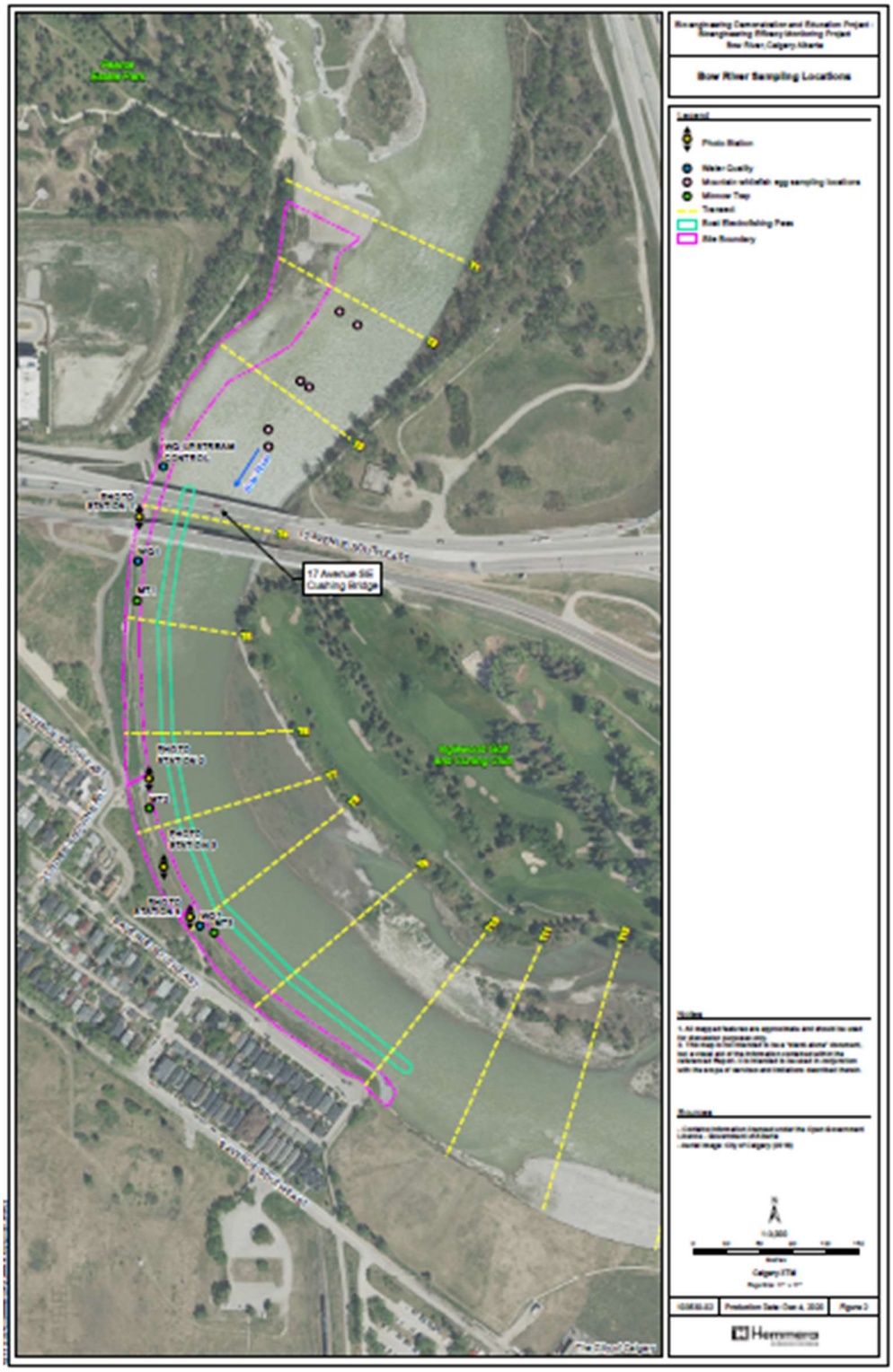

Figure 2 Sampling Locations

1.2.1 Winter

A shore-based winter assessment was required to document the potential of overwinter use of the within the fish habitat enhancement structures (i.e., vegetated timber crib wall and box fascines) at Sites 1 and 2. Sampling was conducted by a crew of three biologists, led by a QAES on January 7, 2020. Sampling required the use of an underwater camera (Go Pro™), and snorkel observations to document the potential of overwinter use of the fish shelter constructed under the vegetated timber crib wall at Site 1, and the near-bank habitat adjacent to the box fascines at Sites 2.

1.2.2 Spring

A spring assessment of fish use occurred post-freshet on June 18, 2020. The goal of this survey was to document fish presence during the potential spawning period of rainbow trout (*Oncorhynchus mykiss*) and to observe the condition, functionality, and use of underwater enhancement structures (e.g. boulder cluster, riprap apron, crib wall fish shelters) by fish. Due to the cool spring and prolonged run off, river conditions created unsafe conditions for snorkel surveys and spawning surveys as water levels were higher than normal and the water was very turbid. No fish sampling (e.g. electrofishing) occurred during the spring survey, given its concurrence to a presumed spawning period of rainbow trout.

This assessment was limited to site photos and in situ water quality parameters, assessment of substrate size/type, and habitat type (e.g., run, riffle, flat) that would facilitate or impede spawning efforts.

A spring spawning assessment was not conducted in 2020 due to high flows and turbid water creating unsafe conditions.

1.2.3 Summer

A more comprehensive fish habitat assessment, including quantification of in-stream and near-stream characteristics of value to fish, was completed from September 17 to 18, 2020. The timing was intended to coincide with declining water levels, increasing water clarity, and the growing season for riparian vegetation.

During the summer assessment, habitat data was collected to quantify in-stream and near-stream conditions and document habitat enhancement values. Enhancement values will be compared to those predicted by the Project's DFO Self Assessment Analysis. Habitat assessment data was collected at the from 100m upstream of Site 1, through all riverine habitat adjacent to Sites 2 and 4, to 600 m downstream of the downstream extent of Site 4, and included:

- Transect data approximately every 100 m in the assessed reach, including measurements of bankfull width, wetted width, and bank height, recorded to the nearest 0.1 m.
- A photographic assessment of fish habitat enhancements (e.g. boulder clusters) and bank stabilization features (e.g. bank riprap) installed at the Sites 1 to 4 to support visual assessments of physical habitat quality and stability.
- Collection of water quality data (e.g. dissolved oxygen, temperature, conductivity, and pH) from Site 1 and Site 4 and from the upstream control site location established upstream of the Project area. Water quality parameters (dissolved oxygen, conductivity, pH, and water temperature) was collected using a handheld water quality meter, such as an Aquatroll 500 and CHEMets Kit (Dissolved Oxygen K-7512). Water quality data were compared against standards identified in the Canadian Council of Ministers of the Environment (CCME) Guidelines for the Protection of Freshwater Organisms.

- Channel pattern, substrate type, confinement, embeddedness, stream shading, stage, in-stream and near-stream cover (e.g. overhanging vegetation, woody debris, in-stream vegetation, boulder, undercut banks, and depth), and other water body characteristics was also documented throughout the reach.

Based on data collected, and observations made, during the summer assessment, fish habitat potential ratings were assigned, using the qualification as defined in the Hemmera's Fish Habitat Sampling Field Guide V3.0 (2019), as 'preferred', 'suitable', 'marginal', or 'unsuitable'.

Fish sampling was conducted by a field crew of two fisheries biologists, led by a QAES, along a 750 m section of the Project area. Fish were sampled to determine fish presence and relative abundance within the Project sites. Fish sampling locations established in 2019 were sampled in 2020 using baited Gee-type minnow traps adjacent to the habitat enhancement structures at Sites 1, 2, and 4. All traps were baited with dry cat food and allowed to fish overnight to maximize fishing effort and efficiency. Traps were set for a maximum of 18 hours per the conditions of the Project's Fish Research Licence (No. 20-1511 RL, Government of Alberta 2019). Minnow traps were set in locations with low velocity to maintain the health and minimize the stress of the captured fish. The location of all minnow traps is shown in **Figure 2.** A single boat electrofishing pass was conducted by the field crew, using an electrofisher (Smith Root 2.5 GPP) mounted on a zodiac boat, through the length of the Project area. The location of the boat electrofishing pass is shown in **Figure 2.**

Fish captured during the assessment were held for processing in buckets containing water from the Bow River. Buckets were continually aerated with a bubbler and supplemented or replaced with oxygenated water as needed. All captured fish were enumerated, identified to species and life stage, measured (fork length), weighed, and released into a suitable area near the capture location. Fish capture data was analyzed to determine overall use of habitats within the study area, as well as species richness and abundance (i.e., CPUE). Fish species composition and abundance was compared between Sites 1 to 4 using Site 4 as the control site for the project.

1.2.4 Fall

Similar to the spring assessment, the purpose of the fall assessment was to document evidence of spawning brown trout (*Salmo trutta*) and mountain whitefish (*Prosopium williamsoni*) relative to the location of the underwater enhancement structures. The fall assessment was completed on December 2, 2020 after brown trout and mountain whitefish spawning periods. The assessment observed the potential use of habitat within, and adjacent to, in-stream enhancement structures (e.g. boulder cluster, riprap apron, crib wall fish shelters), particularly by fall spawning species (e.g. brown trout and mountain whitefish). The fall assessment included a spawning survey (redd survey) focusing on brown trout, which extended from 500m upstream of Site 1, through all riverine habitat adjacent to Sites 2 and 4, to 500 m downstream of the downstream extent of Site 4. Sampling of mountain whitefish eggs was completed using kick nets at transects downstream from suitable mountain whitefish spawning habitat. Transect locations and sampling efforts established in 2019 will be replicated in each subsequent year. As with the spring survey, resulting spawning data is only to provide validation of fish use of the Project's enhancement structures.

1.3 Results

1.3.1 Physical Condition Stability

A visual assessment of the bio-engineering treatments along the RDB of the Bow River at Sites 1, 2 and 4 was conducted during all four seasonal monitoring periods, to document the physical condition and stability of the area.

Results of the 2020 visual assessment and photographic data indicate that the physical condition of the treatments, including fish habitat structures (e.g., boulder clusters, fish shelters and box fascines), continue to be stable, with no signs of erosion, scour, or displacement. Photographic data collected from each of the established photo stations are presented in Attachment A, Photos 1 to 32.

1.3.2 Fish Habitat Characteristics

The assessed reach of the Bow River is characterized as a low gradient (i.e., <1%) and a regular meander pattern that is frequently confined by its valley walls. A summary of the fish habitat characteristics observed at each Site (i.e., Site 1, Site 2, and Site 4) during the summer fish habitat assessments are presented in Attachment B. A detailed fish habitat map of the assessed reach is presented in Attachment C. Fish habitat within each site in the Project area (i.e., Site 1, Site 2, and Site 4) is presented below, along with a summary of fish habitat for the entire assessed reach.

1.3.2.1 Site 1

The upstream boundary of Site 1 is located approximately 280 m upstream of the 17 Avenue Cushing Bridge, immediately downstream of Harvie Passage, with the downstream boundary located approximately 200 m downstream of the Cushing Bridge (**Figure 1**).

Fish habitat within the upstream section of Site 1 (downstream of Harvie Passage and upstream of the Cushing Bridge) consists of deep run (R1) habitat transitioning into riffle (RF) habitat back into deep run (R1) habitat through the thalweg and mid channel, with a shallow run (R3) along the RDB (Attachment C). Fish habitat within the area immediately surrounding the Cushing Bridge consists of R1 habitat through the mid channel thalweg, and P1 habitat along the RDB. R1 habitat extends through the downstream section of Site 1. Bankfull width and wetted width range from 180 m to 109 m and 155 m to 75 m, respectively. Bank stability is relatively stable along both banks in the upstream section of Site 1, with high stability along the left downstream bank (LDB) downstream of the Cushing Bridge. Bank stability is considered stable along the RDB immediately downstream of the Cushing Bridge. Deciduous trees, shrubs, and grasses are present along both the RDB and LDB.

Maximum water depth in 2020 ranges from 0.54 m in R3 habitat to approximately 7.00 m in R1 and P1 habitat. There is a deep scour hole present in the P1 habitat adjacent to Site 1 downstream of the Cushing Bridge with depths reaching over 7 m. This pool habitat is considered very important habitat, providing overwintering habitat and thermal refuge from summer water temperatures approaching or exceeding tolerance thresholds for trout (Hemmera 2018). Substrates throughout Site 1 consist primarily of boulder and cobbles in R1 and RF habitat. Pool habitat (P1) substrates consist primarily of boulder, cobble, and fines; consistent with substrates observed in the Hemmera Fish and Fish Habitat Assessment (2017). Cover throughout Site 1 is provided primarily by depth and turbulence, with limited overhanging cover provided by

woody vegetation along the LDB. Boulder substrates present throughout run and pool habitats likely provide instream cover for fish. Constructed fish shelters and boulder clusters also provide instream cover.

Deep run (R1) and pool (P1) habitat is likely utilized as 'suitable' holding, feeding, and overwintering habitat for adult and juvenile fish, with shallower R3 habitat functioning as holding and rearing habitat for juvenile fish. P1 and R1 habitat within the downstream section of Site 1 likely provides 'important' overwintering habitat, with a maximum water depth of approximately 7.00 m. Gravel and cobble substrates located at the downstream end of R3 habitat on RDB above Cushing's Bridge provides 'suitable' spawning habitat for rainbow trout and brown trout, and mountain whitefish spawning likely occurs over cobble and large gravels located in R1 habitat throughout the site.

1.3.2.2 Site 2

Site 2 is located approximately 260 m downstream of the 17 Avenue Cushing Bridge at the first riprap groyne constructed along the RDB, extending for approximately 140 m downstream to the downstream riprap groyne along the RDB to the upstream boundary of Site 4 (**Figure 1**).

Fish habitat within Site 2 consists almost entirely of a R1 habitat, with a P1 habitat located immediately downstream of riprap groynes constructed out into the Bow River at the upstream extent of the RDB of Site 2, adjacent to a city of Calgary pathway in Inglewood (Attachment C). Bankfull width and wetted width are relatively uniform throughout Site 2, approximately 170 m and 90 m, respectively. Bank stability along the RDB is high through the site as a result of the installation of box fascines and brush mattresses.

Water depth is relatively uniform through this section, ranging from 1 m to 2 m. P1 habitat immediately downstream of the upstream riprap groyne has a maximum depth of 4 m. Substrates consist primarily of boulder and large cobbles in R1 habitat and boulder and riprap within P1 habitat downstream of flood mitigation structures (groynes). Cover is provided primarily by depth and turbulence, and by boulder and riprap substrates. Large woody debris has accumulated within the P1 habitat immediately downstream of the upstream riprap groyne along the RDB. Large woody debris provides suitable overhanging and instream cover. Overhanging cover is otherwise severely limited throughout Site 2.

Deep run (R1) habitat likely provides 'suitable' holding, feeding, and overwintering habitat for adult and juvenile fish. P1 habitat present downstream of riprap groynes provides a velocity refuge for fish as well as 'suitable' holding, feeding, and potential overwintering habitat for juvenile and adult fish. There is 'marginal' spawning habitat for salmonids through this section of the Bow River due to the larger size of substrates.

1.3.2.3 Site 4

Site 4 is bounded on the upstream end by the downstream riprap groyne constructed along the RDB and extends to the downstream extent of bank armoring (**Figure 1**).

Fish habitat within Site 4 remains consistent with observations made during the Hemmera 2017 and 2019 assessment, with fish habitat comprised primarily of R1 habitat, transitioning into R2 habitat at the downstream end of the site (Hemmera 2017). Bankfull width and wetted width are relatively uniform throughout Site 4, ranging from 100 m to 230 m and 78 m to 170 m, respectively. Bank stability is very high, with the entire RDB composed of class II and class III riprap, and LDB heavily vegetated with shrubs and grasses. Substrate consists primarily of cobble and boulder with a maximum depth of approximately 1 m in

the thalweg. Cover is provided primarily by depth and turbulence and partially by large riprap present along the RDB and boulder substrate (Attachment C). Site 4 has little to no overhanging cover as a result of bank armoring along the RDB and lack of mature bank vegetation.

Deep run (R1) habitat provides 'suitable' holding and feeding habitat for adult and juvenile fish. R3 habitat present at the downstream end of Site 4 provides 'suitable' holding and feeding habitat for juvenile fish. Due to the maximum depth of approximately 1 m, this section of the Bow River provides 'marginal' overwintering habitat. There is 'marginal' spawning habitat for salmonids (e.g. brown trout and rainbow trout) due to the lack of suitable gravel substrates through the reach.

1.3.2.4 Summary

Fish habitat at all sites remains consistent with observations made during the 2019 assessment. The entire assessed reach is dominated by R1 habitat alternating with various pool habitat (P1 and P2), along the RDB.

Substrate throughout the assessed reach is dominated by boulder and cobble in run habitats (R1, R2, and R3), and cobble and large gravel in riffle habitat. Substrates within pool habitats (P1 and P2) consist primarily of boulder, cobble, and fines. Maximum water depth throughout the assessed reach ranges from 0.50 m to 6.95 m with an average of 1.50 m.

Bankfull width throughout the assessed reach ranges from 103 m to 232 m, with an average width of approximately 162 m. Wetted width ranges from 78 m to 171 m, with an average width of 114 m. Bank stability and shape throughout the assessed reach ranges from sloped and stable in areas armoured with riprap, to near vertical and stable along the RDB immediately downstream of the 17 Avenue Cushing Bridge. Banks consisted primarily of fines and cobble. Riparian vegetation is dominated by mature deciduous forest, with areas armoured by riprap dominated by shrubs and grasses.

1.3.3 Water Quality Field Parameters

Water quality parameters were collected at three water quality sampling stations throughout the four seasonal monitoring periods. Water quality stations established in 2019 were sampled in 2020. Two water quality stations were located in Site 1 and Site 4. A third station was established as a control site upstream of Cushing Bridge. The location of water quality sampling stations is presented in **Figure 2**.

In situ water quality parameters collected at each station included dissolved oxygen, pH, conductivity, and water temperature. The results of water quality sampling in Site 1 and Site 4 were compared to standards identified in the Canadian Council of Ministers of the Environment (CCME) Guidelines for the Protection of Freshwater Organisms (CCME 1999). Water quality parameters collected in Site 1 and 4 were also compared with the parameters collected in the upstream Control Reach to confirm that water quality in Sites 1 and 4 were similar to natural variation within the river.

Seasonal water quality parameters measured in 2020 are presented in **Table 3**. Overall, all water quality parameters measured in Site 1 and 4 and Control Reach were within federal guidelines (CCME 1999). Water quality measurements in 2020 were similar to measurements recorded in Year 1, showing similar seasonal variability in temperature, dissolved oxygen, and conductivity.

Table 3 Summary of Water Quality Data During the 2020 Bio-Efficacy Post-Construction Monitoring Program

Site	Season	Temperature (°C)	Dissolved Oxygen (mg/L)	pH	Conductivity (µS/cm)
Upstream Control	Winter	0.47	12.4	8.75	402.52
	Spring	7.98	10.89	8.45	448.90
	Summer	15.45	9.30	8.78	331.12
	Fall	0.55	13.11	8.71	379.60
Site 1	Winter	0.46	12.99	8.75	399.48
	Spring	7.67	11.01	8.66	449.15
	Summer	15.40	9.29	8.80	316.25
	Fall	0.68	12.98	8.65	386.89
Site 4	Winter	-0.01	12.78	8.70	404.07
	Spring	8.01	11.00	8.66	449.20
	Summer	15.78	9.21	8.66	317.29
	Fall	0.58	12.96	8.57	394.45

1.3.4 Fish Use

The fish enhancement structures within Site 2 (i.e. box fascines) were dry at the time of the winter assessment, preventing overwintering use of the structures by fish. Similar to 2019, one fish was observed utilizing the Site 1 fish shelters during the winter assessment; the fish could not be identified to species due to high turbidity present at the time of the survey.

During the summer assessment, a total of 45 fish consisting of 6 species were captured at Site 1, 42 fish consisting of 8 species were captured at Site 2, and 33 fish consisting of 3 species were captured at Site 4. Fish species richness separated by site within the Project area is presented in **Table 4**.

The Bow River, from its headwaters to the confluence with the Oldman River, is known to support 35 fish species (Fisheries and Wildlife Management Information System [FWMIS], 2019), however, within the vicinity of the Project (i.e., between Bearspaw and Carseland Dams) only 22 of these species, including 11 sportfish species, have a probable potential of occurrence. Of these 22 species, 10 were captured within the Project area in Year 1, including 6 sportfish and 4 non-sportfish species. In Year 2, 9 species were captured, including 5 sportfish and 4 non-sportfish species (**Table 4**). Total fish capture data is presented in **Table 5**; raw fish data is presented in Attachment D. Representative photos of each fish species captured in 2020 are presented in Attachment A, Photos 33 to 41

Table 4 2020 Bio-Efficacy Post-Construction Monitoring Program Fish Species Diversity

Common Name[1]	Scientific Name	Historic Presence in the Bow River[1]	BDEP Site		
			Site 1	Site 2	Site 3
SPORTFISH					
brook trout	*Salvelinus fontinalis*	X			

Common Name[1]	Scientific Name	Historic Presence in the Bow River[1]	BDEP Site		
			Site 1	Site 2	Site 3
bull trout	*Salvelinus confluentus*	X			
brown trout	*Salmo trutta*	X	X	X	X
burbot	*Lota lota*	X	X	X	
cutthroat trout[2]	*Oncorhynchus clarki*	X			
lake whitefish	*Coregonus clupeaformis*	X			
mountain whitefish	*Prosopium williamsoni*	X		X	
northern pike	*Esox lucius*	X		X	
rainbow trout[3]	*Oncorhynchus mykiss*	X	X	X	X
yellow perch[4]	*Perca flavescens*	X			
walleye	*Sander vitreus*	X			
NON-SPORTFISH					
brook stickleback	*Culaea inconstans*	X			
fathead minnow	*Pimephales promelas*	X			
lake chub	*Couesius plumbeus*	X			
longnose dace	*Rhinichthys cataractae*	X	X		
longnose sucker	*Catostomus catostomus*	X	X	X	X
mountain sucker	*Catostomus platyrhynchus*	X			
Prussian carp	*Carissius gibclio*	X			
pearl dace	*Margariscus margarita*	X			
spoonhead sculpin	*Cottus ricei*	X			
trout-perch	*Percopsis omiscomaycus*	X		X	
white sucker	*Catostomus commersoni*	X	X	X	
2020 Species Richness		22	6	8	3
2019 Species Richness			7	2	6

Sources:

1. List compiled from FWMIS, 2019; Nelson and Paetz, 1992.

Notes:

1. Cutthroat trout in the Bow River near the Project represent introduced stocks and are not considered native stocks of Westslope Cutthroat Trout (*Onchorhynchus clarkii lewisi*).
2. Rainbow trout in the Bow River near the Project represent introduced stocks and are not considered native stocks of Athabasca Rainbow Trout.
3. The historical range of yellow perch does not include the Bow River; however, numerous specimens have been captured in irrigation canals near the Project area.

Table 5 2020 Bio-Efficacy Post-Construction Monitoring Program Total Fish Numbers Captured Per Species

Site	BNTR	BURB	LKCH	LNDC	LNSC	MNWH	NRPK	RNTR	TRPR	WHSC	YLPR	Total
Site 1	2	1	0	1	12	0	0	26	0	3	0	45
Site 2	2	1	0	0	9	23	1	1	1	4	0	42
Site 4	5	0	0	0	25	0	0	3	0	0	0	33
2020 Total	9	2	0	1	46	23	1	30	1	7	0	120
2019 Total	2	1	1	1	18	1	1	4	0	10	9	48

Notes:

BNTR - Brown Trout, BURB – Burbot, LKCH – Lake Chub, LNDC – Longnose Dace, LNSC – Longnose Sucker, MNWH – Mountain Whitefish, NRPK – Northern Pike, RNTR – Rainbow Trout, TRPR – Trout Perch, WHSC - White Sucker, YLPR – Yellow Perch

A total of 8 fish and 2 species were captured using minnow trapping, including longnose sucker and white sucker. Minnow trap CPUE was determined for each trap as number of fish captured per trap-hour (fish/trap-hour). Minnow trap CPUE was greatest in Site 2 (0.0220 fish/trap-hour). Site 1 CPUE (0.0120 fish/trap hour). **Figure 3** summarizes minnow trap CPUE separated by site. In addition, CPUE was calculated for individual fish species as the number of fish per species per trap-hour (number per species/trap-hour), separated by reach. Overall, white sucker (*Catostomus commersoni*) had the greatest CPUE of all fish captured at each site. **Figure 4** presents minnow trap CPUE for individual fish species separated by site.

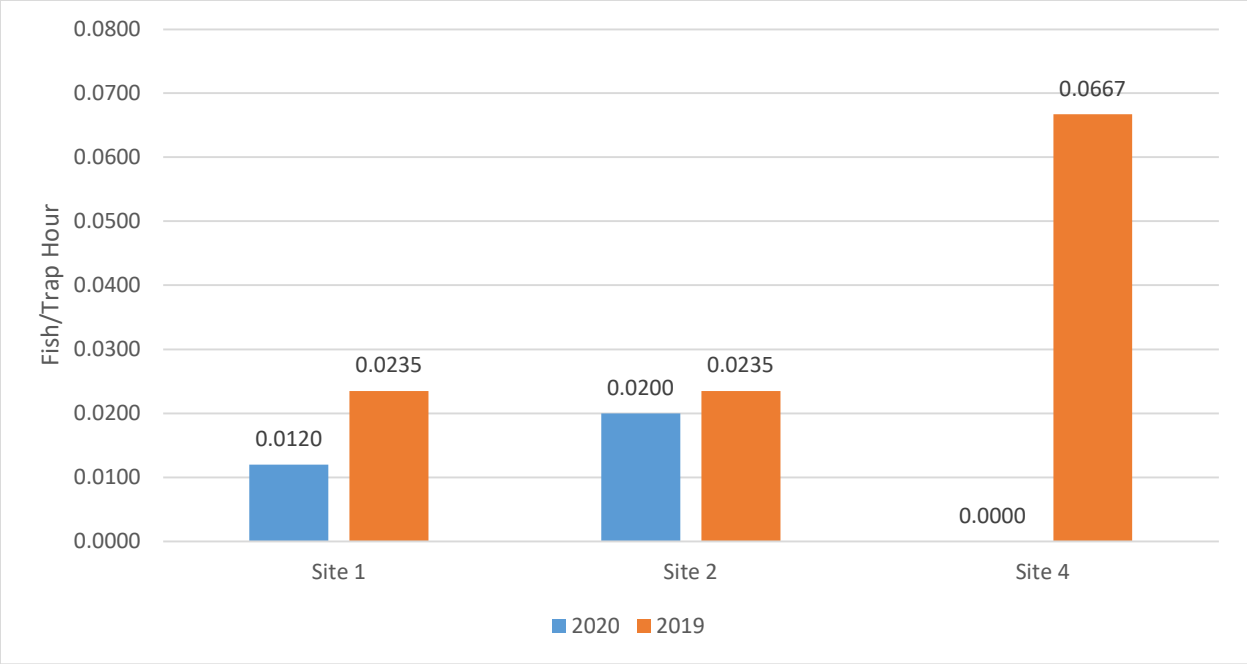

Figure 3 2020 Bio-Efficacy Post-Construction Monitoring Program Minnow Trapping CPUE

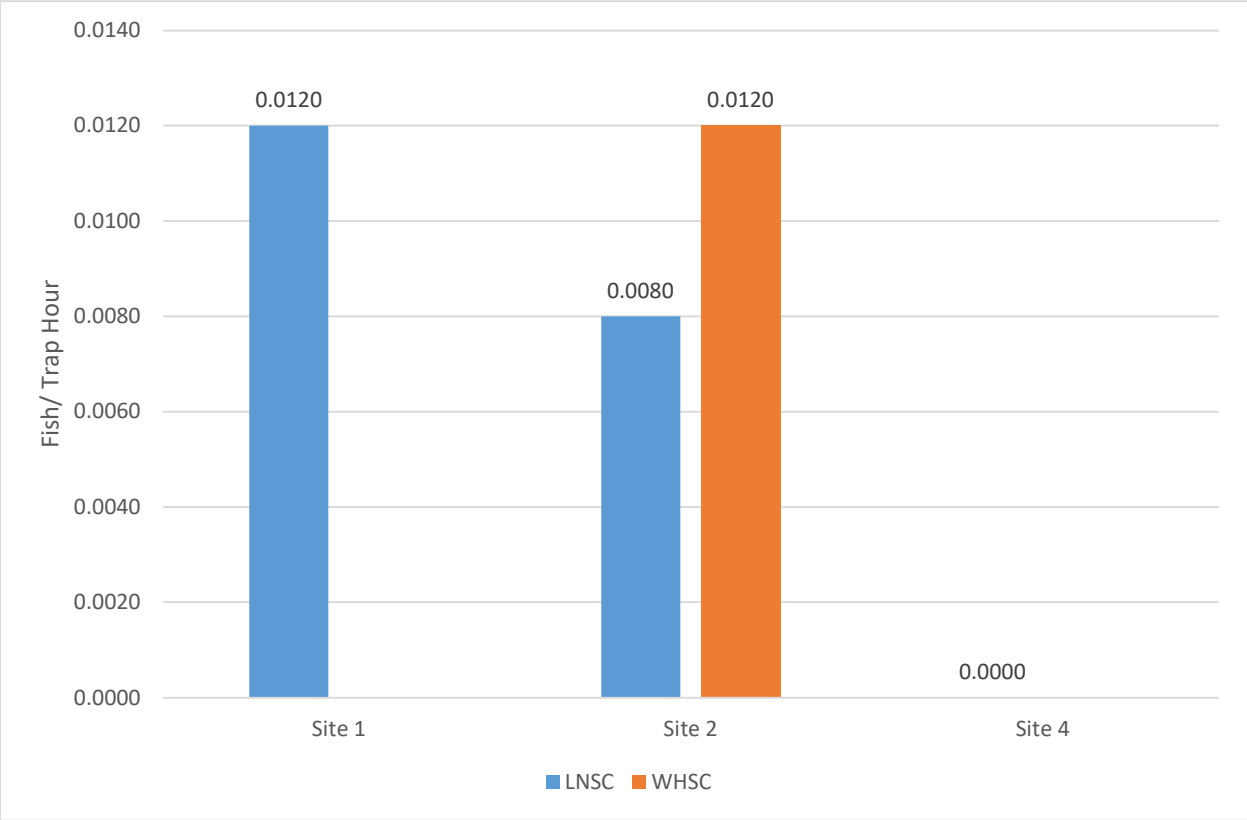

Figure 4 2020 Bio-Efficacy Post-Construction Monitoring Program Minnow Trap CPUE for Individual Fish

A total of 112 fish and 9 species were captured using boat electrofishing, including longnose dace, longnose sucker, white sucker, trout perch, burbot, brown trout, rainbow trout, mountain whitefish and northern pike. Electrofishing CPUE was determined for each site as number of fish captured per second of electrofishing effort (fish/electrofishing second). Electrofishing CPUE was greatest at Site 2 (0.0911 fish/electrofishing-second), followed by Site 1 (0.0868 fish/ electrofishing-second), with Site 4 having the lowest CPUE (0.0716 fish/electrofishing-second). **Figure 5** summarizes electrofishing CPUE separated by site. In addition, CPUE was calculated for individual fish species as the number of fish per species per electrofishing second (number per species/electrofishing second) and separated by reach. Longnose sucker had the greatest CPUE in Site 4 (0.0623 fish/electrofishing second). Mountain whitefish was the second highest CUPE (0.0567 fish/electrofishing second) in Site 2. In Site 1 rainbow trout was the third highest CPUE of 0.0537 fish/electrofishing. **Figure 6** presents electrofishing CPUE for individual fish species separated by site.

