# FORDING RIVER HABITAT REHABILITATION NEAR THE CONCRETE ARCH BRIDGE


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## Abstract


Teck Coal retained the services of Lotic Environmental, MN Gaboury, and Kerr Wood Leidal to design the Fording River Habitat Rehabilitation near Concrete Arch Bridge offsetting measure required as part of Teck's Line Creek Phase II mine extension fish habitat offsetting plan. The design team employed a natural channel design process to develop the rehabilitation design. This approach used regional relationships of channel morphology-vs-drainage area and channel metrics from undisturbed reaches as a natural template to identify channel metrics and processes assumed to be outside of what would be expected for a natural site. A design was developed with specific treatments to promote an accelerated recovery of habitat quality over time, allowing the river to repair itself. Channel width-to-depth ratio, percent pools, and woody debris abundance were key aspects targeted for rehabilitation. Rehabilitation treatments were completed in fall 2016 and included 27 instream jams and 103 bar top structures in 1,280 m of channel. Two meander bends were reconstructed, each with riffle structures to provide bed stability. Bioengineering was completed in spring 2019. Year 3 (2019) represented the first full post-construction effectiveness monitoring of habitat and fish use. Results suggest that the target habitat features were beginning to develop.



**Key Words:** habitat rehabilitation, natural channel design, Westslope Cutthroat Trout, large woody debris jams, regional channel morphology relationships, effectiveness monitoring.

# INTRODUCTION

The upper Fording River holds an isolated population of genetically pure Westslope Cutthroat Trout (WCT; *Oncorhynchus clarkii lewisi*) (Rubidge and Taylor 2005). This watershed also includes three of Teck Coal's five open-pit mines operated in south-eastern British Columbia. The interaction of this important WCT population and large-scale industry has necessitated a considerable number of studies and environmental assessments to better understand this population, its habitat, and to help mitigate adverse impacts that could occur as a result of resource development.

Continued mine development often requires projects to work through provincial and federal environmental assessment processes. These assessments characterize the existing environment and identify when potential impacts to a component of the environment can be mitigated through mine design modification. As per the federal *Fisheries Act*, a proponent of any project is required to offset impacts to a fisheries resource through habitat offsetting where significant residual impacts remain following mitigation.

In 2009, Teck Coal began the environmental assessment process for its Line Creek Phase II project. The environmental assessment determined that habitat offsetting would be required. In collaboration with the Elk Valley Fish and Fish Habitat Committee (EVFFHC[1]), Teck Coal prepared an offsetting plan that included four offsetting measures for the Line Creek Phase II project. The plan was developed collaboratively with the EVFFHC and endorsed by them in May 2016 with construction to occur in the fall of 2016.

The Fording River Habitat Rehabilitation near Concrete Arch Bridge was selected as one of four offsetting measures for the Line Creek Phase II mine extension; located in the Fording River watershed in south-eastern British Columbia (Figure 1). The site was degraded following the large flood of June 2013. High flows, coupled with a lack of riparian cover caused extensive bank erosion, over-widening of the channel, and a loss of pool habitat with associated large woody debris (LWD) cover. Fish use data indicated that while adult WCT used the Fording River near the Concrete Arch for spawning, they were not using it in its present state for summer rearing or overwintering (Cope et al. 2016). It was suspected that the shallow depths, lack of pools, and lack of overhead cover made the area unsuitable due to unsuitable depth/velocity, an elevated risk of predation, and potential formation of anchor ice in winter (Robinson et al. 2015). It was also likely that the WCT that did use the area for spawning were at risk of predation. Primary objectives for this offsetting measure were to:

- restore the channel form and function (e.g., riffle-pool morphology) to provide greater fish habitat values for spawning, overwintering, rearing and migration habitat; and,

- recover reclaimed areas to conditions that support the ecological trajectory towards natural climax riparian ecosystems to provide long-term stability to the fluvial system while supporting microhabitats for small mammals, avi fauna, amphibians and invertebrates. The vegetation species selection, distribution and densities along with landform design will aim to support biodiversity values.

[1] The EVFFHC is a group including representatives from Fisheries and Oceans Canada, the BC Ministry of Forests, Lands, Natural Resources Operations and Rural Development, and the Ktunaxa Nation Council.

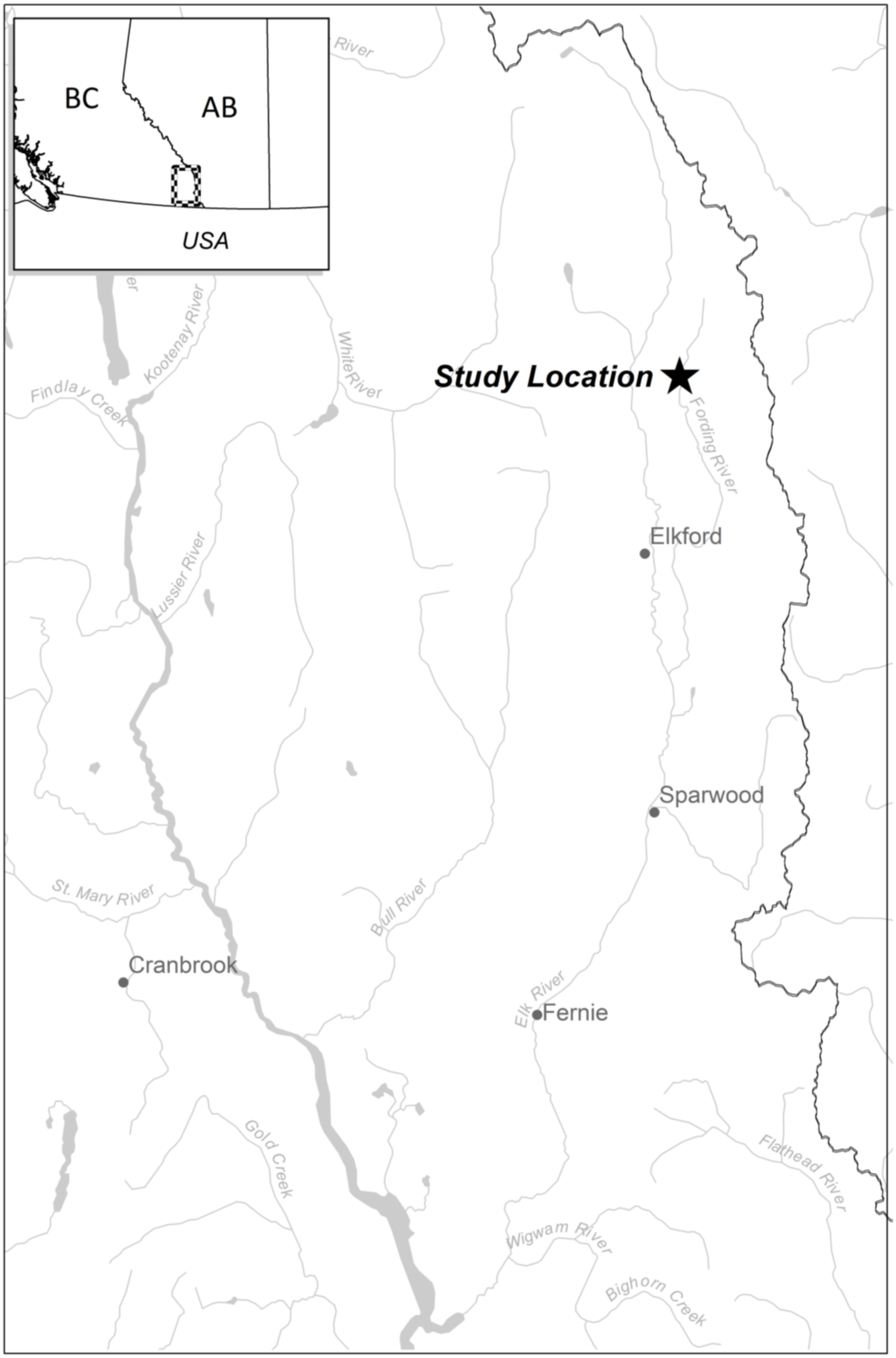


**Figure 1. Site location map.**

## Rehabilitation Design Process

The design team of Lotic Environmental, MN Gaboury, and Kerr Wood Leidal were retained to develop the offsetting plan and rehabilitation prescription. The design approach followed a natural channel design process to develop the rehabilitation prescription. Furthermore, the approach was to install specific structures to promote an accelerated recovery of habitat quality overtime; in other words, to allow the river to repair itself.

Rehabilitation objectives for the upper Fording River were developed in collaboration with the EVFFHC from an extensive fish and fish habitat data set. The key objectives identified were: 1. Maintain/restore connectivity throughout the watershed; 2. Improve access to/construct tributary habitat; and 3. Enhance overwintering habitat were those key objectives. A reconnaissance survey was completed in the upper Fording River that produced a list of 12 potential offsetting measures capable of addressing the key objectives (Robinson and Sutherland 2014). The list was shortened by applying screening criteria such as constructability, cost per area gained, and overall anticipated value to the system. Seven measures were selected and concept designs were developed for each. The first step in the concept design process was a geomorphic assessment. The geomorphic assessment was primarily based on a review of historical hard-copy air photographs and digital orthophotos, and was used to describe the geomorphic environment of each measure. The results were used to confirm suitability of each location for constructing rehabilitation works by discussing anticipated long-term channel stability. From this, and through consultation with the EVFFHC, four offsetting measures were selected for the LCO Phase II project. The Fording River Habitat Rehabilitation near Concrete Arch Bridge addressed two of three key EVFFHC objectives for the Fording River watershed: (1) connectivity throughout the watershed, and (2) enhancing overwintering habitat.