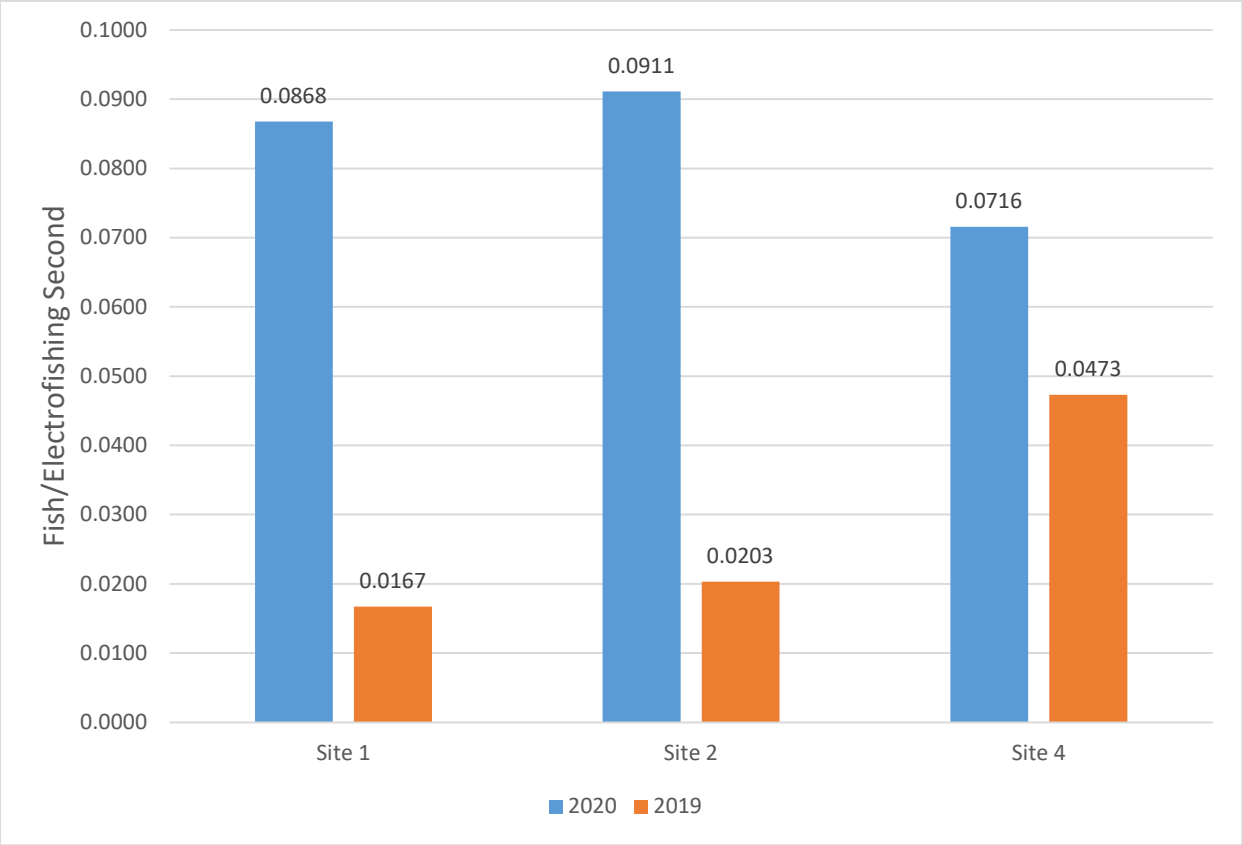

Figure 5 2020 Bio-Efficacy Post-Construction Monitoring Program Electrofishing CPUE

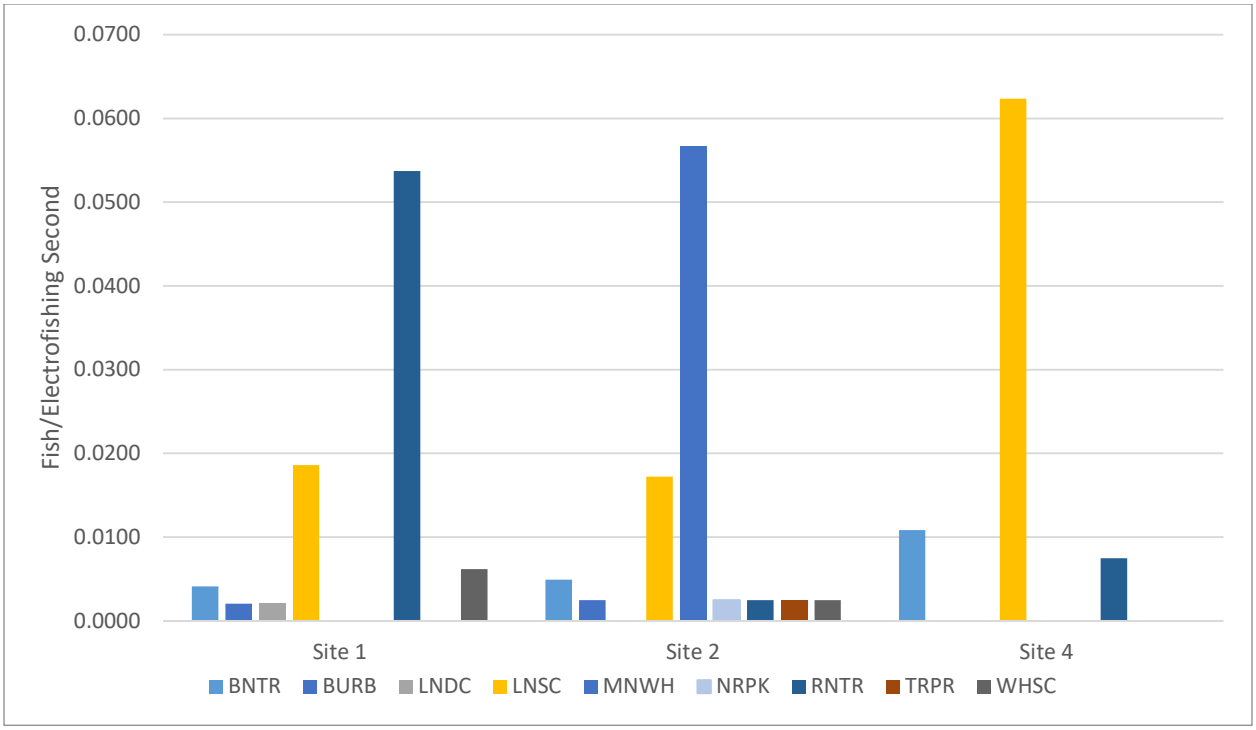

Figure 6 2020 Bio-Efficacy Post-Construction Monitoring Program Electrofishing CPUE for Individual Fish Species Captured

1.3.4.1 Summary

Monitoring data collected throughout 2019 and 2020 indicate that fish residing in the Bow River have begun to utilize fish habitat enhancement structures within Site 1, 2 and 4. During the winter assessment, fish presence was observed at Site 1, confirming the use of enhancement structures by fish in the winter. Site 2 did not provide winter habitat to fish, as the site was dry during the assessment. Spring assessments were not completed due to high and turbid water. During the summer assessment, fish were captured in the vicinity of fish habitat enhancement structures within all sites.

Compared with historical fish capture data from the Bow River (FWMIS 2019), 9 of 22 species were captured during Year 2 of monitoring, including 5 sportfish and 4 non-sportfish species. Abundance of fish species within the Project area could not be compared with historical data, as fish sampling surveys were not previously conducted in similarly characterized Bow River habitat within proximity to the Project site (FWMIS 2019).

Between sites the, CPUE for minnow trapping and electrofishing was highest at Site 2 (i.e. 0.0200 fish/trap hour; 0.0911 fish/electrofishing second). Site 1 and 2 had relatively similar CPUE for both fish capture methods and had higher CPUE than observed at Site 4.

Site 2 had the highest abundance and diversity of fish species, including five sportfish species (i.e., brown trout, burbot, mountain whitefish, northern pike, and rainbow trout). Site 2 had the highest CPUE (0.0911 fish/electrofishing-second) with mountain whitefish being the most captured. Although Site 1 had the second highest fish abundance (i.e. CPUE), it had the most number of fish captured and the single highest species captured (rainbow trout) (**Table 5**). Bioengineering enhancements were most diverse at Site 1, with boulder

clusters, a riprap apron, crib wall fish shelters, and box fascines. The species abundance observed at Site 1 may have been supported by the variation in cover and microhabitats provided by the habitat enhancements. Site 4 had higher abundance of forage fish, with longnose sucker being most prevalent. Site 4 had no habitat enhancements and has the least amount of variation in cover and microhabitats.

As expected, species composition and fish abundance observed during Year 2 was higher than Year 1 as the BDEP sites naturalize following the construction of the fish habitat enhancements. Fish use and population data collected in 2020 indicated a higher CPUE in 2020 (0.2494 fish/electrofishing-second) versus 2019 CPUE of 0.0844 fish/electrofishing-second.

1.3.5 Spawning Use

A spring spawning assessment was not conducted in 2020 due to high flows and turbid water creating unsafe conditions.

The fall spawning assessment included a brown trout redd survey and kick-net sampling to identify mountain whitefish eggs. The assessment was conducted on December 2, 2020 following the conclusion of brown trout and mountain whitefish spawning periods. No redds were identified within the surveyed reach. Suitable mountain whitefish spawning habitat was identified and kicked sampled for mountain whitefish eggs. Six locations within the upstream extent of Site 1 (i.e., upstream of the Cushing Bridge) were sampled and mountain whitefish eggs were observed at each location (**Figure 2**, and Attachment A, Photos 42 to 43).

1.3.5.1 Summary

Although potential spring and fall salmonid spawning habitat was documented during the summer habitat assessment, no redds or salmonid spawning was observed during the fall spawning assessments in 2020. Mountain whitefish eggs were observed during kick sampling within suitable habitat in the upstream extent of Site 1.

1.4 Summary

The overall Project goals were to effectively stabilize unstable and steep banks; restore flood affected habitat with new fish habitats (e.g. bank overhangs, in-stream refugia, boulder clusters, large woody debris, shade/cover by riparian plantings, etc.), design and construct methods to facilitate increased awareness and understanding of flood recovery processes, and improve riverbank aesthetics in the area. The Project was not expected to permanently destroy or alter fish habitat at a spatial scale intensity that would limit or diminish the ability of fish to use the Project area for migration, foraging, overwintering, rearing, and spawning purposes. The purpose of the fish and fish habitat monitoring component is to evaluate the fisheries habitat use and potential of the habitat enhancements at Sites 1, 2 and 4 (Hemmera 2018).

The results of the Year 2 (2020) monitoring indicate that fish are using the project area for migration, foraging, overwintering, rearing, and spawning purposes and utilizing the Project's habitat enhancement structures. Fish were observed using and were captured within the vicinity of the new habitat structures throughout the Project area. Fish were observed in the fish shelters, boulder clusters, and surrounding habitats during winter, and summer assessments. Although, no fish were observed in the fall, mountain whitefish eggs were observed in the upstream section of Site 1. The highest abundance of fish was captured in Site 1 and the highest diversity of species were captured in Site 2.

Based on the fish use monitoring results, Sites 1 and 2 are providing high quality fish habitat in comparison to Site 4. Species composition and fish abundance observed during Year 2 are expected to vary in subsequent monitoring years as the BDEP sites naturalize following the construction of the fish habitat enhancements.

Overall, the Project has not permanently altered or destroyed fish habitat. Fish are still using the Project area for migration, foraging, overwintering, rearing, and spawning purposes.

- Recommendations for monitoring in in 2021 are related to the timing and equipment of the monitoring program:
- the crew will monitor the ice conditions of the Bow River beginning in January to determine safe conditions for completing the winter and spring assessment (i.e., stable and thick ice for on-ice survey or ice-free open water conditions for snorkel survey);
- during the summer assessment, the crew will continue to use a smaller boat for more effective sampling of near shore habitats adjacent to Sites 1 and 2.

1.5 References

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2.0 WILDLIFE

2.1 Introduction

The Bio-efficacy Monitoring Program at the Bioengineering Demonstration and Education Project (BDEP, the Project) site at the Bow River (a component of the City of Calgary's Riparian Action Program), has the goal of determining long-term riparian health trends by evaluating riparian habitat recovery at numerous flood affected and restored sites along the Bow River within city limits. The objectives to monitor, evaluate, and report on the overall effectiveness of the Project in relation to a more conventional riprap bank protection mitigation (i.e., hard armouring)project are to be completed over a ten-year post-construction monitoring program, which was initiated in 2019. This monitoring program involves both Effectiveness Monitoring and Trend Monitoring, as defined below:

- **Effectiveness Monitoring:** Effectiveness monitoring assesses post-restoration conditions at both treatment and control sites to evaluate changes in riparian habitat recovery resulting from the Riparian Action Program implementation.
- **Trend Monitoring:** Trend monitoring will be used to understand the riparian health in the restoration areas and whether it is improving, remaining constant, or deteriorating over the monitoring period.

The ten-year wildlife monitoring component of the Project is to occur over five separate monitoring years, with the first year of monitoring completed in 2019 (i.e., monitoring will occur in 2019, 2020, 2021, 2023, and 2028), and across three separate sites (Site 1, Site 2 and Site 4), as described below and shown in **Figure 7**.

Site 1 is located adjacent to the pedestrian pathway, extending north of the 17th Avenue Southeast (SE) bridge and Calgary Transit bridge, for approximately 591 m in length, and 2.75 ha in area. To provide for an improved wildlife corridor between the habitats to the south and north of the bridge, substrate was added under the bridge, consisting of a six metre wide vegetated soil area designated as "wildlife-friendly" riprap to allow for wildlife to travel along the edge of the Bow River. Vegetation was planted to create a natural visual screen between the Bow River and the pedestrian pathway to help facilitate wildlife movement through the area.

Site 2 is located adjacent to Site 1, extending approximately 128 m to the south of the 17th Avenue SE bridge, and approximately 0.44 ha in area. This site was designed to have riparian vegetation and habitat restored to provide for suitable nesting habitat for breeding birds, including passerines, waterbirds and raptor species known to occur within the Project area.

Site 4 is located south of Site 2 and has used conventional riprap, including large boulders placed along the bank and into the edge of the Bow River, as a bank restoration method. Site 4 was selected to represent a control site, where baseline conditions can be used to compare the effectiveness and trends observed in Sites 1 and 2, which are considered the treatment areas of the Project.

This report provides a summary of Year 2 (2020) of the wildlife monitoring program, along with comparisons to Year 1 (2019) of the monitoring program, and comments on the observed effectiveness of the Project at each of the three sites. An analysis of trends in the findings will be completed following the Year 3 (2021) monitoring.

2.2 Methods

Wildlife monitoring was conducted in compliance with the *Bioengineering Efficacy Monitoring Plan* (Hemmera 2018). The Year 2 (2020) monitoring scope was comprised of trail camera monitoring at Site 1 to assess wildlife corridor usage by mammals, and breeding bird surveys and wildlife feature monitoring at all three Sites to assess habitat suitability and wildlife use. Wildlife features previously identified during the *Preliminary Natural Assessment Report* (Hemmera 2017), and during Year 1 (2019) of the monitoring plan implementation (two known bank swallow (*Riparia riparia*) colonies) were also monitored in Year 2 (2020).

Four trail cameras were deployed at Site 1 in Year 2 (2020), which represented one additional camera location (Camera 5), relative to Year 1 (2019). Trail cameras were installed on January 21, 2020 and removed on November 20, 2020, with data downloads and general camera condition checks completed on May 14, July 28, and September 25.

Year 2 (2020) breeding bird surveys and wildlife feature monitoring consisted of five breeding bird survey plots (three plots in Site 1, and one plot in each of Site 2 and Site 4), at the same locations as the Year 1 (2019). Wildlife feature monitoring consisted of monitoring for active raptor nests, and estimates of use at two known bank swallow colonies (**Figure 1**). Two rounds of breeding bird survey point counts were completed at each plot location on May 28 and June 16. These surveys followed the methods outlined in the *Sensitive Species Inventory Guidelines* (Alberta Environment and Sustainable Resource Development [ESRD] 2013) for breeding birds and prairie raptors. Bank swallow colony use was assessed by recording the total maximum number of bank swallows entering and exiting bank cavities over a five-minute period.

All surveys were conducted under appropriate conditions for the identification breeding birds (i.e., appropriate time of day, temperatures greater than 0°C, winds less than 20 km/hr, and no precipitation).

With the exception of one additional camera at Site 1, Year 2 (2020) wildlife camera locations, breeding bird survey plots, and known wildlife features were the same as Year 1 (2019) (**Figure 7**).

2.2.1 Desktop Review

A desktop review to identify known sensitive wildlife features was conducted for the *Bioengineering Efficacy Monitoring Plan* (Hemmera 2018) and consisted of a search of the Alberta Environment and Parks (AEP) Fisheries and Wildlife Management Information System (FWMIS) and the Fish and Wildlife Internet Mapping Tool (FWIMT) (AEP 2017a).

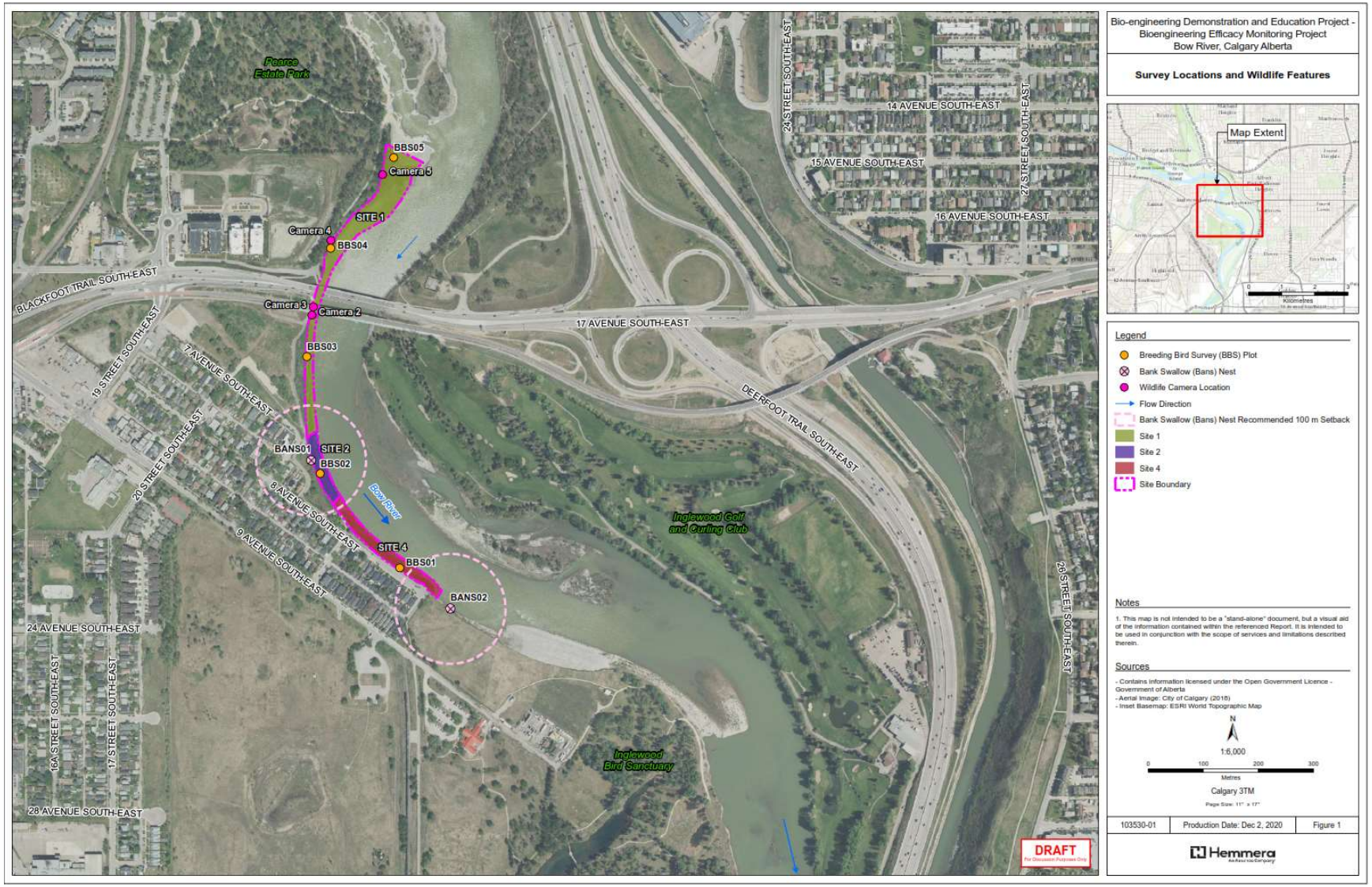

Figure 7 Wildlife survey locations and wildlife features.

2.2.2 Wildlife Monitoring

2.2.2.1 Site 1

Wildlife monitoring at Site 1 included breeding bird surveys at three locations (BBS03, BBS04, and BBS05), raptor nest surveys, and four wildlife cameras (Camera 2, 3, 4, and 5) (**Figure 7)**.

Wildlife Camera Monitoring

Four Reconyx HyperFire 2 wildlife cameras were installed at Site 1. Camera 2 was located approximately 15 m downstream of the 17th Avenue SE bridge on a storm drain outfall and was oriented downwards at an approximate 45-degree angle towards the Bow River. Camera 3 was located under the 17th Avenue SE Bridge facing east, horizontally, towards the Bow River. Camera 4 was located approximately 126 m upstream from the 17th Avenue SE bridge on a storm drain outfall, oriented downwards at an approximate 45-degree angle towards the Bow River. Camera 5 was located approximately 148 m upstream from Camera 4, and approximately 277 m upstream from the 17th Avenue SE Bridge, and oriented downwards facing east, horizontally, at an approximate 45-degree angle towards the Bow River. Wildlife cameras were programmed to capture three images with a one second spacing between images when triggered by motion detection. All cameras were programmed not to trigger for five seconds following a motion triggered event, and camera sensitivity was set to the medium/high mode. Wildlife cameras were all aimed towards the Bow River, away from the adjacent pedestrian pathway to avoid abundant photographs of human activity on the pathway.

The placement of each wildlife trail camera in Site 1 was intended to determine the use of the treatment area by terrestrial mammals as a wildlife corridor. The Camera 5 location was new in 2020 and was added to provide coverage of the furthest upstream extent of Site 1. Similar to the Camera 4 location, the Camera 5 location captured the use of reference riparian habitat to compare wildlife usage with the treatment areas adjacent and beneath the 17th Avenue SE Bridge.

Breeding Bird and Nest Surveys

Breeding bird point count surveys were conducted at three locations in Site 1 (BBS03, BBS04, and BBS05) (**Figure 7**) on May 28 and June 16 with the goal of identifying breeding bird activity. After the completion of the breeding bird survey each day, field assessments focused on observations of active breeding or nesting behaviour within the site. This included identification of swallow colonies (either within the bank of the Bow River, or beneath the 17th Avenue SE Bridge), identifying raptor nests within or directly adjacent to the Project, and any observations of waterfowl utilizing the banks or riparian zones of the Bow River for nesting sites. All nesting behaviour and incidental species observations were recorded and submitted to AEP through the FWMIS.

2.2.2.2 Site 2

Site 2 wildlife monitoring consisted of breeding bird surveys, raptor nest surveys, and monitoring of the bank swallow colony within this Site. No wildlife trail cameras were installed within Site 2 as monitoring focused on suitable nesting and breeding habitat and not constraints to wildlife corridor movement at this location. Breeding bird surveys were conducted at one-point count location (BBS02). The habitat was surveyed for new stick nests and the potential for active raptor nests. The previously identified at this site (BANS01, **Figure 7**) was monitored.

2.2.2.3 Site 4

Similar to Site 2, wildlife monitoring at Site 4 consisted of breeding bird breeding bird surveys, raptor nest surveys, and monitoring of the bank swallow colony within this Site. No wildlife trail cameras were installed within Site 4 as monitoring focused on suitable nesting and breeding habitat and not constraints to wildlife corridor movement at this location. Breeding bird surveys were conducted at one-point count location (BBS01). The habitat was surveyed for new stick nests and the potential for active raptor nests. The previously identified bank swallow colony at this site (BANS02, **Figure 7**) was monitored.

2.3 Results

2.3.1 Desktop Review

The desktop review resulted in the identification of 12 species of management concern observed within 1,000 m of the Project (**Table 6**). A review of FWIMT data identifies the Project as being located within the Sensitive Raptor Range for bald eagles, golden eagles, and prairie falcon, and within the sharp-tailed grouse Range.

Table 6 Provincially or Federally Listed Species Recorded within 1 km of the Project area as of 2018.

Species	Scientific Name	AEP Ranking[a]	SARA Schedule[b]	COSEWIC Ranking[c]
bald eagle	*Haliaeetus leucocephalus*	Sensitive	-	-
Baltimore oriole	*Icterus galbula*	Sensitive	-	-
common nighthawk	*Chordeiles minor*	Sensitive	Schedule 1	Threatened
eastern kingbird	*Tyrannus tyrannus*	Sensitive	-	-
great blue heron	*Ardea herodias*	Sensitive	-	-
harlequin duck	*Histrionicus histrionicus*	Sensitive	-	-
least flycatcher	*Empidonax minimus*	Sensitive	-	-
northern goshawk	*Accipiter gentilis*	Sensitive	-	-
silver-haired bat	*Lasionycteris noctivagans*	Sensitive	-	-
sora	*Porzana carolina*	Sensitive	-	-
western grebe	*Aechmophorus occidentalis*	Sensitive	Schedule 1	Special Concern
western wood-pewee	*Contopus sordidulus*	May be at Risk	-	-

[a] AEP 2017*b;* [b] Government of Canada 2016; [c] COSEWIC 2008

In addition to the desktop review, as noted in the *Preliminary Natural Site Assessment Report* (Hemmera 2017), suitable breeding habitat was identified for bank swallows and nesting raptors within the Project area. Bank swallow colonies were identified during field visits at both Site 2 (1 colony) and Site 4 (1 colony).

Suitable habitat to support various life stages has been identified in and adjacent to the Project for all of the species listed in **Table 6**. The Bow River, in general, provides foraging and/or breeding habitat for several waterbird species (e.g., sora, harlequin duck, western grebe, and great blue heron), while deciduous trees in the riparian zones provide suitable raptor (e.g., bald eagle) and passerine (e.g., least flycatcher) breeding habitat. Bat species are able to utilize the deciduous trees in the riparian zone for summer roosting habitat and may forage for insects over and adjacent to the Bow River.

The following sections summarize the results of wildlife monitoring at each Site. Representative photos of wildlife species captured on the remote cameras are provided in Attachment E.

2.3.2 Site 1

2.3.2.1 Wildlife Camera Monitoring

A total of 916 camera-days of monitoring was conducted at Site 1 (**Table 7**). With the exception of Camera 3 that recorded for the entire 304-day period, each of the other three cameras experienced technical issues that resulted in a reduced sampling period.

During the September 25 camera check it was discovered that the memory card in Camera 2 had reached capacity on August 8, resulting in a total of 256 days of monitoring for the entire study period.

Camera 4 captured images of individuals people knocking the camera over on April 10. The camera was returned to its position during the May 14 camera check, and then was found knocked over again during the July 28 check, resulting in a total of only 195 days of monitoring over the entire study period.

Camera 5 captured images of people individuals vandalizing the camera, rendering it non-functional on August 2. This was not discovered until the September 25 camera check. Given the discovery of the damaged camera late in the monitoring period and irreparable damage to the camera, the Camera 5 location was not replaced after September 25, resulting in a total of only 171 days of monitoring over the entire study period.

Table 7 Active camera days during deployment at Site 1

Camera location	Active Camera Days	Percentage of Monitoring Period Camera was Active	Number of photographs taken
Camera 2	256	84	90
Camera 3	304	100	88
Camera 4	195	64	50
Camera 5	171	56	89
All cameras combined	926	-	317

In total, seven mammal species were observed at Site 1 (**Table 8**). While Canada goose (*Branta canadensis*) were included in the 2019 analysis, this species was not included in the camera analysis for wildlife corridor movement in 2020 as they are not limited to terrestrial movement like the mammal species. Canada goose has been observed to use the corridor habitat; however, they are also able to fly or swim through the Project area without relying on the movement corridor. Therefore, the analysis has been limited to mammal species which rely on the corridor to pass through the Project area. Cameras 2, 3, and 5 recorded similar total numbers of wildlife observations, at 90, 88, and 89, respectively. Camera 4 captured fewer individual observations and species, but this camera was only operational for 64 % of the monitoring period. Camera 5 had high counts of individual wildlife observations, and the highest species diversity (five species), despite being operational for only 56% of the monitoring period, due to vandalism. Both common raccoon (*Procyon lotor*) at Camera 3, and striped skunk (*Mephitis mephitis*) at Camera 2, were only observed on one occasion.

Table 8 Site 1 terrestrial mammal species occurrence by camera location

Camera location	Common racoon	Coyote	Eastern gray squirrel	Mule deer	White-tailed deer	Striped skunk	White-tailed jack rabbit	Total Number of Wildlife Observations
Camera 2	-	39	-	-	39	1	11	90
Camera 3	1	16	-	-	60	-	11	88
Camera 4	-	14	-	-	36	-	-	50
Camera 5	-	31	25	2	18	-	13	89
All Cameras Combined	1	100	25	2	153	1	35	317

Notes: "-" = no observations

White-tailed deer (*Odocoileus virginianus*) was the most common species observed across all cameras (153 individuals), with most observations occurring at Camera 3 (60 individuals). Mule deer (*Odocoileus hemionus*) by comparison was only observed twice, at Camera 5. Coyote (*Canis latrans*) was the second most abundant species, with 100 individual observations across all camera locations. Eastern gray squirrel (*Sciurus carolinensis*) was commonly observed at the Camera 5 location (25 individuals) but was not recorded at any of the other camera locations. Camera 5 is directly adjacent to Pearce Estate Park, which has greater tree cover compared to the other camera locations. This may also, in part, explain the greater species diversity recorded at the Camera 5 location compared to the other camera locations with less diverse surrounding wildlife habitat.

Mean use is a measure of species occurrence which accounts for both the number of individuals and the number of monitoring days. Mean use values represent species occurrence as a ratio of all species observed. Mean use calculations for Site 1 for each species is provided in **Figure 8** below, including a comparison of Year 1 (2019) data with Year 2 (2020) data.

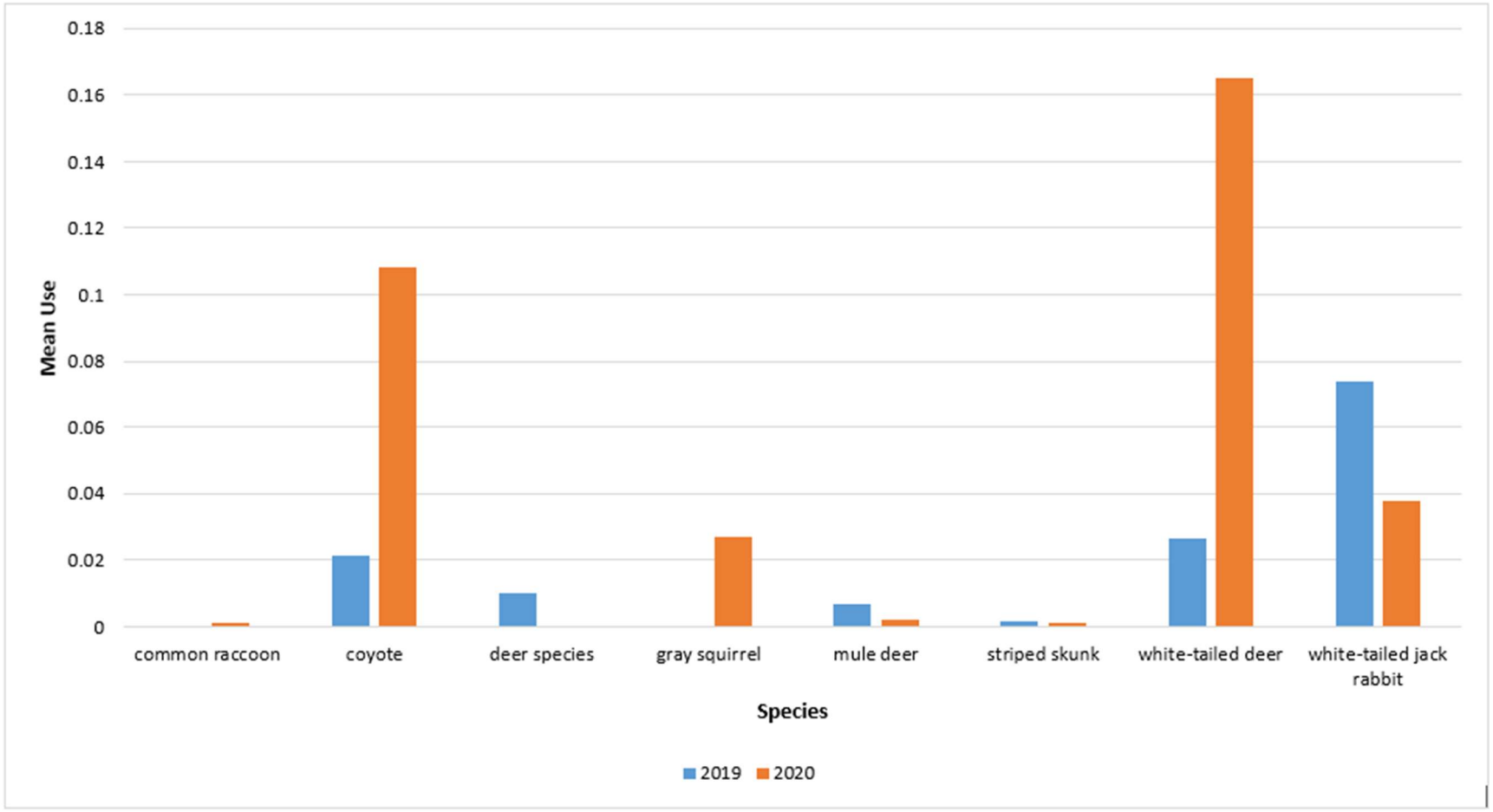

Figure 8 Site 1 species mean use comparison between Year 1 (2019) and Year 2 (2020) wildlife camera data.