Work was then completed to advance concept designs to final designs. Specific to the Fording River Habitat Rehabilitation near Concrete Arch Bridge, the next step was to define channel morphology design criteria based on an undisturbed channel in this section of the Fording River. Natural channel morphology values came from drainage area-based regional relationships and reference reach data from undisturbed portions of the Fording River. Regional relationships between drainage area and channel measurements are useful for estimating channel dimensions such as bankfull width and bankfull depth. Unfortunately, regional curves did not exist for the East Kootenay region at the time of design. Therefore, large regional datasets from Montana (Lawlor 2004) and Idaho (Dunne and Leopold 1978) were used as surrogates. Predictions of channel geometry from these relationships were corroborated by local habitat data collected from related studies (e.g., Robinson 2012; Cope et al. 2016).

Reach-level channel morphology data were collected to describe current conditions at the rehabilitation site. Comparison between existing site conditions and predicted natural channel characteristics helped to identify channel metrics and processes that were outside of what would be expected for a natural site. Treatment designs were then prepared to accelerate channel recovery to a more natural state. Specific to the Fording River Habitat Rehabilitation near Concrete Arch Bridge, channel width-to-depth ratio, percent pools, and amount of LWD present were identified as key aspects targeted for rehabilitation. Rehabilitation treatments were constructed in fall 2016 and included 27 instream LWD structures and 103 bar top structures in 1,280 m of channel (Figure 2). Two natural meander bends were also rehabilitated, each with riffle structures constructed to provide bed stability. Bioengineering (i.e., live staking, rooted cuttings, and brush layers) was completed in spring 2019 to promote riparian vegetation re-establishment.