The common raccoon and eastern gray squirrel were new species observations in Year 2 (2020), while all other species were observed in both monitoring years (**Figure 8**). White-tailed deer and coyote mean use increased from Year 1 (2019) to Year 2 (2020). White-tailed jack rabbit (*Lepus townsendii*) mean use decreased in Year 2 (2020) as compared to Year 1 (2019).

The soil and vegetation treatment areas associated the 17 Avenue SE Bridge within Site 1 were primarily intended to promote the passage of large-bodied terrestrial mammals. Deer presence was recorded at all four of the cameras throughout Site 1, suggesting that wildlife corridor in the Project area is providing effective passage, and that deer are using all areas of Site 1 similarly. Coyote observations within Site 1 show a similar evenly distributed pattern of presence across all camera locations, suggesting that the wildlife corridor area provides effective passage for coyotes as well as deer. With the exception of the eastern gray squirrel discussed in relation to the proximity to the higher tree cover adjacent to Camera 5, it is difficult to draw conclusions about the presence or absence of the other species that had limited numbers of observations. White-tailed jackrabbits were found in relatively equal abundance at all locations, with the exception of Camera 4, where no individuals were recorded. As Camera 4 was intended to act as a reference habitat location, not restricted by the wildlife corridor, there is not an obvious reason why this species was found at both Camera 2 and Camera 3 on the other side of the limited width corridor, and at Camera 5 where corridor width is not limited.

2.3.2.2 Breeding Bird and Nest Surveys

Breeding bird survey observations resulted in a total of 50 individuals representing 20 different species observed within Site 1 in Year 2 (2020), compared to 129 individuals representing 16 different species in Year 1 (2019) (**Table 9**). Of the species identified in the Year 2 (2020) breeding bird surveys, only bank swallow is considered a species of management concern, because it is provincially-listed as Sensitive, and federally listed as Threatened under the *Species at Risk Act* (SARA) and by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (Government of Canada 2016; COSEWIC 2008). No active songbird nests were observed at Site 1 in Year 2 (2020).

Table 9 Species identified in Site 1 breeding bird surveys in 2019 and 2020 monitoring years.

Common Name	Scientific Name	Number of Individuals		AEP Status	SARA Status	COSEWIC Status
		2019	2020			
American goldfinch	*Carduelis tristis*	-	1	-	-	-
American robin	*Turdus migratorius*	5	4	-	-	-
bank swallow	*Riparia riparia*	-	1	Sensitive	Threatened	Threatened
black-billed magpie	*Pica hudsonia*	2	-	-	-	-
black-capped chickadee	*Poecile atricapillus*	1	2	-	-	-
brown-headed cowbird	*Molothrus ater*	4	1	-	-	-
Canada goose	*Branta canadensis*	3	2	-	-	-
cedar waxwing	*Bombycilla cedrorum*	-	4	-	-	-
clay-colored sparrow	*Spizella pallida*	-	3	-	-	-
common goldeneye	*Bucephala clangula*	1	-	-	-	-

Common Name	Scientific Name	Number of Individuals		AEP Status	SARA Status	COSEWIC Status
		2019	2020			
common merganser	*Mergus merganser*	2	3	-	-	-
common raven	*Corvus corax*	-	3	-	-	-
double-crested cormorant	*Phalacrocorax auritus*	2	1	-	-	Not at Risk
European starling	*Sturnus vulgaris*	1	-	Exotic/Alien	-	-
Franklin's gull	*Leucophaeus pipixcan*	70	-	-	-	-
gadwall	*Anas strepera*	4	-	-	-	-
house sparrow	*Passer domesticus*	2	-	Exotic/Alien	-	-
house wren	*Troglodytes aedon*	6	1	-	-	-
killdeer	*Charadrius vociferus*	3	1	-	-	-
least flycatcher	*Empidonax minimus*	3	-	Sensitive	-	-
mallard	*Anas platyrhynchos*	2	1	-	-	-
northern flicker	*Colaptes auratus*	-	1	-	-	-
red-winged blackbird	*Agelaius phoeniceus*	4	4	-	-	-
song sparrow	*Melospiza melodia*	3	7	-	-	-
spotted sandpiper	*Actitis macularius*	3	3	-	-	-
tree swallow	*Tachycineta bicolor*	-	1	-	-	-
warbling vireo	*Vireo gilvus*	2	-	-	-	-
western wood-pewee	*Contopus sordidulus*	1	-	May Be at Risk	-	-
yellow warbler	*Dendroica petechia*	5	6	-	-	-
All Species Combined	**-**	**129**	**50**	**-**	**-**	**-**

Year 2 (2020) surveys recorded 79 fewer individuals and two fewer species than the Year 1 (2019) surveys. This reduction in individuals observed is largely related to the 70 Franklin's gulls observed in 2019, which were not observed in 2020. Franklin's gull is a gregarious species, so it is likely that they were foraging for food in the area, as nesting habitats consisting of shallow water and emergent vegetation are not present in the Project area. One species of management concern identified in Year 1 (2019) (least flycatcher), was not observed in the Year 2 (2020) surveys. Other species observed in one year but not the other represented either a single individual or a small number of individuals. Breeding bird surveys do not represent a comprehensive list of all species that may utilize a habitat, but rather capture a period in time to describe general use. Similar to Year 1 (2019) surveys, Site 1 represented the highest number of individuals and species recorded compared to Site 2 and Site 4, as described in those sections below.

2.3.3 Site 2

2.3.3.1 Breeding Bird and Nest Surveys

There was a total of 29 individuals representing 10 different species observed within Site 1 in Year 2 (2020), compared to 68 individuals representing 8 different species in Year 1 (2019) (**Table 10**). No active songbird nests were observed at Site 2 in Year 2 (2020).

Table 10 Species identified in Site 2 breeding bird surveys in 2019 and 2020 monitoring years.

Common Name	Scientific Name	Number of Individuals		AEP Status	SARA Status	COSEWIC Status
		2019	2020			
American robin	*Turdus migratorius*	-	1	-	-	-
American wigeon	*Anas americana*	1	-	-	-	-
bank swallow	*Riparia*	43	7	Sensitive	Threatened	Threatened
black-billed magpie	*Pica hudsonia*	2	1	-	-	-
black-capped chickadee	*Poecile atricapillus*	-	1	-	-	-
chipping sparrow	*Spizella passerina*	-	1	-	-	-
Franklin's gull	*Leucophaeus pipixcan*	16	-	-	-	-
house sparrow	*Passer domesticus*	3	12	Exotic/Alien	-	-
house wren	*Troglodytes aedon*	-	1	-	-	-
least flycatcher	*Empidonax minimus*	1	-	Sensitive	-	-
mallard	*Anas platyrhynchos*	-	2	-	-	-
red-winged blackbird	*Agelaius phoeniceus*	1	1	-	-	-
song sparrow	*Melospiza melodia*	-	2	-	-	-
spotted sandpiper	*Actitis macularius*	1	-	-	-	-
All species combined	**-**	**68**	**29**	**-**	**-**	**-**

Of the species identified at Site 2 in Year 2 (2020), only one species (bank swallow) is considered a species of management concern. Least flycatcher, which is considered a listed species (AEP 2015), was observed in Year 1 (2019), but not observed in Year 2 (2020).

Year 2 (2020) surveys recorded 39 fewer individuals compared to Year 1 (2019) surveys, but these represented a slightly higher number of total species (10 species compared to the 8 species observed in Year 1 (2019). As described in Section 2.3.2, Site 2 represented half of the number of species observed in Site 1.

2.3.4 Site 4

2.3.4.1 Breeding Bird and Nest Surveys

There was a total of 19 individuals representing 7 different species observed within Site 1 in Year 2 (2020), compared to 24 individuals representing 6 different species in Year 1 (2019) (**Table 11**).

Table 11 Species identified in Site 4 breeding bird surveys in 2019 and 2020 monitoring years.

Common Name	Scientific Name	Number of Individuals		AEP Status	SARA Status	COSEWIC Status
		2019	2020			
American wigeon	*Anas americana*	-	1	-	-	-
black-billed magpie	*Pica hudsonia*	5	1	-	-	-
Canada goose	*Branta canadensis*	6	-	-	-	-
clay-colored sparrow	*Spizella pallida*	3	6	-	-	-
house sparrow	*Passer domesticus*	-	6	Exotic/Alien	-	-
mallard	*Anas platyrhynchos*	8	-	-	-	-
red-winged blackbird	*Agelaius phoeniceus*	-	1	-	-	-
song sparrow	*Melospiza melodia*	1	1	-	-	-
spotted sandpiper	*Actitis macularius*	-	3	-	-	-
tree swallow	*Tachycineta bicolor*	1	-	-	-	-
All species combined	**-**	**24**	**19**	**-**	**-**	**-**

Of the species identified at Site 2 in Year 2 (2020), only one species (bank swallow) is considered a species of management concern. Least flycatcher, which is considered a listed species (AEP 2015), was observed in Year 1 (2019), but not observed in Year 2 (2020).

Of the species identified at Site 2 in Year 2 (2020), none are considered species of management concern. Year 2 (2020) surveys observed a similar number of individuals compared to Year 1 (2019) surveys, representing 7 different species compared to 5 different species observed in Year 1 (2019). Similar to Site 2, Site 4 recorded approximately one third of the total species observed in Site 1.

2.4 Breeding Bird and Nest Comparisons Across Sites

Site 1 incorporates a much larger area with 3 individual breeding bird survey plots compared to a single survey plot in each of the other two sites. Species diversity was highest at Site 1 with 20 species observed, followed by Site 2 (10 species), and Site 4 (7 species). There are differences in suitable nesting habitat availability and habitat complexity observed between Site 1 and the other sites, mainly due to the proximity of Site 1 to Pearce Estate Park, which offers more extensive tree cover and understory relative to the other sites. Site 1 also the highest number of individual birds observed, followed by Site 2 and Site 4.

2.5 Wildlife Features

2.5.1 Raptor Nests

No active raptor nests were observed during field surveys conducted in Year 2 (2020).

2.5.2 Bank Swallow Colony Observations

An assessment of the two previously identified bank swallow colonies (i.e., BANS01 in Site 2, and BANS02 in Site 4) (**Figure 7**) was conducted. A minimum of 18 bank swallows were observed at both BANS01 and BANS02 in 2020, compared to 30 and 34 individuals observed at BANS01 and BANS02, respectively in 2019. This represents a year over year reduction of the estimated number of individuals observed BANS01 (12 individuals) and at BANS02 (16 individuals).

2.5.3 Incidental Observations

In addition to the observations recorded during the standardized breeding bird plots, any additional wildlife observations made were recorded. These observations included blue-winged teal (*Anas discors*), Brewer's blackbird (*Euphagus cyanocephalus*), European starling, Franklin's gull, Lincoln's sparrow (*Melospiza lincolnii*), ring-billed gull (*Larus delawarensis*), rock pigeon (*Columba livia*) , unidentified gull, and warbling vireo (*Vireo gilvus*). None of the incidental species observed are listed provincially or federally.

2.6 Summary

There is no baseline wildlife camera data available prior to the placement of the additional substrate to create the wider corridor beneath the 17th Avenue SE bridge; however, there were similar occurrences of certain species within the reference areas captured by wildlife cameras (i.e., Camera 4) upstream of the bridge corridor. Larger mammals (white-tailed deer and coyote) represented the most abundant species, with relatively equal distributions between all camera locations. Other smaller mammal species had lower mean use at all camera locations, with unequal distribution throughout the Project area. Several of the smaller species (e.g., common raccoon, eastern gray squirrel, striped skunk) were only observed at a single camera location. It is unclear if these species are not utilizing the wildlife corridor in the same way that the larger species were observed, or if there are other factors influencing the camera observations, such as smaller mammals failing to trigger the wildlife cameras as frequently as the larger species.

The greatest species diversity recorded with the wildlife cameras was at the Camera 5 location, where surrounding habitat complexity was observed to be the greatest. While vandalism at the Camera 5 location resulted in the camera only being operational for 56 % of the monitoring period, the number of wildlife observations was comparable to those recorded at Camera 2 which was operational over 90% of the monitoring period and the Camera 3 location which was fully operational. Additional camera checks could more readily identify inoperable cameras resulting in fewer lost monitoring days.

Year 2 (2020) of the wildlife monitoring program allowed for comparisons between the first two years of the program, including indications that some wildlife species are utilizing these habitats similarly to the reference habitats upstream and downstream. Year 3 (2021) of the monitoring program will allow for an additional analysis of directional trends in species and individuals using three years of data. The addition of 2021 data will determine if the changes observed in mean usage of the wildlife corridor and adjacent habitats, and breeding bird and nest surveys observations made in 2020 continue. Reductions in breeding

bird total individuals observed may be related to conditions experienced at the time of the survey, or larger scale trends that may or may not be determined with additional years of data.

2.7 References

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Government of Canada. 2016. Species at Risk Public Registry - Home - SARA. <https://www.registrelep-sararegistry.gc.ca/default.asp?lang=en&n=24F7211B-1>. Accessed 10 Mar 2016.

ATTACHMENT A
Fisheries Photolog

Photo 1: View upstream from Photo Station 1 (Site 1) on January 7,2020.

Photo 2: View upstream from Photo Station 1 (Site 1) on June 18, 2020.

Photo 3: View upstream from Photo Station 1 (Site 1) on September 18, 2020.

Photo 4: View upstream from Photo Station 1 (Site 1) on December 2, 2020.

Photo 5: View downstream from Photo Station 1 (Site 1) on January 7,2020.

Photo 6: View downstream from Photo Station 1 (Site 1) on June 18, 2020.

Photo 7: View downstream from Photo Station 1 (Site 1) on September 18, 2020.

Photo 8: View downstream from Photo Station 1 (Site 1) on December 2, 2020.

Photo 9: View upstream from Photo Station 2 (Site 1) on January 7,2020.

Photo 10: View upstream from Photo Station 2 (Site 1) on June 18, 2020.

Photo 11: View upstream from Photo Station 2 (Site 1) on September 18, 2020.

Photo 12: View upstream from Photo Station 2 (Site 1) on December 2, 2020.

Photo 13: View downstream from Photo Station 2 (Site 1) on January 7,2020.

Photo 14: View downstream from Photo Station 2 (Site 1) on June 18, 2020.

Photo 15: View downstream from Photo Station 2 (Site 1) on September 18, 2020.

Photo 16: View downstream from Photo Station 2 (Site 1) on December 2, 2020.

Photo 17: View upstream from Photo Station 3 (Site 2) on January 7,2020.

Photo 18: View upstream from Photo Station 3 (Site 2) on June 18, 2020.

Photo 19: View upstream from Photo Station 3 (Site 2) on September 18, 2020.

Photo 20: View upstream from Photo Station 3 (Site 2) on December 2, 2020.

Photo 21: View downstream from Photo Station 3 (Site 2) on January 7, 2020.

Photo 22: View downstream from Photo Station 3 (Site 2) on June 18, 2020.

Photo 23: View downstream from Photo Station 3 (Site 2) September 18, 2020.

Photo 24: View downstream from Photo Station 3 (Site 2) on December 2, 2020.

Photo 25: View upstream from Photo Station 4 (Site 4) on January7,2020.

Photo 26: View upstream from Photo Station 4 (Site 4) on June 18, 2020.

Photo 27: View upstream from Photo Station 4 (Site 4) on September 18, 2020.

Photo 28: View upstream from Photo Station 4 (Site 4) on December 2, 2020.

Photo 29: View downstream from Photo Station 4 (Site 4) on January 7,2020.

Photo 30: View downstream from Photo Station 4 (Site 4) on June 18, 2020.

Photo 31: View downstream from Photo Station 4 (Site 4) on September 18, 2020.

Photo 32: View downstream from Photo Station 4 (Site 4) on December 2, 2020.

Photo 33: View of a longnose sucker captured in the Bow River on September 18, 2020.

Photo 34: View of a white sucker captured in the Bow River on September 18, 2020.

Photo 35: View of a longnose dace captured in the Bow River on September 18, 2020.

Photo 36: View of a brown trout captured in the Bow River on September 18, 2020.

Photo 37: View of a rainbow trout captured in the Bow River on September 18, 2020.

Photo 38: View of a northern pike captured in the Bow River on September 18, 2020.

Photo 39: View of a juvenile mountain whitefish captured in the Bow River in September 18, 2020.

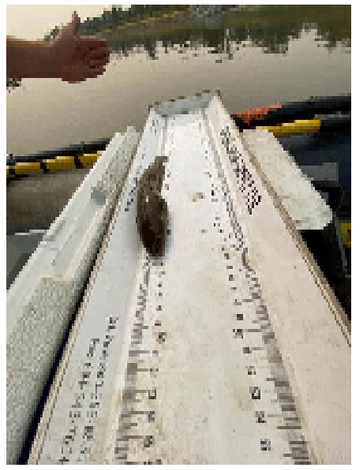

Photo 40: View of a burbot captured in the Bow River on September 18, 2020.

Photo 41: View of a trout perch captured in the Bow River on September 18, 2020.

Photo 42: Mountain whitefish eggs collected in the Bow River on December 2, 2020.

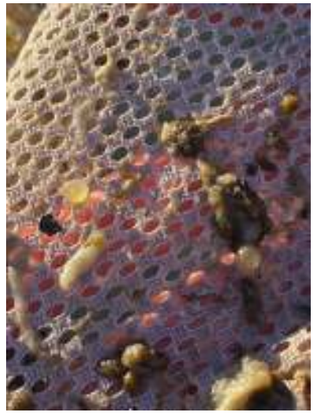

Photo 43: Mountain whitefish eggs collected in the Bow River on December 2, 2020.

ATTACHMENT B
Site Atlas

Watercourse (Site#):	Bow River – Site 1
Habitat Survey Length (# transects):	1,500 m (16)
Restricted Activity Period:	May 1 to July 15, Sept 16 to April 5
Watercourse Class:	Mapped Class C

Field Crew:	M. Piciacchia, C. Davis
Survey Date:	September 18, 2020
Legal Location:	SE/SW-13-24-01 W5M, NE-12-24-01 W5M
UTM (Zone 11):	709435E, 5658357N

Flow Regime	Perennial
Bankfull Width (m): Mean, Range	162.1, 103.0-232.0
Wetted Width (m): Mean, Range	111.0, 65.0-168.0
Depth (m): Mean, Range	1.50, 0.50-6.95
Stream Gradient (%)	2.0
Embeddedness	Low
Beaver Dams	None
Native Channel Width (m)	N/A

Bank Conditions	Left Bank	Right Bank
Bank Shape	Sloping	Vertical
Bank Texture	Cobbles / Fines	Vegetated crib wall
Bank Height (m): Mean, Range	3.3, 2.5-4.0	2.5, 1.5-3.0
Grade of Approach Slopes (%)	4-14	4-10
Riparian Area Width (m)	7	10
Riparian Vegetation Types	Deciduous	Shrubs
Stream Shading	1-10%	

Substrate Composition	Amount
Organics	None
Fines (<2 mm)	Trace
Small Gravel (2-20 mm)	Trace
Large Gravel (21-65 mm)	Subdominant
Cobble (66-250 mm)	Dominant
Boulder (>250 mm)	Subdominant

Water Quality Parameters	
Water Temperature (°C)	15.40
pH	8.80
Dissolved Oxygen (mg/L)	9.29
Conductivity (µS/cm)	316.25
Turbidity (visual)	Clear

Habitat	Length (m)	%
Pool 1 (depth > 1.0 m)	100	8.0
Pool 2 (depth 0.75-1.0 m)	-	-
Pool 3 (depth <0.75 m)	-	-
Run 1 (>1.0 m)	275	41.0
Run 2 (0.75-1.0 m)	-	-
Run 3 (<0.75 m)	123	12.5
Flat 1 (> 1.0 m)	-	-
Flat 2 (0.75-1.0 m)	-	-
Flat 3 (<0.75 m)	-	-
Riffle	225	38.5
Backwater	-	-
Rapid	-	-
Other	-	-

Cover Types	Amount
Boulders	Subdominant
Undercut Banks	None
Overhanging Vegetation	Trace
Woody Debris	Trace
Depth	Dominant
Stain/Turbulence	Dominant
Instream Vegetation	None
Fish Shelters	Trace
Boulder Clusters	Trace
Other	-
Other	-
Other	-
Total Cover	Low

Fish Habitat Potential				
Species	**Spawning Rating**	**Rearing Rating**	**Wintering Rating**	**Adult Holding Rating**
mountain whitefish	Suitable	Suitable	Suitable	Suitable
brown trout	Marginal	Suitable	Suitable	Suitable
rainbow trout	Marginal	Suitable	Suitable	Suitable

Fish species previously documented: brook trout, bull trout, brown trout, burbot, cutthroat trout, lake whitefish, mountain whitefish, northern pike, rainbow trout, yellow perch, walleye, brook stickleback, fathead minnow, lake chub, longnose dace, longnose sucker, mountain sucker, Prussian carp, pearl dace, spoonhead sculpin, trout-perch and white sucker (FWMIS, 2017).

Additional Habitat Comments

The fish habitat within Site 1 (downstream of Harvie Passage and upstream of the Cushing Bridge) consists of alternating deep run (R1) and riffle (RF) habitat. with a shallow run (R3) habitat along the right downstream bank (RDB). Deep pool habitat (P1) is present immediately downstream of the Cushing Bridge. Maximum water depth ranges from 0.40 m in R3 habitat to approximately 7.00 m in R1 and P1 habitat. Substrates throughout Site 1 consist primarily of boulder and cobbles in R1 habitat and cobble and gravel in R3 habitat. Pool habitat (P1) substrates consist primarily of boulder, cobble, and fines. Cover is provided primarily by depth and turbulence, with some overhanging cover provided by woody vegetation along the LDB upstream of the Cushing Bridge, as well as overhanging vegetation from the timber crib wall along the RDB at the enhancement site Boulder substrates present throughout run and pool habitats are likely provide instream cover for fish. Additional instream cover is provided by new constructed fish shelters and boulder clusters. Deep run (R1) and pool (P1) habitat is likely utilized as holding, feeding, and overwintering habitat for adult and juvenile fish, R3 habitat functioning as holding and rearing habitat for juvenile fish. Deep pool (P1) and R1 habitat within the downstream section of Site 1 likely provides excellent overwintering habitat, with a maximum water depth of approximately 7.00 m. Gravel and cobble substrates located at the R3 habitat upstream of Cushing Bridge likely provides suitable spawning habitat for brown trout and rainbow trout. Mountain whitefish spawning habitat is present over cobble and large gravels located in R1 and R3 habitat.

Photo 1: Photo taken at Transect 3, view upstream.

Photo 2: Photo taken at Transect 3, view downstream.

Photo 3: View of left bank at Transect 3.

Photo 4: View of right bank at Transect 3.

Photo 5: Photo taken at Site 1, view of fish shelters and boulder clusters.

Photo 6: Photo taken at Site 1, view downstream of fish shelters and boulder clusters.

Watercourse (Site#):	Bow River – Site 2
Habitat Survey Length (# transects):	1,500 m (16)
Restricted Activity Period:	May 1 to July 15, Sept 16 to April 5
Watercourse Class:	Mapped Class C

Field Crew:	M. Piciacchia, C. Davis
Survey Date:	September 18,2020
Legal Location:	NW/NE-12-24-01 W5M
UTM (Zone 11):	709374E, 5657892N

Flow Regime	Perennial
Bankfull Width (m): Mean, Range	162.1, 100.0-228.0
Wetted Width (m): Mean, Range	111.0, 78.0-168.0
Depth (m): Mean, Range	1.45, 0.50-4.02
Stream Gradient (%)	2.0
Embeddedness	Low
Beaver Dams	None
Native Channel Width (m)	N/A

Bank Conditions	Left Bank	Right Bank
Bank Shape	Vertical	Vertical
Bank Texture	Cobble / Boulder	Cobble / Boulder
Bank Height (m): Mean, Range	3.3, 2.5-4.0	4.2, 1.5-7.0
Grade of Approach Slopes (%)	4-14	4-14
Riparian Area Width (m)	7	8
Riparian Vegetation Types	Deciduous	Shrub
Stream Shading	1-20%	

Substrate Composition	Amount
Organics	None
Fines (<2 mm)	Trace
Small Gravel (2-20 mm)	Trace
Large Gravel (21-65 mm)	Subdominant
Cobble (66-250 mm)	Dominant
Boulder (>250 mm)	Subdominant

Water Quality Parameters	
Water Temperature (°C)	15.45
pH	8.78
Dissolved Oxygen (mg/L)	9.30
Conductivity (µS/cm)	331.12
Turbidity (visual)	Clear

Habitat	Length (m)	%
Pool 1 (depth > 1.0 m)	55	8.0
Pool 2 (depth 0.75-1.0 m)	-	-
Pool 3 (depth <0.75 m)	-	-
Run 1 (>1.0 m)	120	92.0
Run 2 (0.75-1.0 m)	-	-
Run 3 (<0.75 m)	-	-
Flat 1 (> 1.0 m)	-	-
Flat 2 (0.75-1.0 m)	-	-
Flat 3 (<0.75 m)	-	-
Riffle	-	-
Backwater	-	-
Rapid	-	-
Other	-	-

Cover Types	Amount
Boulders	Subdominant
Undercut Banks	None
Overhanging Vegetation	Trace
Woody Debris	Trace
Depth	Dominant
Stain/Turbulence	Dominant
Instream Vegetation	Trace
Other	-
Other	-
Other	-
Other	-
Other	-
Total Cover	Low

Fish Habitat Potential

Species	Spawning Rating	Rearing Rating	Wintering Rating	Adult Holding Rating
mountain whitefish	Suitable	Suitable	Suitable	Suitable
brown trout	Marginal	Suitable	Suitable	Suitable
rainbow trout	Marginal	Suitable	Suitable	Suitable

Fish species previously documented: brook trout, bull trout, brown trout, burbot, cutthroat trout, lake whitefish, mountain whitefish, northern pike, rainbow trout, yellow perch, walleye, brook stickleback, fathead minnow, lake chub, longnose dace, longnose sucker, mountain sucker, Prussian carp, pearl dace, spoonhead sculpin, trout-perch and white sucker (FWMIS, 2017).

Additional Habitat Comments

Site 2 is located approximately 260 m downstream of the 17 Avenue Cushing Bridge at the first riprap groyne constructed along the right downstream bank (RDB), extending for approximately 140 m downstream to a second riprap groyne along the RDB to the upstream boundary of Site 4. Fish habitat within Site 2 consists almost entirely of a deep run (R1) habitat, with deep pool (P1) habitat located immediately downstream of riprap groynes at the upstream and downstream extent of the RDB of Site 2, adjacent to a City of Calgary pathway in Inglewood. Water depth is relatively uniform through this section, ranging from 1.5 m to 2.1 m. Substrates consist primarily of boulder and large cobbles in R1 habitat and boulder and riprap within P1 habitat downstream of flood mitigation structures (groynes). Cover is provided primarily by depth and turbulence, and by boulder and riprap substrates. Large woody debris has accumulated within the P1 habitat immediately downstream of the riprap groyne present at the upstream boundary of Site 2 along the RDB. Large woody debris provides suitable overhanging and instream cover. Overhanging cover is otherwise severely limited throughout Site 2. Deep run (R1) habitat provides excellent holding, feeding, and overwintering habitat for adult and juvenile fish. P1 habitat present downstream of riprap groynes provides a velocity refuge for fish as well as suitable holding and feeding habitat for juvenile fish. There is marginal potential spawning habitat for salmonids throughout Site 2 due to the larger size of substrates. Potential spawning habitat is limited to cobble substrates along a side cobble bar along the LDB. However, spawning habitat is present in Bow River throughout the zone-of-influence.

Photo 1: Photo taken at Transect 7, view upstream.

Photo 2: Photo taken at Transect 7, view downstream.

Photo 3: View of left bank at Transect 7.

Photo 4: View of right bank at Transect 7.

Photo 5: Photo taken at Site 2, upstream view.

Photo 6: Photo taken at Site 2, downstream view.

Watercourse (Site#):	Bow River – Site 4
Habitat Survey Length (# transects):	1,500 m (16)
Restricted Activity Period:	May 1 to July 15, Sept 16 to April 5
Watercourse Class:	Mapped Class C

Field Crew:	M. Piciacchia, C. Davis
Survey Date:	September 18, 2020
Legal Location:	NW-12-24-01 W5M
UTM (Zone 11):	709488E, 5657767N

Flow Regime	Perennial
Bankfull Width (m): Mean, Range	162.1, 103.0-232.0
Wetted Width (m): Mean, Range	114.0, 78.0-170.0
Depth (m): Mean, Range	1.50, 0.50-6.95
Stream Gradient (%)	2.0
Embeddedness	Low
Beaver Dams	None
Native Channel Width (m)	N/A

Bank Conditions	Left Bank	Right Bank
Bank Shape	Vertical	Vertical
Bank Texture	Boulder / Cobble	Boulder / Cobble
Bank Height (m): Mean, Range	3.3, 2.5-4.0	4.2, 1.5-7.0
Grade of Approach Slopes (%)	4-14	4-14
Riparian Area Width (m)	7	8
Riparian Vegetation Types	Deciduous	Shrubs
Stream Shading	1-20%	

Substrate Composition	Amount
Organics	None
Fines (<2 mm)	Trace
Small Gravel (2-20 mm)	Trace
Large Gravel (21-65 mm)	Subdominant
Cobble (66-250 mm)	Dominant
Boulder (>250 mm)	Subdominant

Water Quality Parameters	
Water Temperature (°C)	15.78
pH	8.66
Dissolved Oxygen (mg/L)	9.21
Conductivity (µS/cm)	317.29
Turbidity (visual)	Clear

Habitat	Length (m)	%
Pool 1 (depth > 1.0 m)	100	6.8
Pool 2 (depth 0.75-1.0 m)	50	0.5
Pool 3 (depth <0.75 m)	-	-
Run 1 (>1.0 m)	605	43.5
Run 2 (0.75-1.0 m)	-	-
Run 3 (<0.75 m)	55	0.7
Flat 1 (> 1.0 m)	-	-
Flat 2 (0.75-1.0 m)	-	-
Flat 3 (<0.75 m)	-	-
Riffle	595	48.5
Backwater	-	-
Rapid	-	-
Snye	-	-

Cover Types	Amount
Boulders	Subdominant
Undercut Banks	None
Overhanging Vegetation	Trace
Woody Debris	Trace
Depth	Dominant
Stain/Turbulence	Dominant
Instream Vegetation	Trace
Other	-
Other	-
Other	-
Other	-
Total Cover	Low

Fish Habitat Potential				
Species	**Spawning Rating**	**Rearing Rating**	**Wintering Rating**	**Adult Holding Rating**
mountain whitefish	Suitable	Suitable	Marginal	Suitable
brown trout	Marginal	Suitable	Marginal	Suitable
rainbow trout	Marginal	Suitable	Marginal	Suitable

Fish species previously documented: brook trout, bull trout, brown trout, burbot, cutthroat trout, lake whitefish, mountain whitefish, northern pike, rainbow trout, yellow perch, walleye, brook stickleback, fathead minnow, lake chub, longnose dace, longnose sucker, mountain sucker, Prussian carp, pearl dace, spoonhead sculpin, trout-perch and white sucker (FWMIS, 2017).