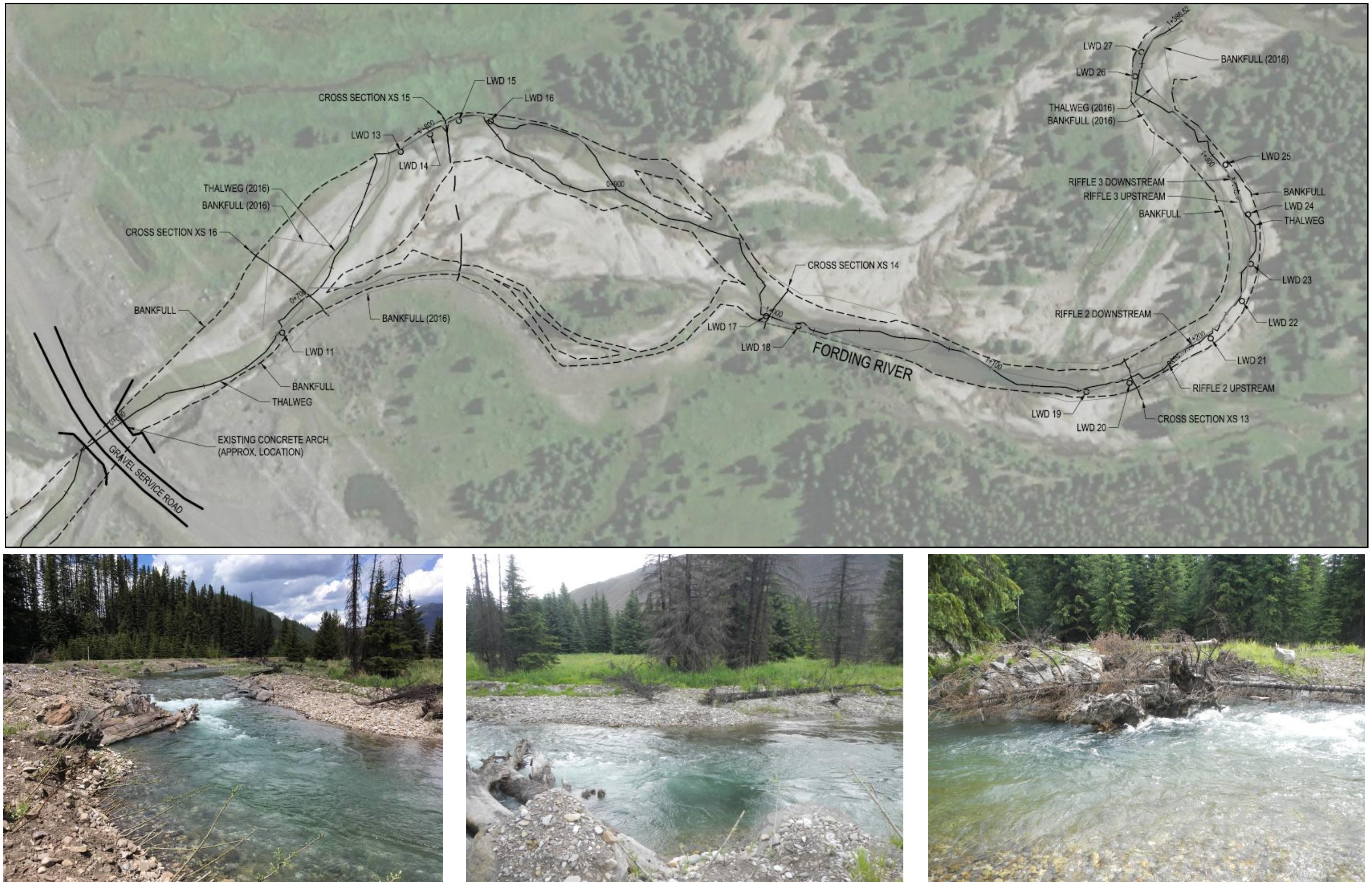


**Figure 2. Plan view of lower half of the rehabilitation reach (top), downstream view of LWD 21 (bottom left), cross-channel view of LWD 21 (bottom middle), and cross-channel view of LWD 25 (bottom right).**