Additional Habitat Comments

Site 4 is bounded on the upstream end by the second (downstream) riprap groyne constructed along the RDB and extends to the downstream extent of bank riprapping along the RDB. Site 4 extends to the mid channel to the wetted edge of the cobble side bar along the LDB. Fish habitat within Site 4 is comprised primarily of deep run (R1) habitat, transitioning into shallow depth run (R3) habitat at the downstream end of the site. Bank stability is very high, with the entire RDB composed of class II and class III riprap. Substrate consists primarily of cobble and boulder with a maximum depth of approximately 1.5 m in the thalweg. Cover is provided primarily by depth and turbulence and partially by large riprap present along the RDB and boulder substrate. Site 4 has little to no overhanging cover as a result of bank armoring along the RDB and lack of bank vegetation.

Deep run (R1) habitat provides suitable holding and feeding habitat for adult and juvenile fish. R3 habitat present at the downstream end of the reach provides holding and feeding habitat for juvenile fish. Due to the maximum depth of approximately 1.5 m, this section of the Bow River provides marginal to suitable overwintering habitat. There is marginal spawning habitat for salmonids (e.g. brown trout and rainbow trout) due to the lack of suitable gravel substrates through the reach, however, spawning habitat is present in the Bow River .

Photo 1: Photo taken at Transect 10, view upstream.

Photo 2: Photo taken at Transect 10, view downstream

Photo 3: View of left bank at Transect 10.

Photo 4: View of right bank at Transect 10.

Photo 5: Photo taken at Transect 9, view upstream.

Photo 6: Photo taken at Transect 8, view downstream.

ATTACHMENT C
Habitat Maps

Bioengineering Demonstration
and Education Project
Bow River, Calgary, Alberta

Bow River Fish Habitat

Legend

- Transect
- Pool
- Riffle
- Run
- Site Boundary

Channel Unit/Habitat

R1 Class 1 Run; Deep Run >1.0 m
R2 Class 2 Run; Moderate Run 0.75 - 1.0 m
R3 Class 3 Run; Shallow Run < 0.75 m

P1 Class 1; Deep Pool >1.0 m
P2 Class 2; Moderate Pool 0.75 - 1.0 m
P3 Class 3; Shallow Pool < 0.75 m

RF Riffle
SN Syne
BW Backwater

Co Cobble
Gr Gravel
Bl Boulder
F Fines

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a “stand-alone” document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Contains information licensed under the Open Government Licence - Government of Alberta
- Aerial Image: City of Calgary (2019)

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Metres

Calgary 3TM

Page Size: 11" x 17"

103530-02	Production Date: Nov 25, 2020	Figure 3A

Hemmera
An Ausenco Company

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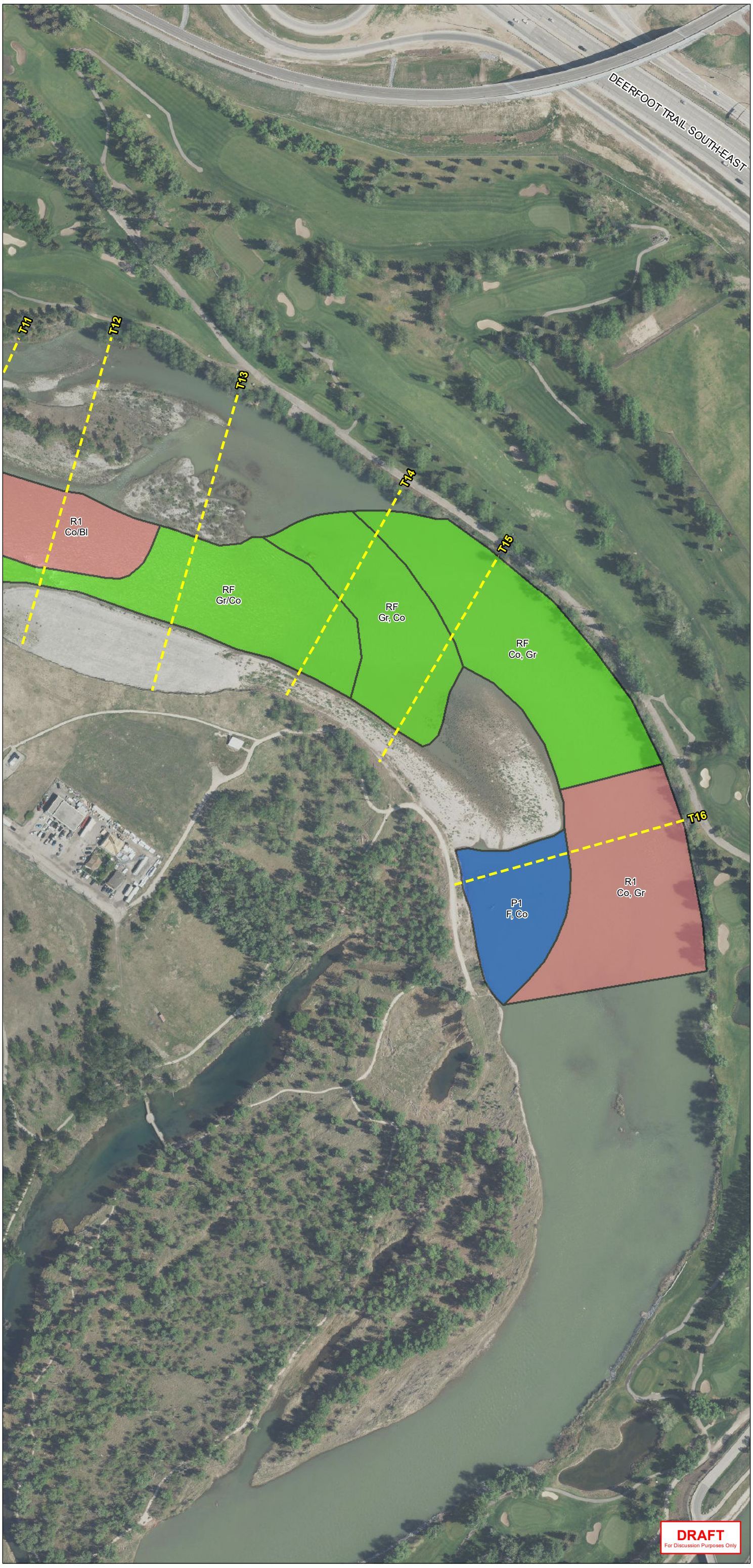
Bio-engineering Demonstration and Education Project -
Bioengineering Efficacy Monitoring Project
Bow River, Calgary Alberta

Bow River Fish Habitat



Legend

- Transect
- Pool
- Riffle
- Run

Channel Unit/Habitat

R1 Class 1 Run; Deep Run >1.0 m
R2 Class 2 Run; Moderate Run 0.75 - 1.0 m
R3 Class 3 Run; Shallow Run < 0.75 m

P1 Class 1; Deep Pool >1.0 m
P2 Class 2; Moderate Pool 0.75 - 1.0 m
P3 Class 3; Shallow Pool < 0.75 m

RF Riffle
SN Syne
BW Backwater

Co Cobble
Gr Gravel
Bl Boulder
F Fines

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a “stand-alone” document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

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- Aerial Image: City of Calgary (2019)

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Metres

Calgary 3TM

Page Size: 11" x 17"

103530-02	Production Date: Nov 25, 2020	Figure 3B

Hemmera
An Ausenco Company

Path: S:\Geomatics\Projects\103530\02\mxd\Fig3B_103530_02_FishHabitat_201125.mxd

ATTACHMENT D
Raw Fish Data

Table D-1 Bow River Raw Fish Data 2020

Species	Fish Count	Length (mm)	Weight (g)	Sex	Life Stage
LNSC	1	335	480	Unknown	Adult
LNSC	1	315	470	Unknown	Adult
LNSC	1	227	310	Unknown	Juvenile
LNSC	1	318	460	Unknown	Adult
LNSC	1	247	250	Unknown	Juvenile
LNSC	1	390	279	Unknown	Adult
LNSC	1	167	100	Unknown	Juvenile
BNTR	1	207	127	Unknown	Juvenile
LNSC	1	480	310	Unknown	Adult
BNTR	1	231	200	Unknown	Juvenile
LNSC	1	227	180	Unknown	Juvenile
LNSC	1	180	80	Unknown	Juvenile
RNTR	1	170	69	Unknown	Juvenile
LNSC	1	108	30	Unknown	Juvenile
LNSC	1	93	12	Unknown	Juvenile
LNSC	1	140	40	Unknown	Juvenile
BNTR	1	215	150	Unknown	Juvenile
BNTR	1	196	148	Unknown	Juvenile
LNSC	1	170	45	Unknown	Juvenile
LNSC	1	196	148	Unknown	Juvenile
RNTR	1	197	156	Unknown	Juvenile
LNSC	1	101	14	Unknown	Juvenile
RNTR	1	182	146	Unknown	Juvenile
LNSC	1	97	11	Unknown	Juvenile
LNSC	1	194	55	Unknown	Juvenile
LNSC	1	193	51	Unknown	Juvenile
BNTR	1	87	9	Unknown	Juvenile
LNSC	1	90	8	Unknown	Juvenile
LNSC	1	85	6	Unknown	Juvenile
LNSC	1	70	4	Unknown	Juvenile
LNSC	1	76	5	Unknown	Juvenile
LNSC	1	80	6	Unknown	Juvenile
LNSC	1	75	5	Unknown	Juvenile

Species	Fish Count	Length (mm)	Weight (g)	Sex	Life Stage
NRPK	1	820	2200	Unknown	Adult
MNWH	1	92	12	Unknown	Juvenile
MNWH	1	95	11	Unknown	Juvenile
MNWH	1	85	10	Unknown	Juvenile
MNWH	1	79	8	Unknown	Juvenile
LNSC	1	156	33	Unknown	Juvenile
MNWH	1	92	11	Unknown	Juvenile
MNWH	1	91	9	Unknown	Juvenile
LNSC	1	121	25	Unknown	Juvenile
MNWH	1	91	8	Unknown	Juvenile
MNWH	1	107	12	Unknown	Juvenile
MNWH	1	189	22	Unknown	Juvenile
BNTR	1	117	15	Unknown	Juvenile
MNWH	1	97	9	Unknown	Juvenile
MNWH	1	67	7	Unknown	Juvenile
MNWH	1	85	7	Unknown	Juvenile
MNWH	1	100	11	Unknown	Juvenile
MNWH	1	71	7	Unknown	Juvenile
MNWH	1	102	10	Unknown	Juvenile
MNWH	1	110	14	Unknown	Juvenile
MNWH	1	72	6	Unknown	Juvenile
MNWH	1	81	9	Unknown	Juvenile
LNSC	1	132	101	Unknown	Juvenile
MNWH	1	110	14	Unknown	Juvenile
MNWH	1	78	5	Unknown	Juvenile
MNWH	1	91	7	Unknown	Juvenile
BURB	1	205	132	Unknown	Juvenile
MNWH	1	98	9	Unknown	Juvenile
MNWH	1	99	9	Unknown	Juvenile
BNTR	1	86	7	Unknown	Juvenile
LNCS	1	188	33	Unknown	Juvenile
RNTR	1	82	7	Unknown	Juvenile
LNSC	1	178	30	Unknown	Juvenile
TRPR	1	85	4	Unknown	Juvenile

Species	Fish Count	Length (mm)	Weight (g)	Sex	Life Stage
LNSC	1	189	144	Unknown	Juvenile
LNSC	1	210	150	Unknown	Juvenile
WHSC	1	480	720	Unknown	Adult
BURB	1	201	121	Unknown	Juvenile
RNTR	1	65	5	Unknown	Juvenile
RNTR	1	110	14	Unknown	Juvenile
RNTR	1	90	9	Unknown	Juvenile
RNTR	1	85	6	Unknown	Juvenile
RNTR	1	86	7	Unknown	Juvenile
RNTR	1	91	8	Unknown	Juvenile
RNTR	1	110	9	Unknown	Juvenile
WHSC	1	90	8	Unknown	Juvenile
RNTR	1	85	8	Unknown	Juvenile
RNTR	1	86	6	Unknown	Juvenile
RNTR	1	91	9	Unknown	Juvenile
RNTR	1	92	7	Unknown	Juvenile
RNTR	1	94	9	Unknown	Juvenile
RNTR	1	96	11	Unknown	Juvenile
RNTR	1	96	10	Unknown	Juvenile
RNTR	1	98	11	Unknown	Juvenile
LNSC	1	31	2	Unknown	Young of the Year
WHSC	1	112	13	Unknown	Juvenile
LNSC	1	98	9	Unknown	Juvenile
RNTR	1	91	8	Unknown	Juvenile
RNTR	1	86	8	Unknown	Juvenile
LNSC	1	50	4	Unknown	Juvenile
BNTR	1	96	10	Unknown	Juvenile
RNTR	1	91	9	Unknown	Juvenile
RNTR	1	108	13	Unknown	Juvenile
RNTR	1	88	9	Unknown	Juvenile
LNSC	1	41	3	Unknown	Young of the Year
LNSC	1	228	123	Unknown	Juvenile
LNSC	1	490	650	Unknown	Adult
RNTR	1	112	14	Unknown	Juvenile

Species	Fish Count	Length (mm)	Weight (g)	Sex	Life Stage
RNTR	1	84	8	Unknown	Juvenile
BNTR	1	101	12	Unknown	Juvenile
LNDC	1	69	5	Unknown	Juvenile
WHSC	1	51	5	Unknown	Juvenile
LNSC	1	211	121	Unknown	Juvenile
LNSC	1	190	118	Unknown	Juvenile
LNSC	1	200	119	Unknown	Juvenile
RNTR	1	88	7	Unknown	Juvenile
RNTR	1	86	8	Unknown	Juvenile
RNTR	1	88	8	Unknown	Juvenile
RNTR	1	29	3	Unknown	Young of the Year
LNSC	1	62	6	Unknown	Juvenile
LNSC	1	56	4	Unknown	Juvenile
LNSC	1	61	7	Unknown	Juvenile
LNSC	1	76	8	Unknown	Juvenile
LNSC	1	55	6	Unknown	Juvenile
WHSC	1	45	3	Unknown	Juvenile
WHSC	1	48	2	Unknown	Juvenile
WHSC	1	48	2	Unknown	Juvenile

ATTACHMENT E
Wildlife Photolog

Species: Gray Squirrel (*Sciurus carolinensis*)
Camera Location: BDEP05
Date: January 28, 2020

Species: Striped Skunk (*Mephitis mephitis*)
Camera Location: BDEP02
Date: January 23, 2020

Species: Common Raccoon (*Procyon lotor*)
Camera Location: BDEP03
Date: April 19, 2020

Species: White-tailed Jack Rabbit (*Lepus townsendii*)
Camera Location: BDEP05
Date: March 8, 2020

Species: Mule Deer (*Odocoileus hemionus*)
Camera Location: BDEP05
Date: June 24, 2020

Species: White-tailed Deer (*Odocoileus virginianus*)
Camera Location: BDEP02
Date: January 23, 2020

Species : Coyote (*Canis latrans*)
Camera Location : BDEP05
Date: February 29, 2020

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Appendix C

Riparian Health Assessment Field Data Sheets

Prepared by: Longview Ecological

ALBERTA WETLAND HEALTH ASSESSMENT FOR LARGE RIVERS

Polygon ID: BDEP Site #1

Project: CoC RMP	Observer: AD
Client: CoC	Date: Sept 9/20
Property Name: –	Watershed: South Saskatchewan River
Field Name: –	River Name: Bow River
Legal Land Location: –	Photos: 316 – 320
Natural Subregion: Foothills Fescue	

Coordinates: E709489, N5658485 E709344, N5657966 (downstream end)

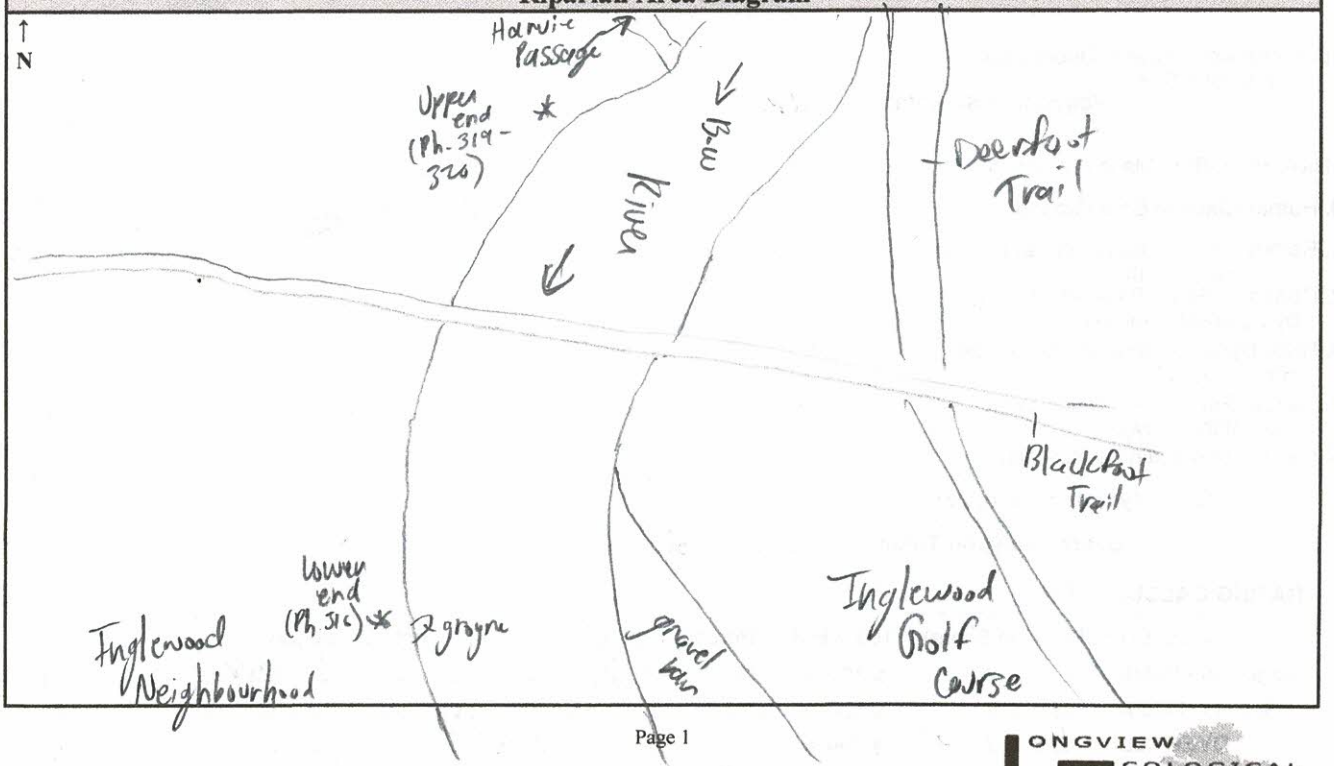
Comments:

RIBEOXY 1

Dominant Plant Species

Graminoids	% Cover	Forbs	% Cover	Shrubs	% Cover	Trees	% Cover
ELYMTRA	30	TRIFHYB	1	SALINT	25	POPUBAL	60
ELYMCAN	2	TARAOFF	1	SALIFAM	15	POPUTRE	2
BROMINE	1	MEDISAT	4	CORNSTO	7	FRAXPEN	5
PHALARU	2	MELISPP	2	ELAEOM	3	SALIFRA	3
AGROSTO	1	PLANMAJ	<1	ROSAWOO	2	PICEPUN	1
DESCCES	<1	TANAVUL	5	DASIFRU	<1		
		CIRSARV	2	VIBUOPU	<1		
		ARCTMIN	1	SYMPOCC	<1		
		SONCULI	1	AMELALN	<1		

Riparian Area Diagram



LONGVIEW ECOLOGICAL

POPUBAL + SALINT regen. along gravel bar at N end

RIVER HEALTH EVALUATION

Polygon Number: _____ Record ID No: Site #1

	Actual Score	Possible Score	Comment
1. Cottonwood and Poplar Regeneration	4	6	POPUBAL plantings + cuttings along S ½ of reach; mature POPUBAL along N ½
2. Regeneration of other Native Tree Species	3	3	Planted POPUTRE; a few mature FRAXPEN
3. Regeneration of Preferred Shrub Species	2	6	Many SALINT + SALIFAM cuttings are now mature planted POPUBAL + POPUTRE are ≤ 11 ~ 7.5cm dbh
4. Standing Decadent and Dead Woody Material	2	3	Some decadent POPUBAL north of bridges
5a. Browse Util. of Preferred Trees and Shrubs	3	3	None observed
5b. Woody Veg. Removal other than Browsing	3	3	Some trees were removed at start of project
6. Total Canopy Cover of Woody Species	3	3	~30% S of bridge, ~70% N of bridge
7a. Total Canopy Cover of Invasive Plant Species	1	3	See below
7b. Density/Distribution Pattern of Invasive Plant Species	0	3	" "

List Invasive Plant Species present, including Percent Canopy Cover and Density Distribution Class:

	Can.Cov.	Dens.Dist.		Can.Cov.	Dens.Dist.		Can.Cov.	Dens.Dist.
blueweed:			field bindweed:			spotted knapweed:		
* Canada thistle:	2	8	leafy spurge:			tall buttercup:		
caragana:			nodding thistle:			tamarisk/salt cedar:		
cleavers:			ox-eye daisy:			white cockle:		
* common burdock:	<1	6	perennial sow-thistle:			yellow toadflax:		
common hound's-tongue:			purple loosestrife:					
* common tansy:	5	8	Russian knapweed:					
Dalmatian Toadflax:			Russian olive:					
diffuse knapweed:			* scentless chamomile:	<1	3	Others: VICICRA	<1	5
downy chess:			* smooth perennial sow-thistle:	<1	8	Others: CLEMTAN	<1	3
European buckthorn:						VERBTHA	<1	2

2c. Are there elevated status species for this county? (Yes; No; NC):

Elevated Sps 1: _____ Elevated Sps 2: _____ Elevated Sps 3: _____

8. Disturbance-increaser Undesirable Herbaceous Species	1	3	High MEDISAT, MELISP cover in cuttings area; TRAGDUB, POAPRAT, MEDISAT, BROMINE, PLAMAJ, MELALB, POTEANS, ARTEABS, POTENOR, TRIHYB, ASTRCIC, LACSER, THLARV, HORJUB, TRIPREP, MELIOFF, AGROCRI, AGROSTO, ELYMREP, MEDICUP, ARTEBIE, FALCON, CREPTEC, KOCHSCO, PHLEPRA
Vegetation Subtotal:	22	36	
9. River Bank Root Mass Protection	2	6	Minor amounts of riprap (~10%); planted area has high grass cover
10. Human-Caused Bare Ground	4	6	Some along BDEP pathway + trails N of bridge
11. Removal or Addition of Water from/to River System	6	9	Weir located just upstream
12. Control of Flood Peak and Timing by Upstream Dam(s)	0	9	Bearspaw Dam located upstream
13. River Banks Structurally Altered by Human Activity	0	6	Bank S of bridge has all been altered (~50% of area)
14. Human Physical Alteration to the Rest of the Polygon	0	3	" " " " " " ; 2 bridges + concrete pathway
15. Natural Floodplain Accessibility	6	6	No restrictions to floodplain accessibility
Soil / Hydrology Subtotal:	18	45	
Overall Polygon Total:	40	81	

- High BROMINE cover N of bridge + ELYMREP
- Unvegetated pathways

RATING CALCULATION

(Actual Score/Possible Score) X 100 = Rating Percent

					Descriptive Category
Vegetation Rating:	22 / 36	x 100 =	61%		Healthy with Problems
Soil / Hydrology:	18 / 45	x 100 =	40%		Unhealthy
OVERALL:	40 / 81	**x 100 =**	49%		"

30 - Planted bench - 12% woody
20 - Live cuttings - 18% "

ALBERTA WETLAND HEALTH ASSESSMENT FOR LARGE RIVERS

Polygon ID: BDEP Site #2

Project: CoC RMP	Observer: AD
Client: CoC	Date: Sept. 9/20
Property Name: ~	Watershed: South Saskatchewan River
Field Name: ~	River Name: Bow River
Legal Land Location: ~	Photos: 314 - 315
Natural Subregion: Foothills Fescue	

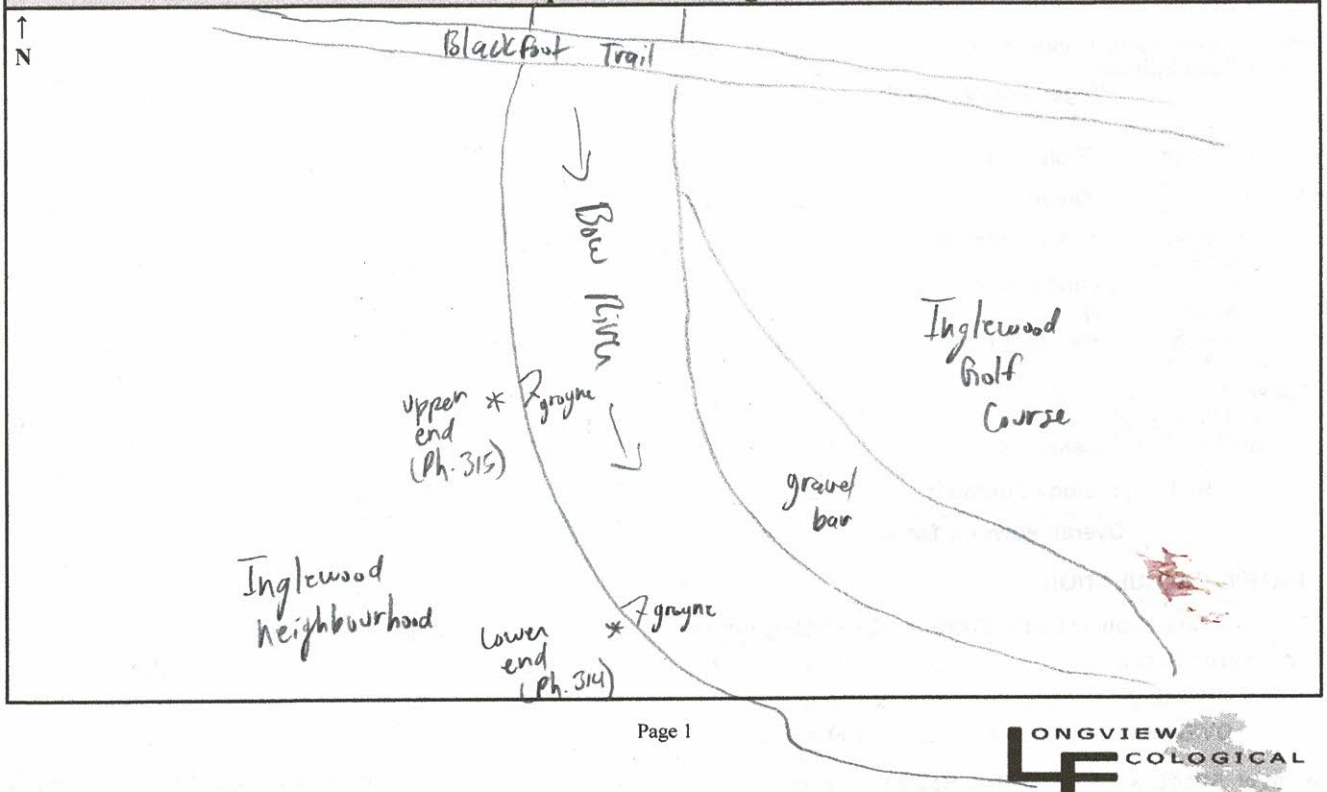
Coordinates: E709344, N5657966 (upstream end); E709403, N5657842 (downstream end)

Comments:

Dominant Plant Species

Graminoids	% Cover	Forbs	% Cover	Shrubs	% Cover	Trees	% Cover
FESTRUB	20	MEDISAT	5	ROSAWOO	2	POPUBAL	10
ELYMTRA	10	CIRSARV	1	RUBIDRY	2	ACERNEG	<1
CALIPER	8	TANAVUL	1	ELAEAGN	2	POPUTRE	<1
AGROSTO	7	ARTEABS	<1	PRUNVIR	5	PICEGLA	<1
ELYMCAN	2	SONCULI	1	SALIINT	15	PINUCON	<1
PHLEPRA	1	TRIFHYB	1	SALIFAR	10		
BROMINE	2	MEDILUP	2	CORNSTO	5		
		MELISPP	<1				

Riparian Area Diagram



LONGVIEW ECOLOGICAL

RIVER HEALTH EVALUATION

Polygon Number: _____ Record ID No: Site #2

	Actual Score	Possible Score	Comment
1. Cottonwood and Poplar Regeneration	6	6	A few mature POPUSAL, but mostly live cuttings + planted trees
2. Regeneration of other Native Tree Species	3	3	Some ACENEG seedlings, POPUTRE plantings
3. Regeneration of Preferred Shrub Species	6	6	Many SALINT + SHAPER installed are now mature (>6ft.), but still >15% regen.
4. Standing Decadent and Dead Woody Material	3	3	Minor from dead cuttings
5a. Browse Util. of Preferred Trees and Shrubs	3	3	None
5b. Woody Veg. Removal other than Browsing	3	3	None
6. Total Canopy Cover of Woody Species	2	3	Good on S bank; N bank only planted at base;
7a. Total Canopy Cover of Invasive Plant Species	1	3	See below
7b. Density/Distribution Pattern of Invasive Plant Species	0	3	" "

List Invasive Plant Species present, including Percent Canopy Cover and Density Distribution Class:

	Can.Cov.	Dens.Dist.		Can.Cov.	Dens.Dist.		Can.Cov.	Dens.Dist.
blueweed:			field bindweed:			spotted knapweed:		
* Canada thistle:	1	8	leafy spurge:			tall buttercup:		
caragana:			nodding thistle:			tamarisk/salt cedar:		
cleavers:			ox-eye daisy:			*white cockle:	<1	2
common burdock:			perennial sow-thistle:			*yellow toadflax:	<1	3
common hound's-tongue:			purple loosestrife:					
* common tansy:	1	5	Russian knapweed:					
Dalmatian Toadflax:			Russian olive:					
diffuse knapweed:			*scentless chamomile:	<1	2	Others: VICCRA	<1	5
downy chess:			*smooth perennial sow-thistle:	1	8	Others: CLEMTAN	<1	2
European buckthorn:						CAMPRAP	<1	2
						HYOSNIG	<1	2

2c. Are there elevated status species for this county? (Yes; No; NC):

Elevated Sps 1: _____ Elevated Sps 2: _____ Elevated Sps 3: _____

8. Disturbance-increaser Undesirable Herbaceous Species	2	3	- High MEDISAT cover along bench MEDISAT, BROMINE, POAPRAT, MEUALB, ELYMREP, HORJUB, TARAOFF, PLANMAJ, TRIFHYB, ARTEABS, TRAGDUB, ARTEBIE, TRIFREP, PHLEPRA, MELOFF, CIRSVUL, AVENFAT, THLARV, LACTSER, MEDILUP, PHLEPRA, AGROSTO
Vegetation Subtotal:	~~27~~	36	
9. River Bank Root Mass Protection	2	6	Riprap covers ~5%; good survival of cuttings; N bank left is
10. Human-Caused Bare Ground	4	6	Some along pathway along bench (17.) + [illegible]
11. Removal or Addition of Water from/to River System	6	9	Weir located just upstream from site
12. Control of Flood Peak and Timing by Upstream Dam(s)	0	9	Bearspaw Dam located upstream
13. River Banks Structurally Altered by Human Activity	0	6	Most of bank (4m band) has been disturbed + riprap installed
14. Human Physical Alteration to the Rest of the Polygon	0	3	Most of polygon (except eroded bank) has been disturbed
15. Natural Floodplain Accessibility	6	6	No restrictions to floodplain accessibility
Soil / Hydrology Subtotal:	18	45	
Overall Polygon Total:	45	81	

Eroded N bank not included

RATING CALCULATION

	(Actual Score/Possible Score) X 100 = Rating Percent			Descriptive Category
Vegetation Rating:	27 / 36	x 100 =	75%	Healthy, but with Problems
Soil / Hydrology:	18 / 45	x 100 =	40%	Unhealthy
OVERALL:	45 / 81	**x 100 =**	56%	"

5 - Riprap
35 - Bank
25 - Planted bench
35 - Unplanted bench

ALBERTA WETLAND HEALTH ASSESSMENT FOR LARGE RIVERS

Polygon ID: BD EP. Site #4

Project: CoC RMP	Observer: AD
Client: CoC	Date: Sept. 8/20
Property Name: —	Watershed: South Saskatchewan River
Field Name: —	River Name: Bow River
Legal Land Location: —	Photos: 311-313
Natural Subregion: Foothills Fescue	

Coordinates: E709403, N5657842 (upstream end) E709581, N5657672 (downstream end)

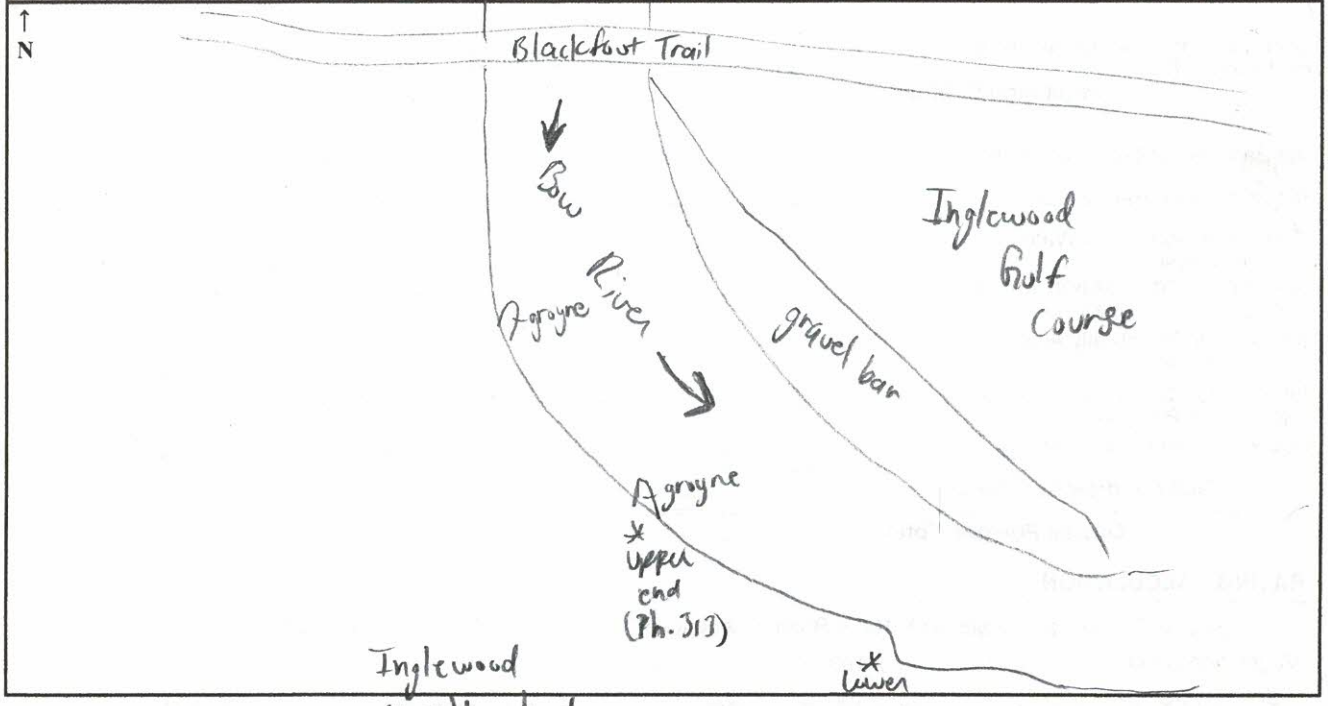
Comments:

ELAECOM 2
AMELAN <1

Dominant Plant Species

Graminoids	% Cover	Forbs	% Cover	Shrubs	% Cover	Trees	% Cover
BROMINE	15	CIRSARV	2	CORNSTO	10	POPUBAL	5
ELYMREP	7	SONCOLI	1	SALINT	20	POPUTRE	5
ELYMCAN	5	TANAVUL	1	SALIPAM	7	ACERNEG	<1
POAPALU	2	ARTEABS	<1	RIBEAUR	10	FRAXPEN	<1
ELYMTRA	3	TARAOFF	1	ROSAWOO	3	POPUDEL	<1
DESCCES	5	TRIPINO	<1	DASIFRU	3		
PHLEPRA	2	CIRSVUL	<1	ALNUTEN	2		
AGROSTO	15	SOLIALT	1	SALIGEO	3		
				PRUNVIR	1		

Riparian Area Diagram



LONGVIEW ECOLOGICAL

Mid-bank has livecuttings + planted shrubs (regen.)