# METHODS

Establishment of an effectiveness monitoring program is a requirement of an offsetting plan. Effectiveness monitoring is required to determine if an offsetting measure is functioning as intended, and the effectiveness of any contingency measures, if required and implemented. An effectiveness monitoring program sets out numerous physical and biological conditions that must be met. This is typically completed over a 10 year period, with interim monitoring occurring in Year 1, 3, 5 and 7 to show that the offsetting measure is on target to meet the requirements after the 10 years. Monitoring methods at the Fording River Habitat Rehabilitation near Concrete Arch Bridge followed those used to describe preconstruction conditions and effectiveness monitoring results were presented as changes relative to those conditions. To date, physical habitat effectiveness monitoring surveys have been completed in 2019 (three years post construction). Fish population monitoring data were collected in 2017 under the Upper Fording River WCT Population Study, being completed by Westslope Fisheries Ltd. (Cranbrook, BC).

## Physical Habitat Effectiveness Monitoring

Topographic and fish habitat surveys were used to assess changes in channel morphology relative to as-built conditions. Topographic surveys were completed using real time kinematic (RTK) GPS. Data from the surveys were used to describe channel longitudinal profiles and cross-sections established at permanent benchmarks during the as-built surveys. Channel morphology metrics of width-to-depth ratio and sinuosity were derived from the topographic surveys.

Fish habitat surveys were conducted following the BC Fish Habitat Level 1 Fish Habitat Assessment Procedure (FHAP) (Johnston and Slaney 1996). The offsetting measure site was first stratified into individual habitat units (e.g., pool, riffle, glide and cascade) during the topographic survey. The continuous survey provided measurements of habitat type and length to provide an absolute estimate of linear proportions of each habitat type. Complete sampling was then conducted to record data on channel geometry (e.g., width, depth, slope), cover type and abundance, and disturbance indicators for each habitat unit delineated. Six channel morphology metrics (i.e., channel complexity, percent pool (by area), pool frequency (mean pool spacing), holding pools (adult migration), LWD pieces per channel length, and percent wood cover in pools) derived from the FHAP surveys were used to assess channel condition (see Section 2.2.3). Width-to-depth ratio was also calculated from FHAP data.

Eight channel metrics derived from the topographic surveys and Level 1 FHAP procedures were selected to describe habitat conditions. Quality rating categories were derived from literature values for each metric (Table 1).

**Table 1. Metric criteria for defining poor, fair and good quality habitat, and channel structure and form (modified after Johnston and Slaney 1996, Newbury and Gaboury 1994, and Rosgen 1996).**

| Metric | Quality Rating | | |
|---|---|---|---|
| | **Poor** | **Fair** | **Good** |
| 1. Bankfull width-to-depth ratio | >25:1 | 16-25:1 | ≤15:1 |
| 2. Sinuosity | <1.2 | 1.2 | >1.2 |
| 3. Channel complexity | <2 mesohabitat units/10xWbf | 2-3 mesohabitat units/10xWbf | ≥3 mesohabitat units/10xWbf |
| 4. Percent pool (by area)* | <30 | 30-40 | 40-60 |
| 5. Pool frequency (mean pool spacing)* | >10 channel widths/pool | >8-10 channel widths/pool | <8 channel widths/pool |
| 6. Holding pools (adult migration) | <1 pool/km >1 m deep with good cover (30% of pool area) | 1-2 pools/km >1 m deep with good cover (30% of pool area) | >2 pools/km >1 m deep with good cover (30% of pool area) |
| 7. LWD pieces per channel length, measured as bankfull width* | <1 | 1-2 | >2 |
| 8. Percent wood cover in pools* (i.e., wood cover as a percent of pool area) | pools in reach average 0-5% LWD cover | pools in reach average 6-20% LWD cover | pools in reach average >20% LWD cover |

*For riffle pool streams with mean gradient <2%, bankfull widths <15 m, and for summer/winter rearing use.

## Fish Use Effectiveness Monitoring

The fish use component of effectiveness monitoring was adult summer rearing use. This was assessed through snorkel surveys conducted by Westslope Fisheries Ltd. (Cope et al. 2017). The methods for the snorkel survey followed the previous methods used in Cope et al. (2016). Snorkel sections were further differentiated into control and treatment habitat rehabilitation sub-sections to facilitate this effectiveness monitoring. Prior to commencing the snorkel survey a two-person crew marked the Fording River Habitat Rehabilitation near Concrete Arch Bridge subsection and a control subsection located immediately downstream of the rehabilitation section. Snorkel surveys were completed using a crew of 2 - 3 swimmers, swimming in a downstream direction searching for suitable habitat. Suitable habitat would include adequate water depths and available cover, especially from the added LWD structures from 2016. During swimming all observed fish were counted and categorized into 100 mm size classes (e.g., 0 – 100 mm, 100 – 200 mm, 200 – 300 mm, 300 – 400 mm, 400 – 500 mm) (Cope et al. 2016). After swimming a section the crew members would stop and discuss observations to reduce duplication of numbers (Cope et al. 2016). If the crew felt necessary, short sections would be resampled (Cope et al. 2016). The crew would record the number of fish and size classes on diver tablets for each treatment and control section.

# RESULTS

## Physical Habitat Effectiveness Monitoring

Topographic surveys and a Level 1 FHAP assessment were completed in July 2019. As per the offsetting plan: 1) Bankfull width-to-depth ratio; 2) Percent pool (by area); and, 3) LWD pieces per channel length (i.e., per 10x bankfull width) all ranked as “poor” under preconstruction conditions measured in 2016 and were therefore set with target values to achieve a *Good* ranking after 10 years of effectiveness monitoring (Table 2). Data from 2019 show that each of these three metrics had improved. Both percent pool and LWD per channel length values improved to an extent that the ranks increased from *Poor* to *Fair*. Bankfull width-to-depth ratio improved numerically, but not to the extent to improve it from its *Poor* ranking. Two other metrics that improved from *Fair* to *Good* were Pool frequency and Percent wood cover in pools. As they both ranked as *Fair* during preconstruction surveys, they were not listed as metrics with effectiveness monitoring targets. Improving pool quantity and quality was considered key to meeting the design objectives of improving connectivity and overwintering opportunity.

**Table 2. Channel morphology and habitat metrics and rankings for 2016 and 2019.**

| Metric | 2016 | | 2019 | |
|---|---|---|---|---|
| | Existing value | Existing rank | Existing value | Existing rank |
| Bankfull width-to-depth ratio | 45.4 | Poor | 34.3 | Poor |
| Sinuosity | 1.50 | Good | 1.56 | Good |
| Channel complexity | 8.9 | Good | 5.66 | Good |
| Percent pool (by area) | 5% | Poor | 27% | Fair |
| Pool frequency (mean pool spacing) (channel widths/pool) | 8.3 | Fair | 5.5 | Good |
| Holding pools (adult migration) | 3.8 | Good | 10.6 | Good |
| LWD pieces per channel length, measured as bankfull width | 0.6 | Poor | 1.7 | Fair |
| Percent wood cover in pools (i.e., wood cover as a percent of pool area) | 10% | Fair | 23% | Good |

Proportion of habitat area by habitat unit type was also investigated. As shown above both pool area and pool frequency were found to have increased from 2016 to 2019. Investigating the proportion of habitat area across all types showed that this increase came largely from a reduction in glide habitat (Table 3). Riffle habitat area remained relatively unchanged.