Planted POPUTRE <7.5 dbh form majority of cover

RIVER HEALTH EVALUATION

Polygon Number: _____ Record ID No: Site #4

	Actual Score	Possible Score	Comment
1. Cottonwood and Poplar Regeneration	6	6	Some planted + volunteer POPUSAL - a few mature individuals
2. Regeneration of other Native Tree Species	3	3	A few ACENEG + FRAXPEN volunteers; some mature POPUTR
3. Regeneration of Preferred Shrub Species	6	6	Upper bank consists of mostly mature planted shrubs
4. Standing Decadent and Dead Woody Material	3	3	A few dead/decadent POPUTRE + POPUBAL, but overall only ~2% of woody cover
5a. Browse Util. of Preferred Trees and Shrubs	2	3	Ungulate browsing of CORNSTO + AMELAIN - no browsing on SALINT + SALEXAM
5b. Woody Veg. Removal other than Browsing	3	3	None
6. Total Canopy Cover of Woody Species	3	3	Most of upper bank is covered in native trees + shrubs
7a. Total Canopy Cover of Invasive Plant Species	1	3	See below
7b. Density/Distribution Pattern of Invasive Plant Species	0	3	" "

Some dead cutting

List Invasive Plant Species present, including Percent Canopy Cover and Density Distribution Class:

	Can.Cov.	Dens.Dist.		Can.Cov.	Dens.Dist.		Can.Cov.	Dens.Dist.
blueweed:			field bindweed:			spotted knapweed:		
* Canada thistle:	2	8	leafy spurge:			tall buttercup:		
caragana:			nodding thistle:			tamarisk/salt cedar:		
cleavers:			ox-eye daisy:			white cockle:		
common burdock:			perennial sow-thistle:			x yellow toadflax:	<1	2
common hound's-tongue:			purple loosestrife:					
* common tansy:	1	5	Russian knapweed:					
Dalmatian Toadflax:			Russian olive:					
diffuse knapweed:			* scentless chamomile:	<1	5	Others: HYOSNIG	<1	2
downy chess:			smooth perennial			Others:		
European buckthorn:			* sow-thistle:	1	8			

2c. Are there elevated status species for this county? (Yes; No; NC):

Elevated Sps 1: _____ Elevated Sps 2: _____ Elevated Sps 3: _____

8. Disturbance-increaser Undesirable Herbaceous Species	2	3	BARRAT TARAOFF MELALB, ELYMREP, THLARV
Vegetation Subtotal:	29	36	CIRVUL, BROINE, PHLPRA, ARTABS, MEDLUP, RUMETRI TRIHYB, TRAGDUB, MEDSAT, PLANMAJ, HORJUB LACTSER, CHENOPO, GLYCLEP
9. River Bank Root Mass Protection	2	6	Riprap covers ~20% of bank; ~50% of bank has deep-rooted trees + shrubs
10. Human-Caused Bare Ground	4	6	Some along downstream 1/3 of site (~3% of total site)
11. Removal or Addition of Water from/to River System	6	9	Irrigation weir located just upstream of site
12. Control of Flood Peak and Timing by Upstream Dam(s)	0	9	Beaverpaw Dam present upstream
13. River Banks Structurally Altered by Human Activity	0	6	Entire bank has been rip-rapped/altered
14. Human Physical Alteration to the Rest of the Polygon	0	3	Entire site has been altered
15. Natural Floodplain Accessibility	6	6	No restrictions to water accessing floodplain
Soil / Hydrology Subtotal:	18	45	
Overall Polygon Total:	47	81	

RATING CALCULATION

(Actual Score/Possible Score) X 100 = Rating Percent

					Descriptive Category
Vegetation Rating:	29	/ 36	x 100 =	81%	Healthy
Soil / Hydrology:	18	/ 45	x 100 =	40%	Unhealthy
OVERALL:	47	/ 81	**x 100 =**	58%	"

15% - 4 - 10%
85% - 40 - 34%
10% - 20 - 2%

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Appendix D

Bioengineering Structural Integrity Assessment Field Forms

Bank Protection/Stabilization Structure Assessment
First Assessment River Reach After Freshet Assessment KWL/Terra

Master Site List No.	46A	RMP Site ID Code (e.g., BE-BOW- 4A)		BE-BOW-46A	
Site Name:	AEP / COC Bioengineering Demonstration Project Site 1-1			Survey year (1/3/5+)	3
Watercourse	Bow River	Weather:	Overcast and 14 degrees		
Crew Initials	MG / PR	Date:	25-Sep-20		

Photo Monitoring

Permanent photo-monitoring location and ID **Other Photos (min 3)**

Refer to Appendix B - Attachment A, photos 1 - 32 and Appendix E

Hydrology

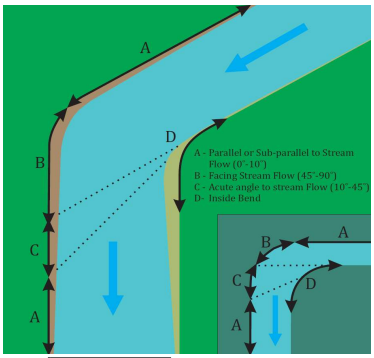
Flow at time of survey 45 m³/s Source: Rivers.alberta.ca

Aspect (N,E,W,S or combined N/E)

Aspect 1 EES % of site 100 Aspect 2 % of site Aspect 3 % of site

Site Location (Select 1 or more and add percentage of each)

A) Parallel or nearly parallel to flow (0° to 10°)	X	100 %
B) Moderate angle to flow (10° to 45°)		%
C) Directly facing flow (45° to 90°)		%
D) Internal bend		%



MEASUREMENTS

Average longitudinal stream slope at site 0.2 %

Estimate of stream width for current year flood flow 134 m

Site Dimensions

Total length of the work (parallel to stream) 69.5 m Total project area 542.1 m²

Avg width of the work in plan view (perp to stream) including landscaping on top of the bank 7.8 m

Average slope of the constructed bank 6 ° Average height of the constructed bank 1.3 m

Crib wall only

Height of Bioengineering Structure	Bank height (from permanent herbaceous or woody vegetation line)	Ratio % Bioeng structure/ Total Bank Height
Average width of the crib wall into the bank (from engineering plans)		m

Site Elevation Measurements

Hydrology Survey	**Rod Height (m)**	**Elevation (m)**	**Survey Notes**
Elevation Benchmark	1.1	1000	Water level at 12:30pm on July 17, 2019
High water mark*	0.27	1000.83	Debris on rodent fence
Water level during survey	1.1	1000	

*Measured at observed debris and/or pollen accumulated on bank

Planted Vegetation Survey*	**Rod Height (m)**	**Elevation (m)**	**Survey Notes**
Elevation Benchmark	1.1	1000	Water level at 12:30pm on July 17, 2019
Elev of lowest woody veg	1.14	999.96	Salix int.
Elev of lowest herbaceous veg		1001.1	Hydroseeded but washed away
Elev of lowest emergent veg		1001.1	

*Lowest elevation of ***planted*** woody, herbaceous, emergent vegetation along riverbank

Existing Vegetation Survey*	**Rod Height (m)**	**Elevation (m)**	**Survey Notes**
Elevation Benchmark	1.1	1000	Water level at 12:30pm on July 17, 2019
Elev of lowest woody veg	0.98	1000.12	Salix int.
Elev of lowest herbaceous veg	1.17	999.93	Grasses
Elev of lowest emergent veg	1.08	1000.02	Bulrush / Scorpus

*Lowest elevation of ***existing native*** woody, herbaceous, emergent vegetation along riverbank (trim line) If not possible, use difference in elevation

between current water surface and existing vegetation either across the stream and/or further D/S or U/S.

Difference in elev between Planted and Existing Veg	Difference (m)
Woody vegetation	-0.16
Herbaceous vegetation	
Emergent vegetation	

WORK STRUCTURE ASSESSMENT

Rock Materials

Riprap Size	lm of application (m)*	% of total riprap
Class 1M (d50=175mm)		0
Class 1 (d50=300mm)		0
Class 2 (d50=500mm)	69.5	100
Class 3 (d50=800mm)		0
Other:		0
Total linear metre (m)	69.5	

Filled in with river gravel

Fish boulder average diameter ____ mm
Fish boulder arrangement/distribution ____

Physical Condition	Rating	Riprap	Fish Boulders
Excellent	5 Very new without any defects	X	
Very Good	4 <5% defects without impacting structural integrity		
Good	3 10-20% defects without impacting structural integrity		
Fair	2 20-40% defects without impacting structural integrity		
Poor	1 Condition which needs immediate attention and repair		

Estimate of Remaining Useful Life	Riprap	Fish Boulders
>10 years	X	
5-10 years		
<5 years		
Negligible		

Gabion Materials

Gabion dimensions
Length ____ mm Width ____ mm Height ____ mm Mesh Opening Size ____ mm

Physical Condition	Rating	Gabions
Excellent	5 Very new without any defects	
Very Good	4 <5% defects without impacting structural integrity	
Good	3 10-20% defects without impacting structural integrity	
Fair	2 20-40% defects without impacting structural integrity	
Poor	1 Condition which needs immediate attention and repair	

Estimate of Remaining Useful Life	Gabions
>10 years	
5-10 years	
<5 years	
Negligible	

Wood Materials

Wood dimensions
Log diameter ____ mm Log length ____ mm Inclination angle ____ °
Timber width ____ mm Timber height ____ mm Timber length ____ mm
Rootwad diameter ____ mm Rootwad length ____ mm Location of root wad ____

Physical Condition	Rating	Logs	Timber	Rootwad
Excellent	5 Very new without any defects			
Very Good	4 <5% defects without impacting structural integrity			
Good	3 10-20% defects without impacting structural integrity			
Fair	2 20-40% defects without impacting structural integrity			
Poor	1 Condition which needs immediate attention and repair			

Estimate of Remaining Useful Life	Logs	Timber	Rootwad
4 >10 years			
3 5-10 years			
2 <5 years			
1 Negligible			

Erosion Control Matting and Geotextiles

Biodegradable erosion control matting product name (BECM)	
Biodegradable geogrid product name (BG)	
Synthetic erosion control matting product name (SECM)	
Synthetic geogrid product name (SG)	
Non woven geotextile product name (NWG)	

Hydromulch with wet meadow mix seed applied mostly washed out

Physical Condition	Rating	BECM	BG	SECM	SG	NWG
Excellent	5 Very new without any defects					
Very Good	4 <5% defects without impacting structural integrity					
Good	3 10-20% defects without impacting structural integrity					
Fair	2 20-40% defects without impacting structural integrity					
Poor	1 Condition which needs immediate attention and repair					

Estimate of Remaining Useful Life	BECM	BG	SECM	SG	NWG
4 >10 years					
3 5-10 years					
2 <5 years					
1 Negligible					

Erosion Control Wattles

Biodegradable wattle product name (BW)	
Synthetic wattle product name (SW)	

Physical Condition	Rating	BW	SW
Excellent	5 Very new without any defects		
Very Good	4 <5% defects without impacting structural integrity		
Good	3 10-20% defects without impacting structural integrity		
Fair	2 20-40% defects without impacting structural integrity		
Poor	1 Condition which needs immediate attention and repair		

Estimate of Remaining Useful Life	BW	SW
4 >10 years		
3 5-10 years		
2 <5 years		
1 Negligible		

Concrete Materials

Concrete product 1 description (C1)	
Concrete product 2 description (C2)	
Concrete product 3 description (C3)	

Physical Condition	Rating	C1	C2	C3
Excellent	5 Very new without any defects			
Very Good	4 <5% defects without impacting structural integrity			
Good	3 10-20% defects without impacting structural integrity			
Fair	2 20-40% defects without impacting structural integrity			
Poor	1 Condition which needs immediate attention and repair			

Estimate of Remaining Useful Life	C1	C2	C3
4 >10 years			
3 5-10 years			
2 <5 years			
1 Negligible			

Steel Materials

Steel product 1 description (S1)	
Steel product 2 description (S2)	
Steel product 3 description (S3)	
Steel product 4 description (S4)	
Steel product 5 description (S5)	

Physical Condition	Rating	S1	S2	S3	S4	S5
Excellent	5 Very new without any defects					
Very Good	4 <5% defects without impacting structural integrity					
Good	3 10-20% defects without impacting structural integrity					
Fair	2 20-40% defects without impacting structural integrity					
Poor	1 Condition which needs immediate attention and repair					

Estimate of Remaining Useful Life	S1	S2	S3	S4	S5
4 >10 years					
3 5-10 years					
2 <5 years					
1 Negligible					

ENVIRONMENTAL AND CONTEXTUAL FACTORS

Erosion/Deposition Observations

Estimate of toe scour at site
Low [ ] Medium [ ] High [ ] N/A [X] Describe: None

Estimate of U/S bank erosion at site (U/S key)
Low [ ] Medium [ ] High [ ] N/A [X] Describe: None

Estimate of D/S bank erosion at site (D/S key)
Low [ ] Medium [ ] High [ ] N/A [X] Describe: None

Estimate of erosion within site/structure
Low [ ] Medium [ ] High [ ] N/A [X] Describe: None

Estimate of sediment accumulation at site
Low [X] Medium [ ] High [ ] N/A [ ] Describe: Accumulated within cobble

Measurement of sediment accumulation at site
Depth: 1 cm Method: Visual
Describe/Location:

Seeps or spring present Yes [ ] No [✠] Describe:

Ice abrasion None [X] Light [ ] Moderate [ ] Severe [ ]

Visual estimate of channel grain size
Silt [ ] Sand [X] Gravel [X] Cobble [X] Boulder [ ] Bedrock [ ]

SITE MOST LIMITING FACTOR(S)

Select from the list below, limiting factors to success:	**ASSIGN A SEVERITY RATING TO EACH OF THE FACTORS BELOW: NONE(0), LIGHT(1), MODERATE(2), SEVERE(3)**	
	After Treatment	**Comments**
Slope instability	0	
Slope gradient	0	
Erosion	0	
Compacted soils	0	
Anoxic soils	0	
Insect damage and disease	1	Insect on foliage of Salix int.
Trampling by people or dogs	0	
Motorized vehicles	0	
Non motorized vehicles	0	
Aspect	0	
Bank profile	0	
Existing vegetation competition[1]	0	
Shade	2	Upper canopy on west side shading side
Maintenance issues[2]	2	Rodent fence
Flooding duration	2	Inundated during high water
Hydraulics (Shear stress)	1	
Infrastructure and available space	0	
Wildlife impact[3]	0	
Comment on wildlife impact:		
Access	0	
Other: 1- Species selection	2	Species such as balsam poplar and hungry willow and
2-		

[1] e.g. from aggressive, fast spreading grasses or invasive weed species

[2] e.g. weeding, fencing or rodent protection) including inadequate or no irrigation, frequency or coverage

[3] Browsing/girdling by Rodent/Beavers/Muskrats

POTENTIAL REPAIR OPTIONS

	Select one
(1) Minor (hand tools, seeding and manual planting)	X
(2) Moderate, may need small machine and material to be brought in (is there access?)	
(3) Major, site needs to be redesigned and reconstructed.	

Description: Fix rodent fence

ALTERNATIVE DESIGN OPTIONS

Description: Live staking in riprap at correct time of year for dormancy; alternate to hydroseeding is plugs of emergents with protection for geese; only use salix interior as a specie

Success Attributes

Good naturalization of vegetated riprap using River gravels to infill riprap; innovative technique using rooted long live cuttings; 2020 riprap not showing and native grasses are establishing looks natural like adjacent gravel bar area and bank

Bank Protection/Stabilization Structure Assessment
First Assessment River Reach After Freshet Assessment KWL/Terra

Master Site List No.	46B	RMP Site ID Code (e.g., BE-BOW- 4A)		BE-BOW-46B	
Site Name:	AEP / COC Bioengineering Demonstration Project Site 1-3			Survey year (1/3/5+)	3
Watercourse	Bow River	Weather:	Slightly overcast and 15 degrees		
Crew Initials	MG / PR	Date:	25-Sep-20		

Photo Monitoring

Permanent photo-monitoring location and ID **Other Photos (min 3)**

Refer to Appendix B - Attachment A, photos 1 - 32 and Appendix E

Hydrology

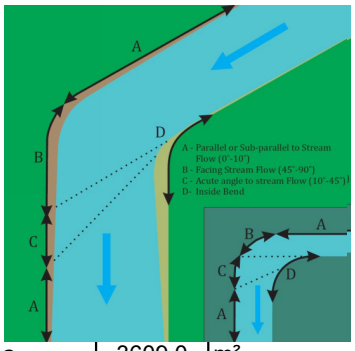
Flow at time of survey 45 m³/s Source: Rivers.alberta.ca

Aspect (N,E,W,S or combined N/E)

Aspect 1 EES % of site 100 Aspect 2 % of site Aspect 3 % of site

Site Location (Select 1 or more and add percentage of each)

A) Parallel or nearly parallel to flow (0° to 10°)	X	70 %
B) Moderate angle to flow (10° to 45°)	X	30 %
C) Directly facing flow (45° to 90°)		%
D) Internal bend		%



MEASUREMENTS

Average longitudinal stream slope at site 0.2 %

Estimate of stream width for current year flood flow 99 m

Site Dimensions

Total length of the work (parallel to stream) 120.3 m Total project area 3609.0 m²

Avg width of the work in plan view (perp to stream) including landscaping on top of the bank 30 m

Average slope of the constructed bank 15 ° Average height of the constructed bank 9 m

Crib wall only

Height of Bioengineering Structure	Bank height (from permanent herbaceous or woody vegetation line)	Ratio % Bioeng structure/ Total Bank Height
1.8	5.5	32.72727273
Average width of the crib wall into the bank (from engineering plans)		1.8 m

Site Elevation Measurements

Hydrology Survey	Rod Height (m)	Elevation (m)	Survey Notes
Elevation Benchmark	1.1	1000	Water level at 12:30pm on July 17, 2019 us of site 1-1
High water mark*	0.27	1000.83	
Water level during survey	1.1	1000	

*Measured at observed debris and/or pollen accumulated on bank

Planted Vegetation Survey*	Rod Height (m)	Elevation (m)	Survey Notes
Elevation Benchmark	2.08	1000	Water level at 1:19pm on July 17, 2019
Elev of lowest woody veg	1.62	1000.46	Dead red osier dogwood
Elev of lowest herbaceous veg	1.59	1000.49	Grasses under coir matting on veg. crib wall
Elev of lowest emergent veg		1002.08	None

*Lowest elevation of *planted* woody, herbaceous, emergent vegetation along riverbank

Existing Vegetation Survey*	Rod Height (m)	Elevation (m)	Survey Notes
Elevation Benchmark	1.1	1000	Water level at 12:30pm on July 17, 2019 us of site 1-1
Elev of lowest woody veg	0.98	1000.12	
Elev of lowest herbaceous veg	1.17	999.93	
Elev of lowest emergent veg	1.08	1000.02	

*Lowest elevation of *existing native* woody, herbaceous, emergent vegetation along riverbank (trim line) If not possible, use difference in elevation between current water surface and existing vegetation either across the stream and/or further D/S or U/S.

Difference in elev between Planted and Existing Veg	Difference (m)

Woody vegetation	0.34
Herbaceous vegetation	0.56
Emergent vegetation	

WORK STRUCTURE ASSESSMENT

Rock Materials

Riprap Size	lm of application (m)*	% of total riprap
Class 1M (d50=175mm)		0
Class 1 (d50=300mm)		0
Class 2 (d50=500mm)	120.3	100
Class 3 (d50=800mm)		0
Other:		0
Total linear metre (m)	120.3	

Fish boulder average diameter 800 mm

Fish boulder arrangement/distribution 3 rock boulder clusters spaced at 1.0m apart

Physical Condition	Rating	Riprap	Fish Boulders
Excellent	5 Very new without any defects	X	**X**
Very Good	4 <5% defects without impacting structural integrity		
Good	3 10-20% defects without impacting structural integrity		
Fair	2 20-40% defects without impacting structural integrity		
Poor	1 Condition which needs immediate attention and repair		

Estimate of Remaining Useful Life	Riprap	Fish Boulders
>10 years	**X**	**X**
5-10 years		
<5 years		
Negligible		

Gabion Materials

Gabion dimensions

Length mm Width mm Height mm Mesh Opening Size mm

Physical Condition	Rating	Gabions
Excellent	5 Very new without any defects	
Very Good	4 <5% defects without impacting structural integrity	
Good	3 10-20% defects without impacting structural integrity	
Fair	2 20-40% defects without impacting structural integrity	
Poor	1 Condition which needs immediate attention and repair	

Estimate of Remaining Useful Life	Gabions
>10 years	
5-10 years	
<5 years	
Negligible	

Wood Materials

Wood dimensions

Log diameter mm Log length mm Inclination angle °

Timber width 150 mm Timber height 150 mm Timber length 6500 mm

Rootwad diameter mm Rootwad length mm Location of root wad

Physical Condition	Rating	Logs	Timber	Rootwad
Excellent	5 Very new without any defects			
Very Good	4 <5% defects without impacting structural integrity			
Good	3 10-20% defects without impacting structural integrity		**X**	
Fair	2 20-40% defects without impacting structural integrity			
Poor	1 Condition which needs immediate attention and repair			

Estimate of Remaining Useful Life	Logs	Timber	Rootwad
4 >10 years			
3 5-10 years		X	
2 <5 years			
1 Negligible			

Erosion Control Matting and Geotextiles

Biodegradable erosion control matting product name (BECM)	
Biodegradable geogrid product name (BG)	Double layered coir 1200 g/m2 - coirwrap 1200
Synthetic erosion control matting product name (SECM)	
Synthetic geogrid product name (SG)	
Non woven geotextile product name (NWG)	Nilex 4512

Physical Condition	Rating	BECM	BG	SECM	SG	NWG
Excellent	5 Very new without any defects					
Very Good	4 <5% defects without impacting structural integrity					X
Good	3 10-20% defects without impacting structural integrity		X			
Fair	2 20-40% defects without impacting structural integrity					
Poor	1 Condition which needs immediate attention and repair					

Estimate of Remaining Useful Life	BECM	BG	SECM	SG	NWG
4 >10 years					X
3 5-10 years					
2 <5 years		X			
1 Negligible					

Erosion Control Wattles

Biodegradable wattle product name (BW)	
Synthetic wattle product name (SW)	

Physical Condition	Rating	BW	SW
Excellent	5 Very new without any defects		
Very Good	4 <5% defects without impacting structural integrity		
Good	3 10-20% defects without impacting structural integrity		
Fair	2 20-40% defects without impacting structural integrity		
Poor	1 Condition which needs immediate attention and repair		

Estimate of Remaining Useful Life	BW	SW
4 >10 years		
3 5-10 years		
2 <5 years		
1 Negligible		

Concrete Materials

Concrete product 1 description (C1)	Lock blocks at back of timber crib wall in fish shelters dim 750x750x1500 (not observed)
Concrete product 2 description (C2)	
Concrete product 3 description (C3)	

Physical Condition	Rating	C1	C2	C3
Excellent	5 Very new without any defects	Not observed		
Very Good	4 <5% defects without impacting structural integrity			
Good	3 10-20% defects without impacting structural integrity			
Fair	2 20-40% defects without impacting structural integrity			
Poor	1 Condition which needs immediate attention and repair			

Estimate of Remaining Useful Life	C1	C2	C3
4 >10 years	Not observed		
3 5-10 years			
2 <5 years			
1 Negligible			

Steel Materials

Steel product 1 description (S1)	Stainless steel crib connection plates
Steel product 2 description (S2)	Stainless bolts
Steel product 3 description (S3)	Galvanized spiral shank spike
Steel product 4 description (S4)	
Steel product 5 description (S5)	

Physical Condition	Rating	S1	S2	S3	S4	S5
Excellent	5 Very new without any defects	X	X	X		
Very Good	4 <5% defects without impacting structural integrity					
Good	3 10-20% defects without impacting structural integrity					
Fair	2 20-40% defects without impacting structural integrity					
Poor	1 Condition which needs immediate attention and repair					

Estimate of Remaining Useful Life	S1	S2	S3	S4	S5
4 >10 years	X	X	X		
3 5-10 years					
2 <5 years					
1 Negligible					

ENVIRONMENTAL AND CONTEXTUAL FACTORS

Erosion/Deposition Observations

Estimate of toe scour at site
Low [ ] Medium [ ] High [ ] N/A [X] Describe: None

Estimate of U/S bank erosion at site (U/S key)
Low [ ] Medium [ ] High [ ] N/A [X] Describe: None

Estimate of D/S bank erosion at site (D/S key)
Low [ ] Medium [ ] High [ ] N/A [X] Describe: None

Estimate of erosion within site/structure
Low [ ] Medium [ ] High [ ] N/A [X] Describe: None

Estimate of sediment accumulation at site
Low [X] Medium [ ] High [ ] N/A [ ] Describe: On the rock bench at low water

Measurement of sediment accumulation at site
Depth: Na Method: Underwater
Describe/Location:

Seeps or spring present Yes [ ] No [✠] Describe:

Ice abrasion None [X] Light [ ] Moderate [ ] Severe [ ]

Visual estimate of channel grain size
Silt [ ] Sand [X] Gravel [X] Cobble [X] Boulder [ ] Bedrock [ ]

SITE MOST LIMITING FACTOR(S)

Select from the list below, limiting factors to success:	ASSIGN A SEVERITY RATING TO EACH OF THE FACTORS BELOW: NONE(0), LIGHT(1), MODERATE(2), SEVERE(3)	
	After Treatment	Comments
Slope instability	0	
Slope gradient	0	
Erosion	0	
Compacted soils	0	
Anoxic soils	0	
Insect damage and disease	1	On foliage
Trampling by people or dogs	0	
Motorized vehicles	0	
Non motorized vehicles	0	
Aspect	0	
Bank profile	0	
Existing vegetation competition[1]	3	Invasives present high seeding application rate; 2020 still a
Shade	0	
Maintenance issues[2]	3	Weeding and fence repair on upstream; 2020 only weeding
Flooding duration	0	
Hydraulics (Shear stress)	2	
Infrastructure and available space	0	
Wildlife impact[3]	0	
Comment on wildlife impact:		
Access	0	
Other: 1-		
2-		

[1] e.g. from aggressive, fast spreading grasses or invasive weed species

[2] e.g. weeding, fencing or rodent protection) including inadequate or no irrigation, frequency or coverage

[3] Browsing/girdling by Rodent/Beavers/Muskrats

POTENTIAL REPAIR OPTIONS

	Select one
(1) Minor (hand tools, seeding and manual planting)	X
(2) Moderate, may need small machine and material to be brought in (is there access?)	
(3) Major, site needs to be redesigned and reconstructed.	

Description: Remove invasives including root system from site before gone to seed and remove from site, cut down all grasses that are competing with cutting and leave on site as mulch for woody veg; repair fence and remove portion protruding u/s.

ALTERNATIVE DESIGN OPTIONS

Description: Vegetated riprap with soil wrap above

Success Attributes

Deep buried cuttings at 35 degree in brush layer within structures ; innovative fish shelter included in timber crib wall to create habitat; 2020 overhanging canopy cover in front of crib wall for fish habitat

Bank Protection/Stabilization Structure Assessment
First Assessment River Reach After Freshet Assessment KWL/Terra

Master Site List No.	46C	RMP Site ID Code (e.g., BE-BOW- 4A)		BE-BOW-46C	
Site Name:	AEP / COC Bioengineering Demonstration Project Site 1-4			Survey year (1/3/5+)	2
Watercourse	Bow River	Weather:	Sunny 15 degrees		
Crew Initials	MG / PR	Date:	25-Sep-20		

Photo Monitoring

Permanent photo-monitoring location and ID **Other Photos (min 3)**

Refer to Appendix B - Attachment A, photos 1 - 32 and Appendix E

Hydrology

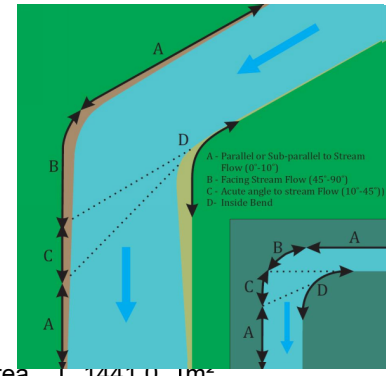
Flow at time of survey 152 m³/s Source: Rivers.alberta.ca

Aspect (N,E,W,S or combined N/E)

Aspect 1 EES % of site 100 Aspect 2 % of site Aspect 3 % of site

Site Location (Select 1 or more and add percentage of each)

A) Parallel or nearly parallel to flow (0° to 10°)		%
B) Moderate angle to flow (10° to 45°)	X	100 %
C) Directly facing flow (45° to 90°)		%
D) Internal bend		%



MEASUREMENTS

Average longitudinal stream slope at site 0.2 %

Estimate of stream width for current year flood flow 147 m

Site Dimensions

Total length of the work (parallel to stream) 65.5 m Total project area 1441.0 m²

Avg width of the work in plan view (perp to stream) including landscaping on top of the bank 22 m

Average slope of the constructed bank 20 ° Average height of the constructed bank 8.5 m

Crib wall only

Height of Bioengineering Structure	Bank height (from permanent herbaceous or woody vegetation line)	Ratio % Bioeng structure/ Total Bank Height
		#DIV/0!
Average width of the crib wall into the bank (from engineering plans)		m

Site Elevation Measurements

Hydrology Survey	**Rod Height (m)**	**Elevation (m)**	**Survey Notes**
Elevation Benchmark	1.1	1000	Water level at 12:30pm on july 17, 2019 us of site
High water mark*	0.27	1000.83	1.24 at Site 1-3 and 1-4 (grasses on fence)
Water level during survey	1.1	1000	
*Measured at observed debris and/or			

Planted Vegetation Survey*	**Rod Height (m)**	**Elevation (m)**	**Survey Notes**
Elevation Benchmark	2.08	1000	Water level at 140pm on July 17, 2019 at Site 1-4
Elev of lowest woody veg	1.84	1000.24	Brush mattress Salix int.
Elev of lowest herbaceous veg	1.1	1000.98	Up slope from B/M under coir matting
Elev of lowest emergent veg		1002.08	

*Lowest elevation of *planted* woody, herbaceous, emergent vegetation along riverbank

Existing Vegetation Survey*	**Rod Height (m)**	**Elevation (m)**	**Survey Notes**
Elevation Benchmark	1.1	1000	Water level at 12:30pm on july 17, 2019 us of site
Elev of lowest woody veg	0.98	1000.12	
Elev of lowest herbaceous veg	1.17	999.93	
Elev of lowest emergent veg	1.08	1000.02	

*Lowest elevation of *existing native* woody, herbaceous, emergent vegetation along riverbank (trim line) If not possible, use difference in elevation between current water surface and existing vegetation either across the stream and/or further D/S or U/S.

Difference in elev between Planted and Existing Veg	Difference (m)
Woody vegetation	0.12
Herbaceous vegetation	1.05
Emergent vegetation	

WORK STRUCTURE ASSESSMENT

Rock Materials

Riprap Size	lm of application (m)*	% of total riprap
Class 1M (d50=175mm)		0
Class 1 (d50=300mm)		0
Class 2 (d50=500mm)	65.5	100
Class 3 (d50=800mm)		0
Other:		0
Total linear metre (m)	65.5	

Fish boulder average diameter 800 mm

Fish boulder arrangement/distribution 3 rock boulder cluster spaced 10m

Physical Condition	Rating	Riprap	Fish Boulders
Excellent	5 Very new without any defects	X	**X**
Very Good	4 <5% defects without impacting structural integrity		
Good	3 10-20% defects without impacting structural integrity		
Fair	2 20-40% defects without impacting structural integrity		
Poor	1 Condition which needs immediate attention and repair		

Estimate of Remaining Useful Life	Riprap	Fish Boulders
>10 years	**X**	**X**
5-10 years		
<5 years		
Negligible		

Gabion Materials

Gabion dimensions

Length mm Width mm Height mm Mesh Opening Size mm

Physical Condition	Rating	Gabions
Excellent	5 Very new without any defects	
Very Good	4 <5% defects without impacting structural integrity	
Good	3 10-20% defects without impacting structural integrity	
Fair	2 20-40% defects without impacting structural integrity	
Poor	1 Condition which needs immediate attention and repair	

Estimate of Remaining Useful Life	Gabions
>10 years	
5-10 years	
<5 years	
Negligible	

Wood Materials

Wood dimensions

Log diameter mm Log length mm Inclination angle °

Timber width mm Timber height mm Timber length mm

Rootwad diameter mm Rootwad length mm Location of root wad

Physical Condition	Rating	Logs	Timber	Rootwad
Excellent	5 Very new without any defects			
Very Good	4 <5% defects without impacting structural integrity			
Good	3 10-20% defects without impacting structural integrity			
Fair	2 20-40% defects without impacting structural integrity			
Poor	1 Condition which needs immediate attention and repair			

Estimate of Remaining Useful Life	Logs	Timber	Rootwad
4 >10 years			
3 5-10 years			
2 <5 years			
1 Negligible			

Erosion Control Matting and Geotextiles

Biodegradable erosion control matting product name (BECM)	
Biodegradable geogrid product name (BG)	900 g/m2 coir geotextile
Synthetic erosion control matting product name (SECM)	
Synthetic geogrid product name (SG)	
Non woven geotextile product name (NWG)	

Physical Condition	Rating	BECM	BG	SECM	SG	NWG
Excellent	5 Very new without any defects					
Very Good	4 <5% defects without impacting structural integrity					
Good	3 10-20% defects without impacting structural integrity		X			
Fair	2 20-40% defects without impacting structural integrity					
Poor	1 Condition which needs immediate attention and repair					

Estimate of Remaining Useful Life	BECM	BG	SECM	SG	NWG
4 >10 years					
3 5-10 years					
2 <5 years		X			
1 Negligible					

Hydro seeding ; low grass establishment and high weed cover

Erosion Control Wattles

Biodegradable wattle product name (BW)	
Synthetic wattle product name (SW)	

Physical Condition	Rating	BW	SW
Excellent	5 Very new without any defects		
Very Good	4 <5% defects without impacting structural integrity		
Good	3 10-20% defects without impacting structural integrity		
Fair	2 20-40% defects without impacting structural integrity		
Poor	1 Condition which needs immediate attention and repair		

Estimate of Remaining Useful Life	BW	SW
4 >10 years		
3 5-10 years		
2 <5 years		
1 Negligible		

Concrete Materials

Concrete product 1 description (C1)	
Concrete product 2 description (C2)	
Concrete product 3 description (C3)	

Physical Condition	Rating	C1	C2	C3
Excellent	5 Very new without any defects			
Very Good	4 <5% defects without impacting structural integrity			
Good	3 10-20% defects without impacting structural integrity			
Fair	2 20-40% defects without impacting structural integrity			
Poor	1 Condition which needs immediate attention and repair			

Estimate of Remaining Useful Life	C1	C2	C3
4 >10 years			
3 5-10 years			
2 <5 years			
1 Negligible			

Steel Materials

Steel product 1 description (S1)	
Steel product 2 description (S2)	
Steel product 3 description (S3)	
Steel product 4 description (S4)	
Steel product 5 description (S5)	

Physical Condition	Rating	S1	S2	S3	S4	S5
Excellent	5 Very new without any defects					
Very Good	4 <5% defects without impacting structural integrity					
Good	3 10-20% defects without impacting structural integrity					
Fair	2 20-40% defects without impacting structural integrity					
Poor	1 Condition which needs immediate attention and repair					

Estimate of Remaining Useful Life	S1	S2	S3	S4	S5
4 >10 years					
3 5-10 years					
2 <5 years					
1 Negligible					

ENVIRONMENTAL AND CONTEXTUAL FACTORS

Erosion/Deposition Observations

Estimate of toe scour at site
Low [ ] Medium [ ] High [ ] N/A [X] Describe: None

Estimate of U/S bank erosion at site (U/S key)
Low [ ] Medium [ ] High [ ] N/A [X] Describe: None

Estimate of D/S bank erosion at site (D/S key)
Low [ ] Medium [ ] High [ ] N/A [X] Describe: None

Estimate of erosion within site/structure
Low [X] Medium [ ] High [ ] N/A [ ] Describe: Minor rilling

Estimate of sediment accumulation at site
Low [X] Medium [ ] High [ ] N/A [ ] Describe: Sediment and debris on matting

Measurement of sediment accumulation at site
Depth [<1cm] Method: Visual
Describe/Location

Seeps or spring present Yes [ ] No [✠] Describe

Ice abrasion None [X] Light [ ] Moderate [ ] Severe [ ]

Visual estimate of channel grain size
Silt [ ] Sand [X] Gravel [X] Cobble [X] Boulder [ ] Bedrock [ ]

SITE MOST LIMITING FACTOR(S)

Select from the list below, limiting factors to success:	ASSIGN A SEVERITY RATING TO EACH OF THE FACTORS BELOW: NONE(0), LIGHT(1), MODERATE(2), SEVERE(3)	
	After Treatment	Comments
Slope instability	0	
Slope gradient	0	
Erosion	1	Rilling on upper slope
Compacted soils	0	
Anoxic soils	0	
Insect damage and disease	1	Insects on leaves
Trampling by people or dogs	0	
Motorized vehicles	0	
Non motorized vehicles	0	
Aspect	0	
Bank profile	0	
Existing vegetation competition[1]	3	Some weeds / existing invasives; 2020 herbaceous
Shade	0	
Maintenance issues[2]	2	Weeding and light erosion, rilling; filling end of contour fascine
Flooding duration	1	Brush mattress coverd with debris
Hydraulics (Shear stress)	2	
Infrastructure and available space	0	
Wildlife impact[3]	0	
Comment on wildlife impact:		
Access	0	
Other: 1-		
2-		

[1] e.g. from aggressive, fast spreading grasses or invasive weed species

[2] e.g. weeding, fencing or rodent protection) including inadequate or no irrigation, frequency or coverage

[3] Browsing/girdling by Rodent/Beavers/Muskrats

POTENTIAL REPAIR OPTIONS

	Select one
(1) Minor (hand tools, seeding and manual planting)	X
(2) Moderate, may need small machine and material to be brought in (is there access?)	
(3) Major, site needs to be redesigned and reconstructed.	

Description: Weeding ; repair of minor erosion and straw wattle along top of slope; cover / fill fascine at us end with soil; fix leaking sprinkler heads and level ground surface where rilling is occurring; raise sprinkler heads to 1m on t posts; 2020 leaking irrigation and minor erosion issues repaired and vegetated

ALTERNATIVE DESIGN OPTIONS

Description: Vegetated riprap toe with vegetated soil wrap above ; coir matting (on lower 2m) of slope with live staking on entire slope.

Success Attributes

Techniques such as contour fascine and brush mattress; seeding application rate appears to be correct. Seeding application at 25kg/ha appears to be correct, therefore less competeition for plant establishment.

Bank Protection/Stabilization Structure Assessment
First Assessment River Reach After Freshet Assessment KWL/Terra

Master Site List No.	46D-1	RMP Site ID Code (e.g., BE-BOW- 4A)		BE-BOW-46D-1	
Site Name:	AEP / COC Bioengineering Demonstration Project Site 2-1 - box fascin			Survey year (1/3/5+)	3
Watercourse	Bow River	Weather:	Sunny 15 degrees		
Crew Initials	MG / PR	Date:	15-Sep-20		

Photo Monitoring

Permanent photo-monitoring location and ID **Other Photos (min 3)**

Refer to Appendix B - Attachment A, photos 1 - 32 and Appendix E

Hydrology

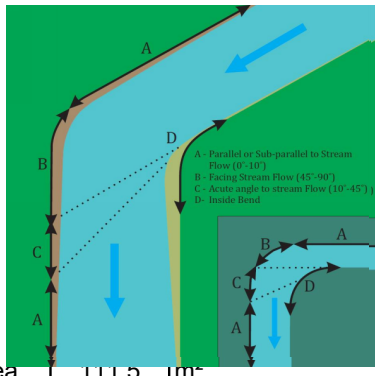
Flow at time of survey 45 m³/s Source: Rivers.alberta.ca

Aspect (N,E,W,S or combined N/E)

Aspect 1 EES % of site 100 Aspect 2 % of site Aspect 3 % of site

Site Location (Select 1 or more and add percentage of each)

A) Parallel or nearly parallel to flow (0° to 10°)	X	70 %
B) Moderate angle to flow (10° to 45°)	X	30 %
C) Directly facing flow (45° to 90°)		%
D) Internal bend		%



MEASUREMENTS

Average longitudinal stream slope at site 0.2 %

Estimate of stream width for current year flood flow 147 m

Site Dimensions

Total length of the work (parallel to stream) 50.7 m Total project area 111.5 m²

Avg width of the work in plan view (perp to stream) including landscaping on top of the bank 2.2 m

Average slope of the constructed bank 8 ° Average height of the constructed bank 0.5 m

Crib wall only

Height of Bioengineering Structure	Bank height (from permanent herbaceous or woody vegetation line)	Ratio % Bioeng structure/ Total Bank Height
		#DIV/0!
Average width of the crib wall into the bank (from engineering plans)		m

Site Elevation Measurements

Hydrology Survey	**Rod Height (m)**	**Elevation (m)**	**Survey Notes**
Elevation Benchmark	1.1	1000	Water level at 12:30pm on July 17, 2019 us site
High water mark*	0.27	1000.83	High water mark at site 2-1 = 0.9 Debris in rodent fence
Water level during survey	1.1	1000	

*Measured at observed debris and/or pollen accumulated on bank

Planted Vegetation Survey*	**Rod Height (m)**	**Elevation (m)**	**Survey Notes**
Elevation Benchmark	1.54	1000	Water level at 2:13pm on July 17, 2019 at Site 2-
Elev of lowest woody veg	1.54	1000	Brush layer under box fascine
Elev of lowest herbaceous veg		1001.54	None
Elev of lowest emergent veg		1001.54	None

*Lowest elevation of *planted* woody, herbaceous, emergent vegetation along riverbank

Existing Vegetation Survey*	**Rod Height (m)**	**Elevation (m)**	**Survey Notes**
Elevation Benchmark	1.1	1000	Water level at 12:30pm on July 17, 2019 us site
Elev of lowest woody veg	0.98	1000.12	
Elev of lowest herbaceous veg	1.17	999.93	
Elev of lowest emergent veg	1.08	1000.02	

*Lowest elevation of *existing native* woody, herbaceous, emergent vegetation along riverbank (trim line) If not possible, use difference in elevation between current water surface and existing vegetation either across the stream and/or further D/S or U/S.

Difference in elev between Planted and Existing Veg	Difference (m)
Woody vegetation	-0.12
Herbaceous vegetation	
Emergent vegetation	

WORK STRUCTURE ASSESSMENT

Rock Materials

Riprap Size	lm of application (m)*	% of total riprap
Class 1M (d50=175mm)		0
Class 1 (d50=300mm)		0
Class 2 (d50=500mm)		0
Class 3 (d50=800mm)		0
Other: Pea gravel	50.7	100
Total linear metre (m)	50.7	

Fish boulder average diameter ____ mm
Fish boulder arrangement/distribution ____

Physical Condition	Rating	Riprap	Fish Boulders
Excellent	5 Very new without any defects		
Very Good	4 <5% defects without impacting structural integrity	X	
Good	3 10-20% defects without impacting structural integrity		
Fair	2 20-40% defects without impacting structural integrity		
Poor	1 Condition which needs immediate attention and repair		

No riprap use

Mostly wa

Estimate of Remaining Useful Life	Riprap	Fish Boulders
>10 years	X	
5-10 years		
<5 years		
Negligible		

No riprap used (pea gravel) fines are washing

Gabion Materials

Gabion dimensions
Length ____ mm Width ____ mm Height ____ mm Mesh Opening Size ____ mm

Physical Condition	Rating	Gabions
Excellent	5 Very new without any defects	
Very Good	4 <5% defects without impacting structural integrity	
Good	3 10-20% defects without impacting structural integrity	
Fair	2 20-40% defects without impacting structural integrity	
Poor	1 Condition which needs immediate attention and repair	

Estimate of Remaining Useful Life	Gabions
>10 years	
5-10 years	
<5 years	
Negligible	

Wood Materials

Wood dimensions
Log diameter 120 mm Log length 1500 mm Inclination angle 90 °
Timber width ____ mm Timber height ____ mm Timber length ____ mm
Rootwad diameter ____ mm Rootwad length ____ mm Location of root wad ____

Physical Condition	Rating	Logs	Timber	Rootwad
Excellent	5 Very new without any defects			
Very Good	4 <5% defects without impacting structural integrity			
Good	3 10-20% defects without impacting structural integrity	X		
Fair	2 20-40% defects without impacting structural integrity			
Poor	1 Condition which needs immediate attention and repair			

Estimate of Remaining Useful Life	Logs	Timber	Rootwad
4 >10 years			
3 5-10 years			
2 <5 years	X		
1 Negligible			

Erosion Control Matting and Geotextiles

Biodegradable erosion control matting product name (BECM)	
Biodegradable geogrid product name (BG)	
Synthetic erosion control matting product name (SECM)	
Synthetic geogrid product name (SG)	
Non woven geotextile product name (NWG)	

Physical Condition	Rating	BECM	BG	SECM	SG	NWG
Excellent	5 Very new without any defects					
Very Good	4 <5% defects without impacting structural integrity					
Good	3 10-20% defects without impacting structural integrity					
Fair	2 20-40% defects without impacting structural integrity					
Poor	1 Condition which needs immediate attention and repair					

Estimate of Remaining Useful Life	BECM	BG	SECM	SG	NWG
4 >10 years					
3 5-10 years					
2 <5 years					
1 Negligible					

Erosion Control Wattles

Biodegradable wattle product name (BW)	
Synthetic wattle product name (SW)	

Physical Condition	Rating	BW	SW
Excellent	5 Very new without any defects		
Very Good	4 <5% defects without impacting structural integrity		
Good	3 10-20% defects without impacting structural integrity		
Fair	2 20-40% defects without impacting structural integrity		
Poor	1 Condition which needs immediate attention and repair		

Estimate of Remaining Useful Life	BW	SW
4 >10 years		
3 5-10 years		
2 <5 years		
1 Negligible		

Concrete Materials

Concrete product 1 description (C1)	
Concrete product 2 description (C2)	
Concrete product 3 description (C3)	

Physical Condition	Rating	C1	C2	C3
Excellent	5 Very new without any defects			
Very Good	4 <5% defects without impacting structural integrity			
Good	3 10-20% defects without impacting structural integrity			
Fair	2 20-40% defects without impacting structural integrity			
Poor	1 Condition which needs immediate attention and repair			

Estimate of Remaining Useful Life	C1	C2	C3
4 >10 years			
3 5-10 years			
2 <5 years			
1 Negligible			

Steel Materials

Steel product 1 description (S1)	Galvanized steel cable on top of fascine
Steel product 2 description (S2)	
Steel product 3 description (S3)	
Steel product 4 description (S4)	
Steel product 5 description (S5)	

Physical Condition	Rating	S1	S2	S3	S4	S5
Excellent	5 Very new without any defects					
Very Good	4 <5% defects without impacting structural integrity	X				
Good	3 10-20% defects without impacting structural integrity					
Fair	2 20-40% defects without impacting structural integrity					
Poor	1 Condition which needs immediate attention and repair					

Estimate of Remaining Useful Life	S1	S2	S3	S4	S5
4 >10 years	X				
3 5-10 years					
2 <5 years					
1 Negligible					

ENVIRONMENTAL AND CONTEXTUAL FACTORS

Erosion/Deposition Observations

Estimate of toe scour at site

Low [ ] Medium [ ] High [ ] N/A [X] Describe: None

Estimate of U/S bank erosion at site (U/S key)

Low [ ] Medium [ ] High [ ] N/A [X] Describe: None

Estimate of D/S bank erosion at site (D/S key)

Low [ ] Medium [ ] High [ ] N/A [X] Describe: None

Estimate of erosion within site/structure

Low [ ] Medium [X] High [ ] N/A [ ] Describe: Placed fill washout at face and behind at some locations

Estimate of sediment accumulation at site

Low [X] Medium [ ] High [ ] N/A [ ] Describe: Behind box fascine

Measurement of sediment accumulation at site

Depth: 1cm Method: Visual

Describe/Location: Behind box fascine

Seeps or spring present: Yes [ ] No [✠] Describe:

Ice abrasion: None [X] Light [ ] Moderate [ ] Severe [ ]

Visual estimate of channel grain size

Silt [ ] Sand [X] Gravel [X] Cobble [X] Boulder [ ] Bedrock [ ]

SITE MOST LIMITING FACTOR(S)

Select from the list below, limiting factors to success:	ASSIGN A SEVERITY RATING TO EACH OF THE FACTORS BELOW: NONE(0), LIGHT(1), MODERATE(2), SEVERE(3)	
	After Treatment	Comments
Slope instability	1	Natural steep slope behind structure
Slope gradient	1	Natural steep slope behind structure
Erosion	2	Slope ravelling behind structure
Compacted soils	0	
Anoxic soils	0	
Insect damage and disease	0	
Trampling by people or dogs	0	
Motorized vehicles	0	
Non motorized vehicles	0	
Aspect	0	
Bank profile	0	
Existing vegetation competition[1]	2	Weeds on slope behind structure
Shade	1	
Maintenance issues[2]	1	Weeding
Flooding duration	2	Impacted survival of brush layer
Hydraulics (Shear stress)	1	
Infrastructure and available space	0	
Wildlife impact[3]	0	
Comment on wildlife impact:		
Access	0	
Other: 1-		
2-		

[1] e.g. from aggressive, fast spreading grasses or invasive weed species

[2] e.g. weeding, fencing or rodent protection) including inadequate or no irrigation, frequency or coverage

[3] Browsing/girdling by Rodent/Beavers/Muskrats

POTENTIAL REPAIR OPTIONS

	Select one
(1) Minor (hand tools, seeding and manual planting)	X
(2) Moderate, may need small machine and material to be brought in (is there access?)	
(3) Major, site needs to be redesigned and reconstructed.	

Description: Weeding and removal of plants

ALTERNATIVE DESIGN OPTIONS

Description: B69 toe fascine was better with tie in ; buried contour fascine behing post and use of native river gravel as fill (better soil contact and less eroded fill material)

Success Attributes

Innovative toe stabilization technique - first in Calgary

Bank Protection/Stabilization Structure Assessment
First Assessment River Reach After Freshet Assessment KWL/Terra

Master Site List No.	46D-2	RMP Site ID Code (e.g., BE-BOW- 4A)		BE-BOW-46D-2	
Site Name:	neering Demonstration Project Site 2-2 (box fascine, brush mattress a			Survey year (1/3/5+)	3
Watercourse	Bow	Weather:	Sunny, clear sky, 15		
Crew Initials	MG / PR	Date:	25-Sep-20		

Photo Monitoring

Permanent photo-monitoring location and ID **Other Photos (min 3)**

Refer to Appendix B - Attachment A, photos 1 - 32 and Appendix E

Hydrology

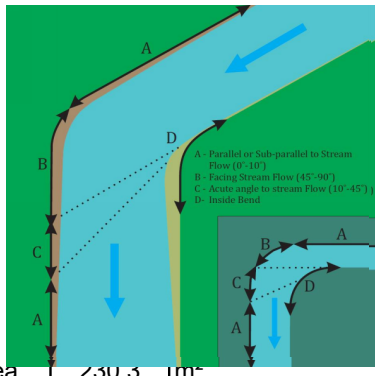
Flow at time of survey 45 m³/s Source: Alberta.rivers.ca

Aspect (N,E,W,S or combined N/E)

Aspect 1 E/NE % of site Aspect 2 % of site Aspect 3 % of site

Site Location (Select 1 or more and add percentage of each)

A) Parallel or nearly parallel to flow (0° to 10°)	A	100 %
B) Moderate angle to flow (10° to 45°)		%
C) Directly facing flow (45° to 90°)		%
D) Internal bend		%



MEASUREMENTS

Average longitudinal stream slope at site 0.2 %

Estimate of stream width for current year flood flow 147 m

Site Dimensions

Total length of the work (parallel to stream) 18.8 m Total project area 230.3 m²

Avg width of the work in plan view (perp to stream) including landscaping on top of the bank 12.25 m

Average slope of the constructed bank 20 ° Average height of the constructed bank 5.6 m

Crib wall only

Height of Bioengineering Structure	Bank height (from permanent herbaceous or woody vegetation line)	Ratio % Bioeng structure/ Total Bank Height
		#DIV/0!
Average width of the crib wall into the bank (from engineering plans)		m

Site Elevation Measurements

Hydrology Survey	**Rod Height (m)**	**Elevation (m)**	**Survey Notes**
Elevation Benchmark	1.1	1000	Water level at 12:30pm on July 17, 2019 us of sit
High water mark*	0.27	1000.83	Water level at 0.86 at site 2-2 (debris in rodent fence)
Water level during survey	1.1	1000	

*Measured at observed debris and/or pollen accumulated on bank

Planted Vegetation Survey*	**Rod Height (m)**	**Elevation (m)**	**Survey Notes**
Elevation Benchmark	1.54	1000	Water level at 2:26pm on July 17, 2019 at site 2-
Elev of lowest woody veg	1.54	1000	Brush layer under box fascine
Elev of lowest herbaceous veg	0.13	1001.41	grasses above brush mattress
Elev of lowest emergent veg		1001.54	

*Lowest elevation of *planted* woody, herbaceous, emergent vegetation along riverbank

Existing Vegetation Survey*	**Rod Height (m)**	**Elevation (m)**	**Survey Notes**
Elevation Benchmark	1.1	1000	Water level at 12:30pm on July 17, 2019 us of sit
Elev of lowest woody veg	0.98	1000.12	
Elev of lowest herbaceous veg	1.17	999.93	
Elev of lowest emergent veg	1.08	1000.02	

*Lowest elevation of *existing native* woody, herbaceous, emergent vegetation along riverbank (trim line) If not possible, use difference in elevation between current water surface and existing vegetation either across the stream and/or further D/S or U/S.

Difference in elev between Planted and Existing Veg	Difference (m)
Woody vegetation	-0.12
Herbaceous vegetation	1.48
Emergent vegetation	

WORK STRUCTURE ASSESSMENT

Rock Materials

Riprap Size	lm of application (m)*	% of total riprap
Class 1M (d50=175mm)		#DIV/0!
Class 1 (d50=300mm)		#DIV/0!
Class 2 (d50=500mm)		#DIV/0!
Class 3 (d50=800mm)		#DIV/0!
Other:		#DIV/0!
Total linear metre (m)		

Fish boulder average diameter ____ mm
Fish boulder arrangement/distribution ____

Physical Condition	Rating	Riprap	Fish Boulders
Excellent	5 Very new without any defects		
Very Good	4 <5% defects without impacting structural integrity		
Good	3 10-20% defects without impacting structural integrity		
Fair	2 20-40% defects without impacting structural integrity		
Poor	1 Condition which needs immediate attention and repair		

Estimate of Remaining Useful Life	Riprap	Fish Boulders
>10 years		
5-10 years		
<5 years		
Negligible		

Gabion Materials

Gabion dimensions
Length ____ mm Width ____ mm Height ____ mm Mesh Opening Size ____ mm

Physical Condition	Rating	Gabions
Excellent	5 Very new without any defects	
Very Good	4 <5% defects without impacting structural integrity	
Good	3 10-20% defects without impacting structural integrity	
Fair	2 20-40% defects without impacting structural integrity	
Poor	1 Condition which needs immediate attention and repair	

Estimate of Remaining Useful Life	Gabions
>10 years	
5-10 years	
<5 years	
Negligible	

Wood Materials

Wood dimensions
Log diameter 100 mm Log length 1500 mm Inclination angle 90 °
Timber width ____ mm Timber height ____ mm Timber length ____ mm
Rootwad diameter ____ mm Rootwad length ____ mm Location of root wad ____

Physical Condition	Rating	Logs	Timber	Rootwad
Excellent	5 Very new without any defects			
Very Good	4 <5% defects without impacting structural integrity			
Good	3 10-20% defects without impacting structural integrity	X		
Fair	2 20-40% defects without impacting structural integrity			
Poor	1 Condition which needs immediate attention and repair			

Estimate of Remaining Useful Life	Logs	Timber	Rootwad
4 >10 years			
3 5-10 years			
2 <5 years	X		
1 Negligible			

Erosion Control Matting and Geotextiles

Biodegradable erosion control matting product name (BECM)	
Biodegradable geogrid product name (BG)	Coir 900
Synthetic erosion control matting product name (SECM)	
Synthetic geogrid product name (SG)	
Non woven geotextile product name (NWG)	

Physical Condition	Rating	BECM	BG	SECM	SG	NWG
Excellent	5 Very new without any defects					
Very Good	4 <5% defects without impacting structural integrity					
Good	3 10-20% defects without impacting structural integrity		X			
Fair	2 20-40% defects without impacting structural integrity					
Poor	1 Condition which needs immediate attention and repair					

Estimate of Remaining Useful Life	BECM	BG	SECM	SG	NWG
4 >10 years					
3 5-10 years					
2 <5 years		X			
1 Negligible					

Erosion Control Wattles

Biodegradable wattle product name (BW)	
Synthetic wattle product name (SW)	

Physical Condition	Rating	BW	SW
Excellent	5 Very new without any defects		
Very Good	4 <5% defects without impacting structural integrity		
Good	3 10-20% defects without impacting structural integrity		
Fair	2 20-40% defects without impacting structural integrity		
Poor	1 Condition which needs immediate attention and repair		

Estimate of Remaining Useful Life	BW	SW
4 >10 years		
3 5-10 years		
2 <5 years		
1 Negligible		

Concrete Materials

Concrete product 1 description (C1)	
Concrete product 2 description (C2)	
Concrete product 3 description (C3)	

Physical Condition	Rating	C1	C2	C3
Excellent	5 Very new without any defects			
Very Good	4 <5% defects without impacting structural integrity			
Good	3 10-20% defects without impacting structural integrity			
Fair	2 20-40% defects without impacting structural integrity			
Poor	1 Condition which needs immediate attention and repair			

Estimate of Remaining Useful Life	C1	C2	C3
4 >10 years			
3 5-10 years			
2 <5 years			
1 Negligible			

Steel Materials

Steel product 1 description (S1)	Galvanized wire
Steel product 2 description (S2)	
Steel product 3 description (S3)	
Steel product 4 description (S4)	
Steel product 5 description (S5)	

Physical Condition	Rating	S1	S2	S3	S4	S5
Excellent	5 Very new without any defects					
Very Good	4 <5% defects without impacting structural integrity	X				
Good	3 10-20% defects without impacting structural integrity					
Fair	2 20-40% defects without impacting structural integrity					
Poor	1 Condition which needs immediate attention and repair					

Estimate of Remaining Useful Life	S1	S2	S3	S4	S5
4 >10 years	X				
3 5-10 years					
2 <5 years					
1 Negligible					

ENVIRONMENTAL AND CONTEXTUAL FACTORS

Erosion/Deposition Observations

Estimate of toe scour at site

Low [ ] Medium [ ] High [ ] N/A [X] Describe [ ]

Estimate of U/S bank erosion at site (U/S key)

Low [ ] Medium [X] High [ ] N/A [ ] Describe [Natural bank swallow exposed bank]

Estimate of D/S bank erosion at site (D/S key)

Low [ ] Medium [ ] High [ ] N/A [X] Describe [ ]

Estimate of erosion within site/structure

Low [ ] Medium [X] High [ ] N/A [ ] Describe [Washout of sediment on face and some areas behind; 2020 same as 2019]

Estimate of sediment accumulation at site

Low [X] Medium [ ] High [ ] N/A [ ] Describe [Within coir Matt brush mattress toe]

Measurement of sediment accumulation at site

Depth [Trace] Method: [Visual]

Describe/Location [Toe of brush mattress]

Seeps or spring present Yes [ ] No [✠] Describe [ ]

Ice abrasion None [X] Light [ ] Moderate [ ] Severe [ ]

Visual estimate of channel grain size

Silt [ ] Sand [X] Gravel [X] Cobble [X] Boulder [ ] Bedrock [ ]

SITE MOST LIMITING FACTOR(S)

Select from the list below, limiting factors to success:	ASSIGN A SEVERITY RATING TO EACH OF THE FACTORS BELOW: NONE(0), LIGHT(1), MODERATE(2), SEVERE(3)	
	After Treatment	Comments
Slope instability	0	
Slope gradient	0	
Erosion	1	At fascine face
Compacted soils	2	At toe of brush mattress / from walking
Anoxic soils	0	
Insect damage and disease	1	Insect damage on leaves
Trampling by people or dogs	2	Toe of brush mattress from walking
Motorized vehicles	0	
Non motorized vehicles	0	
Aspect	0	
Bank profile	0	
Existing vegetation competition[1]	1	Invasive weed present + high seeding application rate;
Shade	0	
Maintenance issues[2]	2	Weeding required
Flooding duration	2	Toe fascine
Hydraulics (Shear stress)	1	Protected by groyne
Infrastructure and available space	0	
Wildlife impact[3]	0	
Comment on wildlife impact:		
Access	0	
Other: 1-		
2-		

[1] e.g. from aggressive, fast spreading grasses or invasive weed species

[2] e.g. weeding, fencing or rodent protection) including inadequate or no irrigation, frequency or coverage

[3] Browsing/girdling by Rodent/Beavers/Muskrats

POTENTIAL REPAIR OPTIONS

	Select one
(1) Minor (hand tools, seeding and manual planting)	X
(2) Moderate, may need small machine and material to be brought in (is there access?)	
(3) Major, site needs to be redesigned and reconstructed.	