**Table 3. Percentage of habitat area by habitat unit type in 2016 and 2019.**

| Habitat Type | Total % 2016 | Total % 2019 | Change |
|---|---|---|---|
| P | 7% | 27% | 20% |
| R | 40% | 52% | 11% |
| G | 49% | 22% | -27% |
| C | 4% | 0% | -4% |
| Total | 100% | 100% | |

Cross-sectional and longitudinal profiles provided an effective qualitative and quantitative assessment of changes in channel morphology. Cross-sectional profiles were surveyed at six permanent transects (Cross Section XS 13-18) (Figure 2). Cross Section XS13 was located on the lower portion of the treatment reach and through the apex of a LWD structure to monitor location of where a pool would likely form. It was shown that the thalweg had deepened approximately 0.30 m. As well, the cross-sectional profile had formed a more typical shape of what would be expected along the outside of a meander (Figure 3). This location was a relatively deep glide in 2016 meaning that extensive pool development would not have been expected from pre-construction conditions. Cross Section XS 16 was located downstream of a LWD structure. This section was through a riffle at the time of construction and the bed scour of 0.4-0.5 m is more indicative of how much scour can occur at a LWD structure (Figure 4).

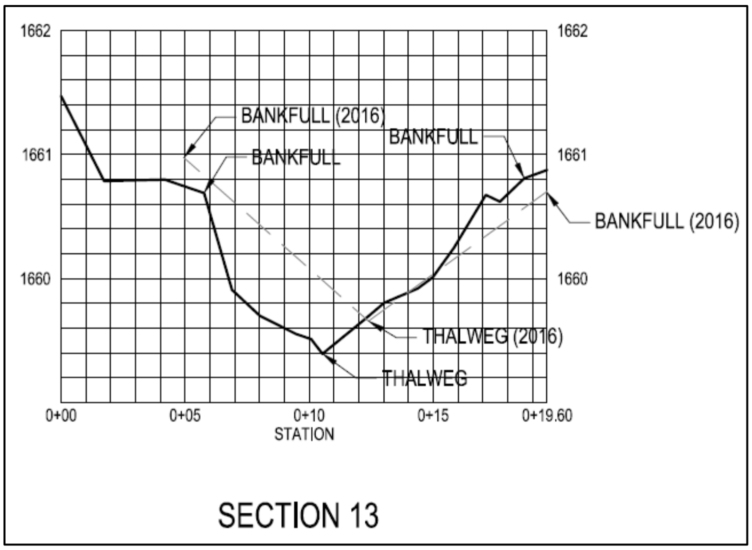


**Figure 3. Cross-sectional profile at Cross Section XS13.**

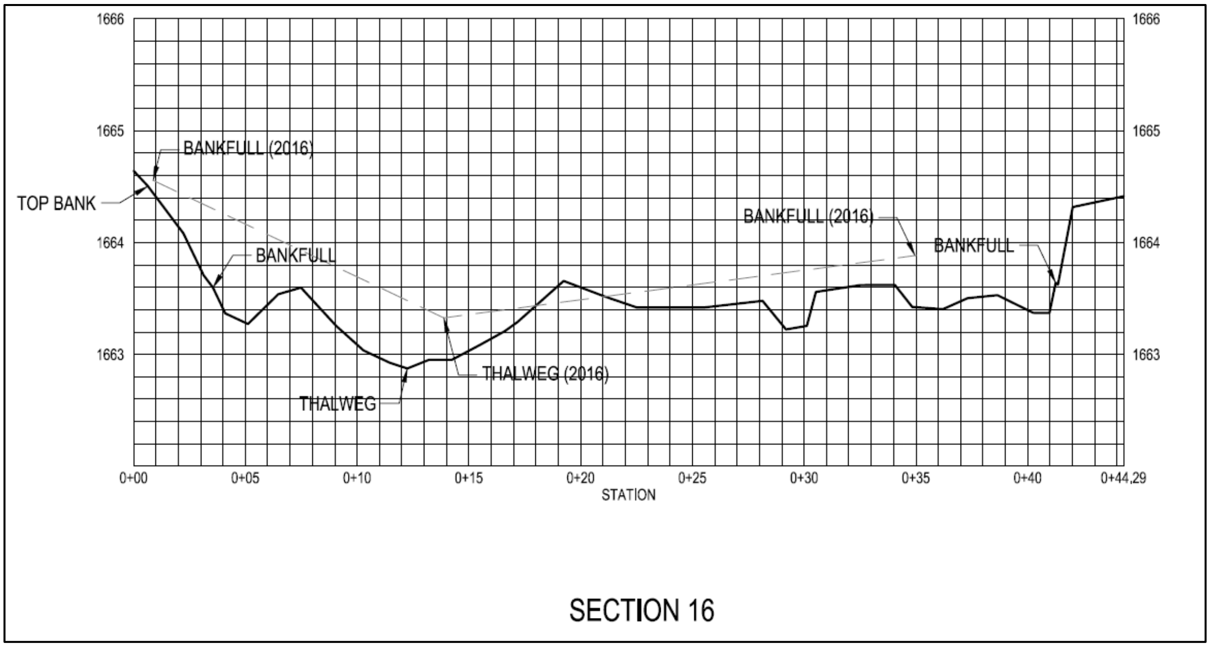