Description: Manual weeding before plants flowers turning into seed and remove plants from site; 2020 replace 11m section of dead contour fascine along upstream top row

ALTERNATIVE DESIGN OPTIONS

Description: Other options used on site 2-2, similar treatment but toe fascine placement into bank, similar treatment but with fascine wall at toe

Success Attributes

Brush mattress and box fascine innovative toe protection technique combination - first trial in Calgary. Good growth in brush mattress. Very good balsam poplar survival

Bank Protection/Stabilization Structure Assessment
First Assessment River Reach After Freshet Assessment KWL/Terra

Master Site List No.	46D-3	RMP Site ID Code (e.g., BE-BOW- 4A)		BE-BOW-46D-3	
Site Name:	Bioengineering Demonstration Project Site 2-2 (box fascine, hedge b			Survey year (1/3/5+)	3
Watercourse	Bow	Weather:	15 C, sunny		
Crew Initials	MG / PR	Date:	25-Sep-20		

Photo Monitoring

Permanent photo-monitoring location and ID **Other Photos (min 3)**

Refer to Appendix B - Attachment A, photos 1 - 32 and Appendix E

Hydrology

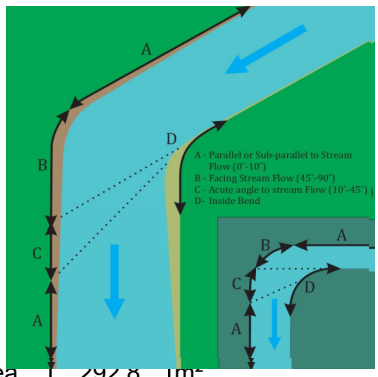
Flow at time of survey 45 m³/s Source: Rivers.alberta.ca

Aspect (N,E,W,S or combined N/E)

Aspect 1 E/NE % of site 100 Aspect 2 % of site Aspect 3 % of site

Site Location (Select 1 or more and add percentage of each)

A) Parallel or nearly parallel to flow (0° to 10°)	B	100 %
B) Moderate angle to flow (10° to 45°)		%
C) Directly facing flow (45° to 90°)		%
D) Internal bend		%



MEASUREMENTS

Average longitudinal stream slope at site 0.2 %

Estimate of stream width for current year flood flow 147 m

Site Dimensions

Total length of the work (parallel to stream) 24 m Total project area 292.8 m²

Avg width of the work in plan view (perp to stream) including landscaping on top of the bank 12.2 m

Average slope of the constructed bank 20 ° Average height of the constructed bank 5.6 m

Crib wall only

Height of Bioengineering Structure	Bank height (from permanent herbaceous or woody vegetation line)	Ratio % Bioeng structure/ Total Bank Height
		#DIV/0!
Average width of the crib wall into the bank (from engineering plans)		m

Site Elevation Measurements

Hydrology Survey	**Rod Height (m)**	**Elevation (m)**	**Survey Notes**
Elevation Benchmark	1.1	1000	Water level at 12:30pm on July 17, 2019 us of site 1-1
High water mark*	0.27	1000.83	Hwm at 0.84 at site 2-2_B
Water level during survey	1.1	1000	

*Measured at observed debris and/or pollen accumulated on bank

Planted Vegetation Survey*	**Rod Height (m)**	**Elevation (m)**	**Survey Notes**
Elevation Benchmark	1.53	1000	Water level at 2:47pm on July 17, 2019 @ Site 2
Elev of lowest woody veg	1.53	1000	Salix int.
Elev of lowest herbaceous veg	1.22	1000.31	Grasses unde coir mat
Elev of lowest emergent veg		1001.53	

*Lowest elevation of *planted* woody, herbaceous, emergent vegetation along riverbank

Existing Vegetation Survey*	**Rod Height (m)**	**Elevation (m)**	**Survey Notes**
Elevation Benchmark	1.1	1000	Water level at 12:30pm on July 17, 2019 us of site 1-1
Elev of lowest woody veg	0.98	1000.12	
Elev of lowest herbaceous veg	1.17	999.93	
Elev of lowest emergent veg	1.08	1000.02	

*Lowest elevation of *existing native* woody, herbaceous, emergent vegetation along riverbank (trim line) If not possible, use difference in elevation between current water surface and existing vegetation either across the stream and/or further D/S or U/S.

Difference in elev between Planted and Existing Veg	Difference (m)
Woody vegetation	-0.12
Herbaceous vegetation	0.38
Emergent vegetation	

WORK STRUCTURE ASSESSMENT

Rock Materials

Riprap Size	lm of application (m)*	% of total riprap
Class 1M (d50=175mm)		#DIV/0!
Class 1 (d50=300mm)		#DIV/0!
Class 2 (d50=500mm)		#DIV/0!
Class 3 (d50=800mm)		#DIV/0!
Other:		#DIV/0!
Total linear metre (m)		

Fish boulder average diameter ____ mm
Fish boulder arrangement/distribution ____

Physical Condition	Rating	Riprap	Fish Boulders
Excellent	5 Very new without any defects		
Very Good	4 <5% defects without impacting structural integrity		
Good	3 10-20% defects without impacting structural integrity		
Fair	2 20-40% defects without impacting structural integrity		
Poor	1 Condition which needs immediate attention and repair		

Estimate of Remaining Useful Life	Riprap	Fish Boulders
>10 years		
5-10 years		
<5 years		
Negligible		

Gabion Materials

Gabion dimensions
Length ____ mm Width ____ mm Height ____ mm Mesh Opening Size ____ mm

Physical Condition	Rating	Gabions
Excellent	5 Very new without any defects	
Very Good	4 <5% defects without impacting structural integrity	
Good	3 10-20% defects without impacting structural integrity	
Fair	2 20-40% defects without impacting structural integrity	
Poor	1 Condition which needs immediate attention and repair	

Estimate of Remaining Useful Life	Gabions
>10 years	
5-10 years	
<5 years	
Negligible	

Wood Materials

Wood dimensions
Log diameter 100 mm Log length 1500 mm Inclination angle 90 °
Timber width ____ mm Timber height ____ mm Timber length ____ mm
Rootwad diameter ____ mm Rootwad length ____ mm Location of root wad ____

Physical Condition	Rating	Logs	Timber	Rootwad
Excellent	5 Very new without any defects			
Very Good	4 <5% defects without impacting structural integrity			
Good	3 10-20% defects without impacting structural integrity	X		
Fair	2 20-40% defects without impacting structural integrity			
Poor	1 Condition which needs immediate attention and repair			

Estimate of Remaining Useful Life	Logs	Timber	Rootwad
4 >10 years			
3 5-10 years			
2 <5 years	X		
1 Negligible			

Erosion Control Matting and Geotextiles

Biodegradable erosion control matting product name (BECM)	
Biodegradable geogrid product name (BG)	Coir wrap 1200
Synthetic erosion control matting product name (SECM)	
Synthetic geogrid product name (SG)	
Non woven geotextile product name (NWG)	

Physical Condition	Rating	BECM	BG	SECM	SG	NWG
Excellent	5 Very new without any defects					
Very Good	4 <5% defects without impacting structural integrity					
Good	3 10-20% defects without impacting structural integrity		X			
Fair	2 20-40% defects without impacting structural integrity					
Poor	1 Condition which needs immediate attention and repair					

Estimate of Remaining Useful Life	BECM	BG	SECM	SG	NWG
4 >10 years					
3 5-10 years					
2 <5 years		X			
1 Negligible					

Erosion Control Wattles

Biodegradable wattle product name (BW)	
Synthetic wattle product name (SW)	

Physical Condition	Rating	BW	SW
Excellent	5 Very new without any defects		
Very Good	4 <5% defects without impacting structural integrity		
Good	3 10-20% defects without impacting structural integrity		
Fair	2 20-40% defects without impacting structural integrity		
Poor	1 Condition which needs immediate attention and repair		

Estimate of Remaining Useful Life	BW	SW
4 >10 years		
3 5-10 years		
2 <5 years		
1 Negligible		

Concrete Materials

Concrete product 1 description (C1)	
Concrete product 2 description (C2)	
Concrete product 3 description (C3)	

Physical Condition	Rating	C1	C2	C3
Excellent	5 Very new without any defects			
Very Good	4 <5% defects without impacting structural integrity			
Good	3 10-20% defects without impacting structural integrity			
Fair	2 20-40% defects without impacting structural integrity			
Poor	1 Condition which needs immediate attention and repair			

Estimate of Remaining Useful Life	C1	C2	C3
4 >10 years			
3 5-10 years			
2 <5 years			
1 Negligible			

Steel Materials

Steel product 1 description (S1)	Galvanized wire
Steel product 2 description (S2)	
Steel product 3 description (S3)	
Steel product 4 description (S4)	
Steel product 5 description (S5)	

Physical Condition	Rating	S1	S2	S3	S4	S5
Excellent	5 Very new without any defects					
Very Good	4 <5% defects without impacting structural integrity	X				
Good	3 10-20% defects without impacting structural integrity					
Fair	2 20-40% defects without impacting structural integrity					
Poor	1 Condition which needs immediate attention and repair					

Estimate of Remaining Useful Life	S1	S2	S3	S4	S5
4 >10 years	X				
3 5-10 years					
2 <5 years					
1 Negligible					

ENVIRONMENTAL AND CONTEXTUAL FACTORS

Erosion/Deposition Observations

Estimate of toe scour at site

Low [ ] Medium [ ] High [ ] N/A [X] Describe [ ]

Estimate of U/S bank erosion at site (U/S key)

Low [ ] Medium [ ] High [ ] N/A [X] Describe [ ]

Estimate of D/S bank erosion at site (D/S key)

Low [ ] Medium [ ] High [ ] N/A [X] Describe [ ]

Estimate of erosion within site/structure

Low [ ] Medium [X] High [ ] N/A [ ] Describe: Fill material washed out of fascine and behind toe fascine; 2020 sediment still

Estimate of sediment accumulation at site

Low [X] Medium [ ] High [ ] N/A [ ] Describe: Trace

Measurement of sediment accumulation at site

Depth: 1cm Method: Visual

Describe/Location: at toe of coir matt up slope from toe fascine

Seeps or spring present Yes [ ] No [✠] Describe [ ]

Ice abrasion None [X] Light [ ] Moderate [ ] Severe [ ]

Visual estimate of channel grain size

Silt [ ] Sand [X] Gravel [X] Cobble [X] Boulder [ ] Bedrock [ ]

SITE MOST LIMITING FACTOR(S)

Select from the list below, limiting factors to success:	ASSIGN A SEVERITY RATING TO EACH OF THE FACTORS BELOW: NONE(0), LIGHT(1), MODERATE(2), SEVERE(3)	
	After Treatment	Comments
Slope instability	0	
Slope gradient	0	
Erosion	1	At toe of fascine on front half
Compacted soils	1	At toe of slope from top face
Anoxic soils	0	
Insect damage and disease	1	On foliage
Trampling by people or dogs	1	At toe of coir matting
Motorized vehicles	0	
Non motorized vehicles	0	
Aspect	0	
Bank profile	0	
Existing vegetation competition[1]	1	Invasive weeds present and high seed application rate;
Shade	0	
Maintenance issues[2]	2	Weeding
Flooding duration	1.5	At toe of structure
Hydraulics (Shear stress)	1	Between groynes
Infrastructure and available space	0	
Wildlife impact[3]	0	
Comment on wildlife impact:		
Access	0	
Other: 1-		
2-		

[1] e.g. from aggressive, fast spreading grasses or invasive weed species

[2] e.g. weeding, fencing or rodent protection) including inadequate or no irrigation, frequency or coverage

[3] Browsing/girdling by Rodent/Beavers/Muskrats

POTENTIAL REPAIR OPTIONS

	Select one
(1) Minor (hand tools, seeding and manual planting)	X
(2) Moderate, may need small machine and material to be brought in (is there access?)	
(3) Major, site needs to be redesigned and reconstructed.	

Description: Manual weeding and remove plants from site prior to weeds begin to seed

ALTERNATIVE DESIGN OPTIONS

Description: Other options used at site 2-2, same treatment with toe fascine cuttings placed into the bank, same treatment but with toe fascine wall

Success Attributes

brush layer design in city of Calgary, good growth on dogwood, cherry, moderate on alder due to poor quality nursery stock.

Bank Protection/Stabilization Structure Assessment
First Assessment River Reach After Freshet Assessment KWL/Terra

Master Site List No.	46D-4	RMP Site ID Code (e.g., BE-BOW- 4A)		BE-BOW-46D-4	
Site Name:	COC Bioengineering Demonstration Project Site 2-2 (box fascine, live s			Survey year (1/3/5+)	3
Watercourse	Bow	Weather:	Sunny, partially cloudy, 15		
Crew Initials	MG / PR	Date:	25-Sep-20		

Photo Monitoring

Permanent photo-monitoring location and ID **Other Photos (min 3)**

Refer to Appendix B - Attachment A, photos 1 - 32 and Appendix E

Hydrology

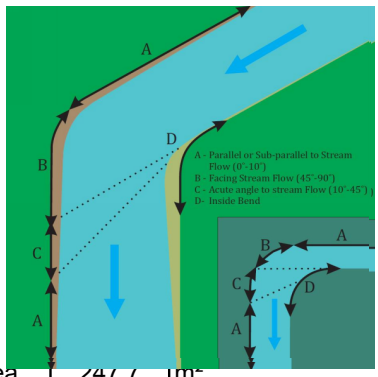
Flow at time of survey 45 m³/s Source: Rivers.alberta.ca

Aspect (N,E,W,S or combined N/E)

Aspect 1 100 % of site E/NE Aspect 2 % of site Aspect 3 % of site

Site Location (Select 1 or more and add percentage of each)

A) Parallel or nearly parallel to flow (0° to 10°)		%
B) Moderate angle to flow (10° to 45°)	B	80 %
C) Directly facing flow (45° to 90°)	C	20 %
D) Internal bend		%



MEASUREMENTS

Average longitudinal stream slope at site 0.2 %

Estimate of stream width for current year flood flow 147 m

Site Dimensions

Total length of the work (parallel to stream) 20.3 m Total project area 247.7 m²

Avg width of the work in plan view (perp to stream) including landscaping on top of the bank 12.2 m

Average slope of the constructed bank 20 ° Average height of the constructed bank 5.6 m

Crib wall only

Height of Bioengineering Structure	Bank height (from permanent herbaceous or woody vegetation line)	Ratio % Bioeng structure/ Total Bank Height
		#DIV/0!
Average width of the crib wall into the bank (from engineering plans)		m

Site Elevation Measurements

Hydrology Survey	**Rod Height (m)**	**Elevation (m)**	**Survey Notes**
Elevation Benchmark	1.1	1000	Water level at 12:30pm on July 17, 2019 us of sit
High water mark*	0.27	1000.83	
Water level during survey	1.1	1000	

*Measured at observed debris and/or pollen accumulated on bank

Planted Vegetation Survey*	**Rod Height (m)**	**Elevation (m)**	**Survey Notes**
Elevation Benchmark	1.54	1000	Water level at 3pm on July 16, 2019 at site 2-2-C
Elev of lowest woody veg	1.57	999.97	Salix int.
Elev of lowest herbaceous veg	1.26	1000.28	Grasses seeded under coir matting
Elev of lowest emergent veg		1001.54	

*Lowest elevation of *planted* woody, herbaceous, emergent vegetation along riverbank

Existing Vegetation Survey*	**Rod Height (m)**	**Elevation (m)**	**Survey Notes**
Elevation Benchmark	1.1	1000	
Elev of lowest woody veg	0.98	1000.12	
Elev of lowest herbaceous veg	1.17	999.93	
Elev of lowest emergent veg	1.08	1000.02	

*Lowest elevation of *existing native* woody, herbaceous, emergent vegetation along riverbank (trim line) If not possible, use difference in elevation between current water surface and existing vegetation either across the stream and/or further D/S or U/S.

Difference in elev between Planted and Existing Veg	Difference (m)
Woody vegetation	-0.15
Herbaceous vegetation	0.35
Emergent vegetation	

WORK STRUCTURE ASSESSMENT

Rock Materials

Riprap Size	lm of application (m)*	% of total riprap
Class 1M (d50=175mm)		#DIV/0!
Class 1 (d50=300mm)		#DIV/0!
Class 2 (d50=500mm)		#DIV/0!
Class 3 (d50=800mm)		#DIV/0!
Other:		#DIV/0!
Total linear metre (m)		

Fish boulder average diameter ____ mm
Fish boulder arrangement/distribution ____

Physical Condition	Rating	Riprap	Fish Boulders
Excellent	5 Very new without any defects		
Very Good	4 <5% defects without impacting structural integrity		
Good	3 10-20% defects without impacting structural integrity		
Fair	2 20-40% defects without impacting structural integrity		
Poor	1 Condition which needs immediate attention and repair		

Estimate of Remaining Useful Life	Riprap	Fish Boulders
>10 years		
5-10 years		
<5 years		
Negligible		

Gabion Materials

Gabion dimensions
Length ____ mm Width ____ mm Height ____ mm Mesh Opening Size ____ mm

Physical Condition	Rating	Gabions
Excellent	5 Very new without any defects	
Very Good	4 <5% defects without impacting structural integrity	
Good	3 10-20% defects without impacting structural integrity	
Fair	2 20-40% defects without impacting structural integrity	
Poor	1 Condition which needs immediate attention and repair	

Estimate of Remaining Useful Life	Gabions
>10 years	
5-10 years	
<5 years	
Negligible	

Wood Materials

Wood dimensions
Log diameter 115 mm Log length 1500 mm Inclination angle 90 °
Timber width ____ mm Timber height ____ mm Timber length ____ mm
Rootwad diameter ____ mm Rootwad length ____ mm Location of root wad ____

Physical Condition	Rating	Logs	Timber	Rootwad
Excellent	5 Very new without any defects			
Very Good	4 <5% defects without impacting structural integrity			
Good	3 10-20% defects without impacting structural integrity	X		
Fair	2 20-40% defects without impacting structural integrity			
Poor	1 Condition which needs immediate attention and repair			

Estimate of Remaining Useful Life	Logs	Timber	Rootwad
4 >10 years			
3 5-10 years			
2 <5 years	X		
1 Negligible			

Erosion Control Matting and Geotextiles

Biodegradable erosion control matting product name (BECM)	
Biodegradable geogrid product name (BG)	Coir wrap 1200
Synthetic erosion control matting product name (SECM)	
Synthetic geogrid product name (SG)	
Non woven geotextile product name (NWG)	

Physical Condition	Rating	BECM	BG	SECM	SG	NWG
Excellent	5 Very new without any defects					
Very Good	4 <5% defects without impacting structural integrity		X			
Good	3 10-20% defects without impacting structural integrity					
Fair	2 20-40% defects without impacting structural integrity					
Poor	1 Condition which needs immediate attention and repair					

Estimate of Remaining Useful Life	BECM	BG	SECM	SG	NWG
4 >10 years					
3 5-10 years					
2 <5 years		X			
1 Negligible					

Erosion Control Wattles

Biodegradable wattle product name (BW)	
Synthetic wattle product name (SW)	

Physical Condition	Rating	BW	SW
Excellent	5 Very new without any defects		
Very Good	4 <5% defects without impacting structural integrity		
Good	3 10-20% defects without impacting structural integrity		
Fair	2 20-40% defects without impacting structural integrity		
Poor	1 Condition which needs immediate attention and repair		

Estimate of Remaining Useful Life	BW	SW
4 >10 years		
3 5-10 years		
2 <5 years		
1 Negligible		

Concrete Materials

Concrete product 1 description (C1)	
Concrete product 2 description (C2)	
Concrete product 3 description (C3)	

Physical Condition	Rating	C1	C2	C3
Excellent	5 Very new without any defects			
Very Good	4 <5% defects without impacting structural integrity			
Good	3 10-20% defects without impacting structural integrity			
Fair	2 20-40% defects without impacting structural integrity			
Poor	1 Condition which needs immediate attention and repair			

Estimate of Remaining Useful Life	C1	C2	C3
4 >10 years			
3 5-10 years			
2 <5 years			
1 Negligible			

Steel Materials

Steel product 1 description (S1)	Galvanized wire
Steel product 2 description (S2)	
Steel product 3 description (S3)	
Steel product 4 description (S4)	
Steel product 5 description (S5)	

Physical Condition	Rating	S1	S2	S3	S4	S5
Excellent	5 Very new without any defects					
Very Good	4 <5% defects without impacting structural integrity	X				
Good	3 10-20% defects without impacting structural integrity					
Fair	2 20-40% defects without impacting structural integrity					
Poor	1 Condition which needs immediate attention and repair					

Estimate of Remaining Useful Life	S1	S2	S3	S4	S5
4 >10 years	X				
3 5-10 years					
2 <5 years					
1 Negligible					

ENVIRONMENTAL AND CONTEXTUAL FACTORS

Erosion/Deposition Observations

Estimate of toe scour at site
Low [ ] Medium [ ] High [ ] N/A [X] Describe

Estimate of U/S bank erosion at site (U/S key)
Low [ ] Medium [ ] High [ ] N/A [X] Describe

Estimate of D/S bank erosion at site (D/S key)
Low [ ] Medium [ ] High [ ] N/A [X] Describe

Estimate of erosion within site/structure
Low [ ] Medium [X] High [ ] N/A [ ] Describe: behind structure; 2020 still present in front half of structure but some fill

Estimate of sediment accumulation at site
Low [X] Medium [ ] High [ ] N/A [ ] Describe: Trace

Measurement of sediment accumulation at site
Depth [Trace] Method: Visual
Describe/Location: at toe of matting

Seeps or spring present Yes [ ] No [✠] Describe

Ice abrasion None [X] Light [ ] Moderate [ ] Severe [ ]

Visual estimate of channel grain size
Silt [ ] Sand [X] Gravel [X] Cobble [X] Boulder [ ] Bedrock [ ]

SITE MOST LIMITING FACTOR(S)

Select from the list below, limiting factors to success:	ASSIGN A SEVERITY RATING TO EACH OF THE FACTORS BELOW: NONE(0), LIGHT(1), MODERATE(2), SEVERE(3)	
	After Treatment	Comments
Slope instability	0	
Slope gradient	0	
Erosion	1	Within toe fascine
Compacted soils	1	At bottom of coir matt
Anoxic soils	0	
Insect damage and disease	1	On foliage
Trampling by people or dogs	1	At toe of matting
Motorized vehicles	0	
Non motorized vehicles	0	
Aspect	0	
Bank profile	0	
Existing vegetation competition[1]	1	Invasive weeds present and high seeding application rate; 2020 planted shrubs are slowly shading out
Shade	0	
Maintenance issues[2]	2	Weeding
Flooding duration	1.5	At toe causing washout of material in toe fascine
Hydraulics (Shear stress)	1	Between spurs
Infrastructure and available space	0	
Wildlife impact[3]	0	
Comment on wildlife impact:		
Access	0	
Other: 1-		
2-		

[1] e.g. from aggressive, fast spreading grasses or invasive weed species

[2] e.g. weeding, fencing or rodent protection) including inadequate or no irrigation, frequency or coverage

[3] Browsing/girdling by Rodent/Beavers/Muskrats

POTENTIAL REPAIR OPTIONS

	Select one
(1) Minor (hand tools, seeding and manual planting)	X
(2) Moderate, may need small machine and material to be brought in (is there access?)	
(3) Major, site needs to be redesigned and reconstructed.	

Description: Weeding of invasive plants before plants start to seed and remove plant material from site

ALTERNATIVE DESIGN OPTIONS

Description: Other options used at site 2-2, same treatment with toe fascine cuttings placed into the bank, same treatment but with toe fascine wall (Schiechtl)

Success Attributes

Innovative toe protection technique, balsam poplar survival is good, good survival overall

Bank Protection/Stabilization Structure Assessment
First Assessment River Reach After Freshet Assessment KWL/Terra

Master Site List No.	46E-1	RMP Site ID Code (e.g., BE-BOW- 4A)		BE-BOW-46E-1	
Site Name:	Bioengineering Demonstration Project Site 4-1 (soil covered riprap an			Survey year (1/3/5+)	2
Watercourse	Bow River	Weather:	Sunny and 11 degrees		
Crew Initials	MG / PR	Date:	25-Sep-20		

Photo Monitoring

Permanent photo-monitoring location and ID **Other Photos (min 3)**

Refer to Appendix B - Attachment A, photos 1 - 32 and Appendix E

Hydrology

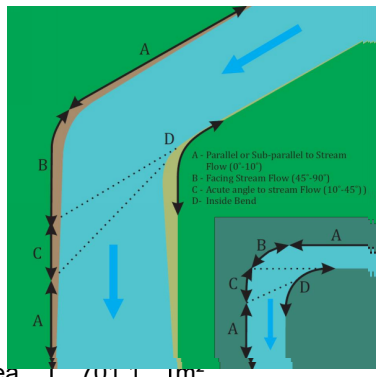
Flow at time of survey 45 m³/s Source: Rivers.alberta.ca

Aspect (N,E,W,S or combined N/E)

Aspect 1 NE % of site 100 Aspect 2 % of site Aspect 3 % of site

Site Location (Select 1 or more and add percentage of each)

A) Parallel or nearly parallel to flow (0° to 10°)		%
B) Moderate angle to flow (10° to 45°)	X	100 %
C) Directly facing flow (45° to 90°)		%
D) Internal bend		%



MEASUREMENTS

Average longitudinal stream slope at site 0.2 %

Estimate of stream width for current year flood flow 150 m

Site Dimensions

Total length of the work (parallel to stream) 57 m Total project area 701.1 m²

Avg width of the work in plan view (perp to stream) including landscaping on top of the bank 12.3 m

Average slope of the constructed bank 13 ° Average height of the constructed bank 3.8 m

Crib wall only

Height of Bioengineering Structure	Bank height (from permanent herbaceous or woody vegetation line)	Ratio % Bioeng structure/ Total Bank Height
		#DIV/0!
Average width of the crib wall into the bank (from engineering plans)		m

Site Elevation Measurements

Hydrology Survey	**Rod Height (m)**	**Elevation (m)**	**Survey Notes**
Elevation Benchmark	1.29	1000	Water level at 11:43 am
High water mark*	0.95	1000.34	mud line over shrubs
Water level during survey	1.29	1000	

*Measured at observed debris and/or pollen accumulated on bank

Planted Vegetation Survey*	**Rod Height (m)**	**Elevation (m)**	**Survey Notes**
Elevation Benchmark	2.42	1000	Water level at 12:24pm
Elev of lowest woody veg	2.03	1000.39	Red osier plug
Elev of lowest herbaceous veg	2.13	1000.29	Grasses
Elev of lowest emergent veg		1002.42	

*Lowest elevation of *planted* woody, herbaceous, emergent vegetation along riverbank

Existing Vegetation Survey*	**Rod Height (m)**	**Elevation (m)**	**Survey Notes**
Elevation Benchmark	1.29	1000	Downstream of site 4-4
Elev of lowest woody veg	1.1	1000.19	Balsam poplar
Elev of lowest herbaceous veg	1.18	1000.11	grasses
Elev of lowest emergent veg		1001.29	

*Lowest elevation of *existing native* woody, herbaceous, emergent vegetation along riverbank (trim line) If not possible, use difference in elevation between current water surface and existing vegetation either across the stream and/or further D/S or U/S.

Difference in elev between Planted and Existing Veg	Difference (m)
Woody vegetation	0.2
Herbaceous vegetation	0.18
Emergent vegetation	

WORK STRUCTURE ASSESSMENT

Rock Materials

Riprap Size	lm of application (m)*	% of total riprap
Class 1M (d50=175mm)		0
Class 1 (d50=300mm)		0
Class 2 (d50=500mm)	57	100
Class 3 (d50=800mm)		0
Other:		0
Total linear metre (m)	57	

Fish boulder average diameter mm

Fish boulder arrangement/distribution

Physical Condition	Rating	Riprap	Fish Boulders
Excellent	5 Very new without any defects	X	
Very Good	4 <5% defects without impacting structural integrity		
Good	3 10-20% defects without impacting structural integrity		
Fair	2 20-40% defects without impacting structural integrity		
Poor	1 Condition which needs immediate attention and repair		

Estimate of Remaining Useful Life	Riprap	Fish Boulders
>10 years	**X**	
5-10 years		
<5 years		
Negligible		

Gabion Materials

Gabion dimensions

Length mm Width mm Height mm Mesh Opening Size mm

Physical Condition	Rating	Gabions
Excellent	5 Very new without any defects	
Very Good	4 <5% defects without impacting structural integrity	
Good	3 10-20% defects without impacting structural integrity	
Fair	2 20-40% defects without impacting structural integrity	
Poor	1 Condition which needs immediate attention and repair	

Estimate of Remaining Useful Life	Gabions
>10 years	
5-10 years	
<5 years	
Negligible	

Wood Materials

Wood dimensions

Log diameter mm Log length mm Inclination angle °

Timber width mm Timber height mm Timber length mm

Rootwad diameter mm Rootwad length mm Location of root wad

Physical Condition	Rating	Logs	Timber	Rootwad
Excellent	5 Very new without any defects			
Very Good	4 <5% defects without impacting structural integrity			
Good	3 10-20% defects without impacting structural integrity			
Fair	2 20-40% defects without impacting structural integrity			
Poor	1 Condition which needs immediate attention and repair			

Estimate of Remaining Useful Life	Logs	Timber	Rootwad
4 >10 years			
3 5-10 years			
2 <5 years			
1 Negligible			

Erosion Control Matting and Geotextiles

Biodegradable erosion control matting product name (BECM)	C125BN
Biodegradable geogrid product name (BG)	
Synthetic erosion control matting product name (SECM)	
Synthetic geogrid product name (SG)	
Non woven geotextile product name (NWG)	

Physical Condition	Rating	BECM	BG	SECM	SG	NWG
Excellent	5 Very new without any defects					
Very Good	4 <5% defects without impacting structural integrity					
Good	3 10-20% defects without impacting structural integrity					
Fair	2 20-40% defects without impacting structural integrity					
Poor	1 Condition which needs immediate attention and repair	X				

Estimate of Remaining Useful Life	BECM	BG	SECM	SG	NWG
4 >10 years					
3 5-10 years					
2 <5 years					
1 Negligible	X				

still some fibre present; did it's job and vegetation has established

Erosion Control Wattles

Biodegradable wattle product name (BW)	Curlex 300mm diameter
Synthetic wattle product name (SW)	

Physical Condition	Rating	BW	SW
Excellent	5 Very new without any defects		
Very Good	4 <5% defects without impacting structural integrity		
Good	3 10-20% defects without impacting structural integrity		
Fair	2 20-40% defects without impacting structural integrity	X	
Poor	1 Condition which needs immediate attention and repair		

Estimate of Remaining Useful Life	BW	SW
4 >10 years		
3 5-10 years		
2 <5 years	X	
1 Negligible		

Concrete Materials

Concrete product 1 description (C1)	
Concrete product 2 description (C2)	
Concrete product 3 description (C3)	

Physical Condition	Rating	C1	C2	C3
Excellent	5 Very new without any defects			
Very Good	4 <5% defects without impacting structural integrity			
Good	3 10-20% defects without impacting structural integrity			
Fair	2 20-40% defects without impacting structural integrity			
Poor	1 Condition which needs immediate attention and repair			

Estimate of Remaining Useful Life	C1	C2	C3
4 >10 years			
3 5-10 years			
2 <5 years			
1 Negligible			

Steel Materials

Steel product 1 description (S1)	Rebar candy canes
Steel product 2 description (S2)	
Steel product 3 description (S3)	
Steel product 4 description (S4)	
Steel product 5 description (S5)	

Physical Condition	Rating	S1	S2	S3	S4	S5
Excellent	5 Very new without any defects					
Very Good	4 <5% defects without impacting structural integrity	X				
Good	3 10-20% defects without impacting structural integrity					
Fair	2 20-40% defects without impacting structural integrity					
Poor	1 Condition which needs immediate attention and repair					

Estimate of Remaining Useful Life	S1	S2	S3	S4	S5
4 >10 years	X				
3 5-10 years					
2 <5 years					
1 Negligible					

ENVIRONMENTAL AND CONTEXTUAL FACTORS

Erosion/Deposition Observations

Estimate of toe scour at site

Low [ ] Medium [ ] High [ ] N/A [X] Describe: None

Estimate of U/S bank erosion at site (U/S key)

Low [ ] Medium [ ] High [ ] N/A [X] Describe: None

Estimate of D/S bank erosion at site (D/S key)

Low [ ] Medium [X] High [ ] N/A [ ] Describe: Toe erosion (eroded/washed out fill placed over riprap)

Estimate of erosion within site/structure

Low [X] Medium [ ] High [ ] N/A [ ] Describe: At toe between wattle and slope

Estimate of sediment accumulation at site

Low [ ] Medium [ ] High [ ] N/A [X] Describe:

Measurement of sediment accumulation at site

Depth [ ] Method:

Describe/Location

Seeps or spring present Yes [ ] No [✠] Describe:

Ice abrasion None [X] Light [ ] Moderate [ ] Severe [ ]

Visual estimate of channel grain size

Silt [ ] Sand [X] Gravel [X] Cobble [X] Boulder [ ] Bedrock [ ]

SITE MOST LIMITING FACTOR(S)

Select from the list below, limiting factors to success:	ASSIGN A SEVERITY RATING TO EACH OF THE FACTORS BELOW: NONE(0), LIGHT(1), MODERATE(2), SEVERE(3)	
	After Treatment	Comments
Slope instability	0	
Slope gradient	0	
Erosion	1	Toe erosion (eroded/washed out fill placed over riprap)
Compacted soils	0	
Anoxic soils	0	
Insect damage and disease	1	On salix interior leaves
Trampling by people or dogs	0	
Motorized vehicles	0	
Non motorized vehicles	0	
Aspect	0	
Bank profile	0	
Existing vegetation competition[1]	3	invasives and seeding competing with native shrubs (high seeding application); grasses should be cleared
Shade	0	
Maintenance issues[2]	2	Straw wattle missing and rodent fence
Flooding duration	0	
Hydraulics (Shear stress)	2	Groyne protection
Infrastructure and available space	0	
Wildlife impact[3]	0	
Comment on wildlife impact:		
Access	0	
Other: 1-		
2-		

[1] e.g. from aggressive, fast spreading grasses or invasive weed species

[2] e.g. weeding, fencing or rodent protection) including inadequate or no irrigation, frequency or coverage

[3] Browsing/girdling by Rodent/Beavers/Muskrats

POTENTIAL REPAIR OPTIONS

	Select one
(1) Minor (hand tools, seeding and manual planting)	X
(2) Moderate, may need small machine and material to be brought in (is there access?)	
(3) Major, site needs to be redesigned and reconstructed.	

Description: Fixing rodent fence and straw wattle ; weeding invasives ; mow grasses and mulch around plants and place millorganite at base of stems (flag shrubs and trees prior to mowing)

ALTERNATIVE DESIGN OPTIONS

Description: As applied site 46E_2 or 46E_3 and using pit run / gravel and live cuttings on slope adjacent to river i.e. no top soil

Success Attributes

Innovative method to vegetate existing riprap; container shrubs appear to be surviving well at the Site is stablizing at the time of survey. Inovative method to place top soil and fill material using telebelt.

Bank Protection/Stabilization Structure Assessment
First Assessment River Reach After Freshet Assessment KWL/Terra

Master Site List No.	46E-2	RMP Site ID Code (e.g., BE-BOW- 4A)	BE-BOW-46E-2
Site Name:	OC Bioengineering Demonstration Project Site 4-2 (void filled riprap an	Survey year (1/3/5+)	
Watercourse	Bow River	Weather:	11 C, sunny
Crew Initials	MG / PR	Date:	25-Sep-20

Photo Monitoring

Permanent photo-monitoring location and ID **Other Photos (min 3)**

Refer to Appendix B - Attachment A, photos 1 - 32 and Appendix E

Hydrology

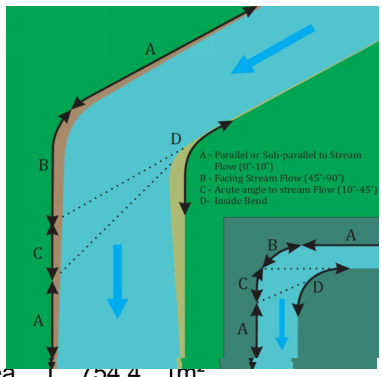
Flow at time of survey 45 m³/s Source: Rivers.alberta.ca

Aspect (N,E,W,S or combined N/E)

Aspect 1 NNE % of site 80 Aspect 2 NE % of site 20 Aspect 3 % of site

Site Location (Select 1 or more and add percentage of each)

A) Parallel or nearly parallel to flow (0° to 10°)	C	100 %
B) Moderate angle to flow (10° to 45°)		%
C) Directly facing flow (45° to 90°)		%
D) Internal bend		%



MEASUREMENTS

Average longitudinal stream slope at site 0.2 %

Estimate of stream width for current year flood flow 150 m

Site Dimensions

Total length of the work (parallel to stream) 65.6 m Total project area 754.4 m²

Avg width of the work in plan view (perp to stream) including landscaping on top of the bank 11.5 m

Average slope of the constructed bank 20 ° Average height of the constructed bank 4 m

Crib wall only

Height of Bioengineering Structure	Bank height (from permanent herbaceous or woody vegetation line)	Ratio % Bioeng structure/ Total Bank Height
		#DIV/0!
Average width of the crib wall into the bank (from engineering plans)		m

Site Elevation Measurements

Hydrology Survey	**Rod Height (m)**	**Elevation (m)**	**Survey Notes**
Elevation Benchmark	1.29	1000	Water level at 11:43 am
High water mark*	0.95	1000.34	Sediment standing on veg (balsam poplar)
Water level during survey	1.29	1000	

*Measured at observed debris and/or pollen accumulated on bank

Planted Vegetation Survey*	**Rod Height (m)**	**Elevation (m)**	**Survey Notes**
Elevation Benchmark	2.42	1000	Water level at 12:14pm
Elev of lowest woody veg	2	1000.42	Red osier potted
Elev of lowest herbaceous veg	2.14	1000.28	grasses
Elev of lowest emergent veg		1002.42	None

*Lowest elevation of *planted* woody, herbaceous, emergent vegetation along riverbank

Existing Vegetation Survey*	**Rod Height (m)**	**Elevation (m)**	**Survey Notes**
Elevation Benchmark	1.29	1000	Water level at 11:43 am
Elev of lowest woody veg	1.1	1000.19	Balsam poplar
Elev of lowest herbaceous veg	1.18	1000.11	grasses
Elev of lowest emergent veg		1001.29	None

*Lowest elevation of *existing native* woody, herbaceous, emergent vegetation along riverbank (trim line) If not possible, use difference in elevation between current water surface and existing vegetation either across the stream and/or further D/S or U/S.

Difference in elev between Planted and Existing Veg	Difference (m)
Woody vegetation	0.23
Herbaceous vegetation	0.17
Emergent vegetation	

WORK STRUCTURE ASSESSMENT

Rock Materials

Riprap Size	lm of application (m)*	% of total riprap
Class 1M (d50=175mm)		0
Class 1 (d50=300mm)		0
Class 2 (d50=500mm)	65.6	100
Class 3 (d50=800mm)		0
Other:		0
Total linear metre (m)	65.6	

Fish boulder average diameter mm

Fish boulder arrangement/distribution

Physical Condition	Rating	Riprap	Fish Boulders
Excellent	5 Very new without any defects	x	
Very Good	4 <5% defects without impacting structural integrity		
Good	3 10-20% defects without impacting structural integrity		
Fair	2 20-40% defects without impacting structural integrity		
Poor	1 Condition which needs immediate attention and repair		

Estimate of Remaining Useful Life	Riprap	Fish Boulders
>10 years	**X**	
5-10 years		
<5 years		
Negligible		

Gabion Materials

Gabion dimensions

Length mm Width mm Height mm Mesh Opening Size mm

Physical Condition	Rating	Gabions
Excellent	5 Very new without any defects	
Very Good	4 <5% defects without impacting structural integrity	
Good	3 10-20% defects without impacting structural integrity	
Fair	2 20-40% defects without impacting structural integrity	
Poor	1 Condition which needs immediate attention and repair	

Estimate of Remaining Useful Life	Gabions
>10 years	
5-10 years	
<5 years	
Negligible	

Wood Materials

Wood dimensions

Log diameter mm Log length mm Inclination angle °

Timber width mm Timber height mm Timber length mm

Rootwad diameter mm Rootwad length mm Location of root wad

Physical Condition	Rating	Logs	Timber	Rootwad
Excellent	5 Very new without any defects			
Very Good	4 <5% defects without impacting structural integrity			
Good	3 10-20% defects without impacting structural integrity			
Fair	2 20-40% defects without impacting structural integrity			
Poor	1 Condition which needs immediate attention and repair			

Estimate of Remaining Useful Life	Logs	Timber	Rootwad
4 >10 years			
3 5-10 years			
2 <5 years			
1 Negligible			

Erosion Control Matting and Geotextiles

Biodegradable erosion control matting product name (BECM)	
Biodegradable geogrid product name (BG)	
Synthetic erosion control matting product name (SECM)	
Synthetic geogrid product name (SG)	
Non woven geotextile product name (NWG)	

Physical Condition	Rating	BECM	BG	SECM	SG	NWG
Excellent	5 Very new without any defects					
Very Good	4 <5% defects without impacting structural integrity					
Good	3 10-20% defects without impacting structural integrity					
Fair	2 20-40% defects without impacting structural integrity					
Poor	1 Condition which needs immediate attention and repair					

Estimate of Remaining Useful Life	BECM	BG	SECM	SG	NWG
4 >10 years					
3 5-10 years					
2 <5 years					
1 Negligible					

Erosion Control Wattles

Biodegradable wattle product name (BW)	Curlex log
Synthetic wattle product name (SW)	

Physical Condition	Rating	BW	SW
Excellent	5 Very new without any defects		
Very Good	4 <5% defects without impacting structural integrity		
Good	3 10-20% defects without impacting structural integrity		
Fair	2 20-40% defects without impacting structural integrity		
Poor	1 Condition which needs immediate attention and repair	X	

Estimate of Remaining Useful Life	BW	SW
4 >10 years		
3 5-10 years		
2 <5 years		
1 Negligible	X	

Concrete Materials

Concrete product 1 description (C1)	
Concrete product 2 description (C2)	
Concrete product 3 description (C3)	

Physical Condition	Rating	C1	C2	C3
Excellent	5 Very new without any defects			
Very Good	4 <5% defects without impacting structural integrity			
Good	3 10-20% defects without impacting structural integrity			
Fair	2 20-40% defects without impacting structural integrity			
Poor	1 Condition which needs immediate attention and repair			

Estimate of Remaining Useful Life	C1	C2	C3
4 >10 years			
3 5-10 years			
2 <5 years			
1 Negligible			

Steel Materials

Steel product 1 description (S1)	
Steel product 2 description (S2)	
Steel product 3 description (S3)	
Steel product 4 description (S4)	
Steel product 5 description (S5)	

Physical Condition	Rating	S1	S2	S3	S4	S5
Excellent	5 Very new without any defects					
Very Good	4 <5% defects without impacting structural integrity					
Good	3 10-20% defects without impacting structural integrity					
Fair	2 20-40% defects without impacting structural integrity					
Poor	1 Condition which needs immediate attention and repair					

Estimate of Remaining Useful Life	S1	S2	S3	S4	S5
4 >10 years					
3 5-10 years					
2 <5 years					
1 Negligible					

ENVIRONMENTAL AND CONTEXTUAL FACTORS

Erosion/Deposition Observations

Estimate of toe scour at site
Low [ ] Medium [ ] High [ ] N/A [X] Describe [ ]

Estimate of U/S bank erosion at site (U/S key)
Low [X] Medium [ ] High [ ] N/A [ ] Describe [Minor toe erosion]

Estimate of D/S bank erosion at site (D/S key)
Low [ ] Medium [X] High [ ] N/A [ ] Describe [Eroded fill on the bank below the bench]

Estimate of erosion within site/structure
Low [ ] Medium [X] High [ ] N/A [ ] Describe [Eroded fill on the bank below the bench]

Estimate of sediment accumulation at site
Low [X] Medium [ ] High [ ] N/A [ ] Describe [Trace on riprap]

Measurement of sediment accumulation at site
Depth [ ] Method: [ ]
Describe/Location [ ]

Seeps or spring present Yes [ ] No [✠] Describe [ ]

Ice abrasion None [X] Light [ ] Moderate [ ] Severe [ ]

Visual estimate of channel grain size
Silt [ ] Sand [X] Gravel [X] Cobble [X] Boulder [ ] Bedrock [ ]

SITE MOST LIMITING FACTOR(S)

Select from the list below, limiting factors to success:	ASSIGN A SEVERITY RATING TO EACH OF THE FACTORS BELOW: NONE(0), LIGHT(1), MODERATE(2), SEVERE(3)	
	After Treatment	Comments
Slope instability	0	
Slope gradient	0	
Erosion	2	Eroded fill at the toe of treatment
Compacted soils	0	
Anoxic soils	0	
Insect damage and disease	0	
Trampling by people or dogs	0	
Motorized vehicles	0	
Non motorized vehicles	0	
Aspect	0	
Bank profile	2	Toe is steep and placed top soil eroding
Existing vegetation competition[1]	2	Invasive weeds present; density of seeded grasses
Shade	0	
Maintenance issues[2]	2	Weeding required, rodent fence to be secure at the bottom and leaning out. Straw wattles to secure to toe of slope
Flooding duration	0	
Hydraulics (Shear stress)	2	
Infrastructure and available space	0	
Wildlife impact[3]	0	
Comment on wildlife impact:		
Access	0	
Other: 1-		
2-		

[1] e.g. from aggressive, fast spreading grasses or invasive weed species

[2] e.g. weeding, fencing or rodent protection) including inadequate or no irrigation, frequency or coverage

[3] Browsing/girdling by Rodent/Beavers/Muskrats

POTENTIAL REPAIR OPTIONS

	Select one
(1) Minor (hand tools, seeding and manual planting)	X
(2) Moderate, may need small machine and material to be brought in (is there access?)	
(3) Major, site needs to be redesigned and reconstructed.	

Description: Repair the rodent fence at toe ; move up the wattle and secure it against existing soil; weeding is needed

ALTERNATIVE DESIGN OPTIONS

Description: Treatment as 46E1 and 46E3 without top soil (pit run / river gravel) planted with live cuttings

Success Attributes

To date good approach to vegetate existing riprap; appears that plugs have higher survival than cuttings; theory that air pockets or temperature fluctuation

Bank Protection/Stabilization Structure Assessment
First Assessment River Reach After Freshet Assessment KWL/Terra

Master Site List No.	46E-3	RMP Site ID Code (e.g., BE-BOW- 4A)	BE-BOW-46E-3
Site Name:	Bioengineering Demonstration Project Site 4-3 (void filled riprap and li	Survey year (1/3/5+)	
Watercourse	Bow River	Weather:	Overcast and 15 degrees
Crew Initials	MG / PR	Date:	25-Sep-20

Photo Monitoring

Permanent photo-monitoring location and ID **Other Photos (min 3)**

Refer to Appendix B - Attachment A, photos 1 - 32 and Appendix E

Hydrology

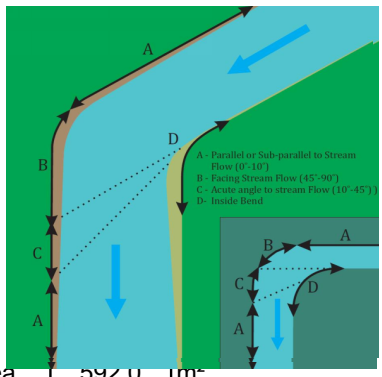
Flow at time of survey 45 m³/s Source: Rivers.alberta.ca

Aspect (N,E,W,S or combined N/E)

Aspect 1 NNE % of site 100 Aspect 2 % of site Aspect 3 % of site

Site Location (Select 1 or more and add percentage of each)

A) Parallel or nearly parallel to flow (0° to 10°)	X	70 %
B) Moderate angle to flow (10° to 45°)	X	30 %
C) Directly facing flow (45° to 90°)		%
D) Internal bend		%



MEASUREMENTS

Average longitudinal stream slope at site 0.2 %

Estimate of stream width for current year flood flow 150 m

Site Dimensions

Total length of the work (parallel to stream) 64 m Total project area 592.0 m²

Avg width of the work in plan view (perp to stream) including landscaping on top of the bank 9.25 m

Average slope of the constructed bank 21 ° Average height of the constructed bank 3.5 m

Crib wall only

Height of Bioengineering Structure	Bank height (from permanent herbaceous or woody vegetation line)	Ratio % Bioeng structure/ Total Bank Height
		#DIV/0!
Average width of the crib wall into the bank (from engineering plans)		m

Site Elevation Measurements

Hydrology Survey	**Rod Height (m)**	**Elevation (m)**	**Survey Notes**
Elevation Benchmark	1.29	1000	Water level at 11:43am
High water mark*	0.95	1000.34	Mud line over shrubs
Water level during survey	1.29	1000	

*Measured at observed debris and/or pollen accumulated on bank

Planted Vegetation Survey*	**Rod Height (m)**	**Elevation (m)**	**Survey Notes**
Elevation Benchmark	2.45	1000	Water level at 12:33pm - water level dropped 3 cr
Elev of lowest woody veg	2.15	1000.3	Salix int.
Elev of lowest herbaceous veg	2.2	1000.25	grasses
Elev of lowest emergent veg		1002.45	

*Lowest elevation of *planted* woody, herbaceous, emergent vegetation along riverbank

Existing Vegetation Survey*	**Rod Height (m)**	**Elevation (m)**	**Survey Notes**
Elevation Benchmark	1.29	1000	Downstream of site 4-4
Elev of lowest woody veg	1.1	1000.19	Balsam poplar
Elev of lowest herbaceous veg	1.18	1000.11	Grasses
Elev of lowest emergent veg		1001.29	

*Lowest elevation of *existing native* woody, herbaceous, emergent vegetation along riverbank (trim line) If not possible, use difference in elevation between current water surface and existing vegetation either across the stream and/or further D/S or U/S.

Difference in elev between Planted and Existing Veg	Difference (m)
Woody vegetation	0.11
Herbaceous vegetation	0.14
Emergent vegetation	

WORK STRUCTURE ASSESSMENT

Rock Materials

Riprap Size	lm of application (m)*	% of total riprap
Class 1M (d50=175mm)		0
Class 1 (d50=300mm)		0
Class 2 (d50=500mm)	64	100
Class 3 (d50=800mm)		0
Other:		0
Total linear metre (m)	64	

Fish boulder average diameter mm

Fish boulder arrangement/distribution

Physical Condition	Rating	Riprap	Fish Boulders
Excellent	5 Very new without any defects	X	
Very Good	4 <5% defects without impacting structural integrity		
Good	3 10-20% defects without impacting structural integrity		
Fair	2 20-40% defects without impacting structural integrity		
Poor	1 Condition which needs immediate attention and repair		

Estimate of Remaining Useful Life	Riprap	Fish Boulders
>10 years	**X**	
5-10 years		
<5 years		
Negligible		

Gabion Materials

Gabion dimensions

Length mm Width mm Height mm Mesh Opening Size mm

Physical Condition	Rating	Gabions
Excellent	5 Very new without any defects	
Very Good	4 <5% defects without impacting structural integrity	
Good	3 10-20% defects without impacting structural integrity	
Fair	2 20-40% defects without impacting structural integrity	
Poor	1 Condition which needs immediate attention and repair	

Estimate of Remaining Useful Life	Gabions
>10 years	
5-10 years	
<5 years	
Negligible	

Wood Materials

Wood dimensions

Log diameter mm Log length mm Inclination angle °

Timber width mm Timber height mm Timber length mm

Rootwad diameter mm Rootwad length mm Location of root wad

Physical Condition	Rating	Logs	Timber	Rootwad
Excellent	5 Very new without any defects			
Very Good	4 <5% defects without impacting structural integrity			
Good	3 10-20% defects without impacting structural integrity			
Fair	2 20-40% defects without impacting structural integrity			
Poor	1 Condition which needs immediate attention and repair			

Estimate of Remaining Useful Life	Logs	Timber	Rootwad
4 >10 years			
3 5-10 years			
2 <5 years			
1 Negligible			

Erosion Control Matting and Geotextiles

Biodegradable erosion control matting product name (BECM)	
Biodegradable geogrid product name (BG)	
Synthetic erosion control matting product name (SECM)	
Synthetic geogrid product name (SG)	
Non woven geotextile product name (NWG)	

Physical Condition	Rating	BECM	BG	SECM	SG	NWG
Excellent	5 Very new without any defects					
Very Good	4 <5% defects without impacting structural integrity					
Good	3 10-20% defects without impacting structural integrity					
Fair	2 20-40% defects without impacting structural integrity					
Poor	1 Condition which needs immediate attention and repair					

Estimate of Remaining Useful Life	BECM	BG	SECM	SG	NWG
4 >10 years					
3 5-10 years					
2 <5 years					
1 Negligible					

Erosion Control Wattles

Biodegradable wattle product name (BW)	Curlex logs - 300mm diameter
Synthetic wattle product name (SW)	

Physical Condition	Rating	BW	SW
Excellent	5 Very new without any defects		
Very Good	4 <5% defects without impacting structural integrity		
Good	3 10-20% defects without impacting structural integrity		
Fair	2 20-40% defects without impacting structural integrity		
Poor	1 Condition which needs immediate attention and repair	X	

Disintegrated

Estimate of Remaining Useful Life	BW	SW
4 >10 years		
3 5-10 years		
2 <5 years		
1 Negligible	X	

should remove with the fence at end of maintenance program

Concrete Materials

Concrete product 1 description (C1)	
Concrete product 2 description (C2)	
Concrete product 3 description (C3)	

Physical Condition	Rating	C1	C2	C3
Excellent	5 Very new without any defects			
Very Good	4 <5% defects without impacting structural integrity			
Good	3 10-20% defects without impacting structural integrity			
Fair	2 20-40% defects without impacting structural integrity			
Poor	1 Condition which needs immediate attention and repair			

Estimate of Remaining Useful Life	C1	C2	C3
4 >10 years			
3 5-10 years			
2 <5 years			
1 Negligible			

Steel Materials

Steel product 1 description (S1)	Rebar canes for wattle tie downs
Steel product 2 description (S2)	
Steel product 3 description (S3)	
Steel product 4 description (S4)	
Steel product 5 description (S5)	

Physical Condition	Rating	S1	S2	S3	S4	S5
Excellent	5 Very new without any defects					
Very Good	4 <5% defects without impacting structural integrity	X				
Good	3 10-20% defects without impacting structural integrity					
Fair	2 20-40% defects without impacting structural integrity					
Poor	1 Condition which needs immediate attention and repair					

Estimate of Remaining Useful Life	S1	S2	S3	S4	S5
4 >10 years	X				
3 5-10 years					
2 <5 years					
1 Negligible					

ENVIRONMENTAL AND CONTEXTUAL FACTORS

Erosion/Deposition Observations

Estimate of toe scour at site
Low [ ] Medium [ ] High [ ] N/A [X] Describe: None

Estimate of U/S bank erosion at site (U/S key)
Low [ ] Medium [X] High [ ] N/A [ ] Describe: Material washed out from bank at us site

Estimate of D/S bank erosion at site (D/S key)
Low [ ] Medium [ ] High [ ] N/A [X] Describe: None

Estimate of erosion within site/structure
Low [ ] Medium [X] High [ ] N/A [ ] Describe: fill along bank - fines washed out gravel r

Estimate of sediment accumulation at site
Low [X] Medium [ ] High [ ] N/A [ ] Describe: Trace on rocks

Measurement of sediment accumulation at site
Depth: Trace Method: Visual
Describe/Location:

Seeps or spring present Yes [ ] No [✠] Describe:

Ice abrasion None [X] Light [ ] Moderate [ ] Severe [ ]

Visual estimate of channel grain size
Silt [ ] Sand [X] Gravel [X] Cobble [X] Boulder [ ] Bedrock [ ]

SITE MOST LIMITING FACTOR(S)

Select from the list below, limiting factors to success:	ASSIGN A SEVERITY RATING TO EACH OF THE FACTORS BELOW: NONE(0), LIGHT(1), MODERATE(2), SEVERE(3)	
	After Treatment	Comments
Slope instability	0	
Slope gradient	0	
Erosion	1	At toe
Compacted soils	0	
Anoxic soils	0	
Insect damage and disease	0	
Trampling by people or dogs	0	
Motorized vehicles	0	
Non motorized vehicles	0	
Aspect	0	
Bank profile	0	
Existing vegetation competition[1]	2	Invasive weeds ; density of gross growth is less than
Shade	0	
Maintenance issues[2]	2	Rodent fence and toe wattles to repair
Flooding duration	0	
Hydraulics (Shear stress)	2	
Infrastructure and available space	0	
Wildlife impact[3]	0	
Comment on wildlife impact:		
Access	0	
Other: 1-		Theory that air pockets below void fill material may not
2-		

[1] e.g. from aggressive, fast spreading grasses or invasive weed species

[2] e.g. weeding, fencing or rodent protection) including inadequate or no irrigation, frequency or coverage

[3] Browsing/girdling by Rodent/Beavers/Muskrats

POTENTIAL REPAIR OPTIONS

	Select one
(1) Minor (hand tools, seeding and manual planting)	X
(2) Moderate, may need small machine and material to be brought in (is there access?)	
(3) Major, site needs to be redesigned and reconstructed.	

Description: Repair the rodent fence ; move up the wattle and secure it against existing soil; weeding required before plants going to seeds

ALTERNATIVE DESIGN OPTIONS

Description: Design options could be 46E_1 and 46E_2 without top soil on side slope (bank) planted with live cuttings.

Success Attributes

To date, successful existing riprap retrofit with void fill and live cuttings ; With 3 years of irrigation plants should establish. telebelt innovative method use to place material in void

KERR WOOD LEIDAL
consulting engineers

Appendix E

Bioengineering Structural Integrity Assessment Photos

Appendix E - Photographs

Site 1 – Structural Assessment: September 25, 2020

Photo credits: Kerr Wood Leidal Associates Ltd. and Terra Erosion Control Ltd.

Photo E-1: Site 1 from 17th AVE SE BRT bridge (looking downstream)

Photo E-2: Site 1 Vegetated Timber Crib wall and wildlife corridor from 17th AVE SE BRT bridge (looking downstream)

Photo E-3: Site 1 vegetated riprap with rooted live cuttings wildlife corridor upstream of Cushing bridge (looking upstream)

Photo E-4: Site 1 vegetated riprap with rooted live cuttings wildlife corridor upstream of Cushing bridge (looking downstream)

Appendix E - Photographs

Photo E-5: Site 1 wildlife trail (looking north)

Photo E-6: Site 1 wildlife trail (looking south)

Photo E-7: Site 1 Vegetated timber crib wall (looking upstream)

Photo E-8: Site 1 Vegetated timber crib wall – willow roots extending down into the river

Appendix E - Photographs

Photo E-9: Site 1 fish shelter

Photo E-10: Site 1 fish shelter

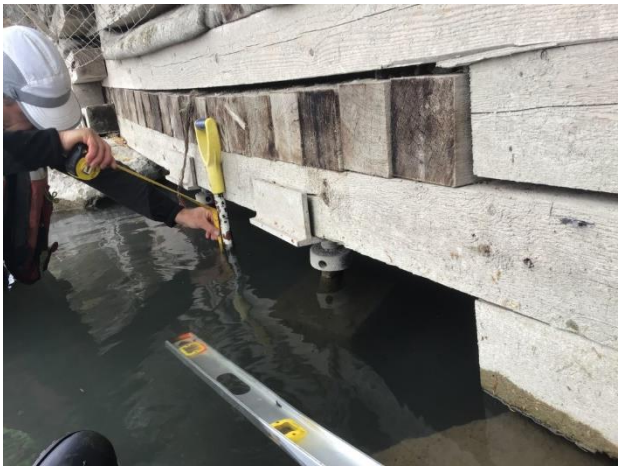


Photo E-11: Site 1 measuring sediment deposition in the fish shelters

Photo E-12: Site 1 setting up spanning timber member deflection measurement points

Appendix E - Photographs

Photo E-13: Site 1 gap in containment materials in the vegetated timber crib wall

Photo E-14: Site 1 timber crib wall vegetation – note alfalfa and clover infestations

Photo E-15: Site 1 brush mattress with rock toe -note very good establishment (looking upstream)

Photo E-16: Site 1 brush mattress with rock toe -note very good establishment (looking west)

Appendix E - Photographs

Site 1 – Vegetation Assessment: September 23, 24 and 28, 2020

Photo credits: Terra Erosion Control Ltd.

Photo E-17: Site 1 replanted live cuttings in vegetated riprap upstream of Cushing Bridge

Photo E-18: Site 1 vegetated riprap with rooted long cuttings quadrat assessment

Photo E-19: Site 1 overhanging cover at vegetated timber crib wall (looking upstream)

Photo E-20: Site 1 dead cuttings in timber crib wall

Appendix E - Photographs

Photo E-21: Site 1 quadrat in vegetated soil wraps

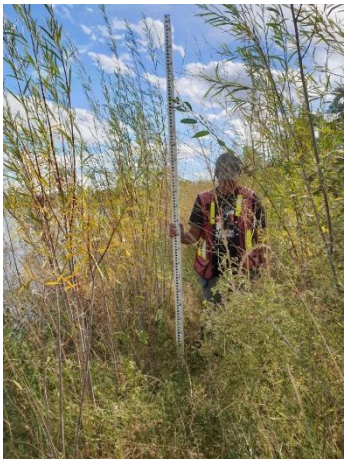


Photo E-22: Site 1 vegetation assessment in vegetated soil wraps

Photo E-23: Site 1 vegetation assessment in wildlife corridor

Photo E-24: Site 1 vegetation assessment in wildlife corridor – note thick herbaceous vegetation cover over planted shrub

Appendix E - Photographs

Site 2 – Structural Assessment: September 25, 2020

Photo credits: Kerr Wood Leidal Associates Ltd. and Terra Erosion Control Ltd.

Photo E-25: Site 2 from upstream groyne (looking downstream)

Photo E-26: Site 2 box fascine toe –no toe erosion observed (looking upstream)

Photo E-27: Site 2 biodegradable coir geogrid in good condition

Photo E-28: Site 2 hedge brush layer and box fascine with good establishment (looking west)

Appendix E - Photographs

Photo E-29: Site 2 brush layer under box fascine establishment – also note good condition of wood posts and steel wire

Photo E-30: Site 2 hedge brush layer establishment and no toe erosion observed

Photo E-31: Site 2 hedge brush layer establishment

Photo E-32: Site 2 from downstream groyne (looking upstream)

Appendix E - Photographs

Site 2 – Vegetation Assessment: September 23, 24 and 28, 2020

Photo credits: Terra Erosion Control Ltd.

Photo E-33: Site 2 vegetation assessment in the contour fascines

Photo E-34: Site 2 quadrat assessment in the brush mattress

Photo E-35: Site 2 box fascine vegetation assessment

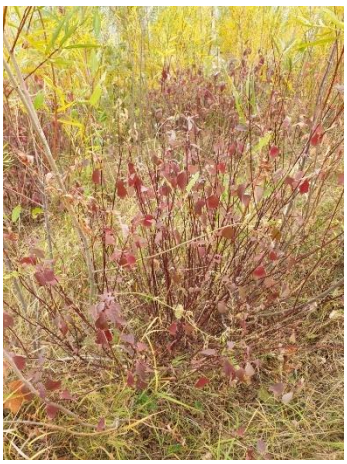


Photo E-36: Site 2 red osier dogwood establishment in the hedge brush layer

Appendix E - Photographs

Site 4 – Structural Assessment: September 25, 2020

Photo credits: Kerr Wood Leidal Associates Ltd. and Terra Erosion Control Ltd.

Photo E-37: Site 4 – note heavy herbaceous growth (looking downstream)

Photo E-38: Site 4 – note erosion of placed toe fill material – observed to be no further erosion in 2020 (looking upstream)

Photo E-39: Site 4 condition of curlex log (looking upstream)

Photo E-40: Site 4 good Balsam poplar establishment (looking downstream)

Appendix E - Photographs

Photo E-41: Site 4 desiccated Balsam poplar

Photo E-42: Site 4 condition of root of desiccated Balsam poplar

Site 2 – Vegetation Assessment: September 23, 24 and 28, 2020

Photo credits: Terra Erosion Control Ltd.

Photo E-43: Site 4 live cutting established around riprap (looking upstream)

Photo E-44: Site 4 vegetation establishment (looking upstream)