**Figure 4. Cross-sectional profile at Cross Section XS16.**

The final assessment of changes in habitat came from a qualitative assessment of the longitudinal profile. A longitudinal profile was used to plot the thalweg from 2016 and 2019, as well as the mean bankfull elevation from 2019. Assessment of changes in thalweg elevation around LWD structures further corroborated the data provided from the topographic surveys, FHAP assessments, and review of the cross-sectional profiles. In all instances, the data suggest that the rehabilitation prescription was successfully increasing the abundance of pool habitat and increasing the amount of functional LWD. However, the previous data did not demonstrate the connection of the two improvements as well as the longitudinal profile did. Two examples of the relationship between LWD and pool scour depths are provided below with LWD 11 and LWD 21. The plot of LWD 11 shows the flow of the Fording River from left to right (Figure 5). This plot shows how the thalweg has dropped in elevation from 2016 to 2019 and clearly demonstrates how this was associated with the hydraulic scour induced by LWD structure 11. Also apparent in the plot is XS 16, which was discussed above. The most drastic change in thalweg profile from 2016 to 2019 observed over the entire Fording River Habitat Rehabilitation near Concrete Arch Bridge was associated with LWD 21. Here the scour created by the LWD structure effectively created approximately 1.5 m of scour over the three year period (Figure 6). The traditional scour pool followed by a downstream tailout can be clearly seen in the profile plot.

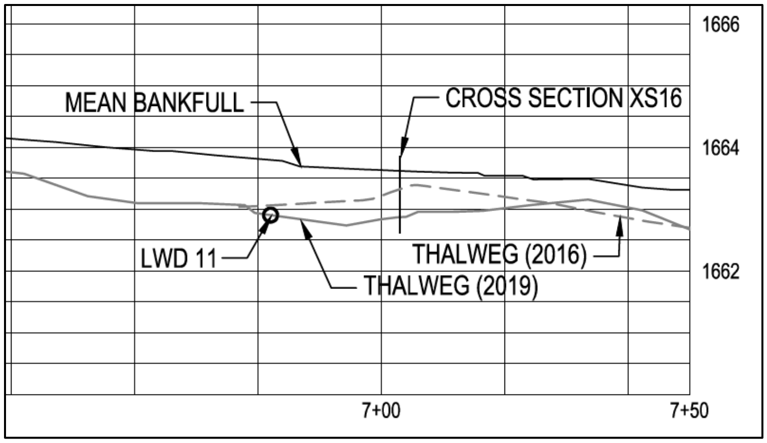


**Figure 5. Longitudinal profile plot of the 2016 and 2019 thalweg in association with LWD 11.**

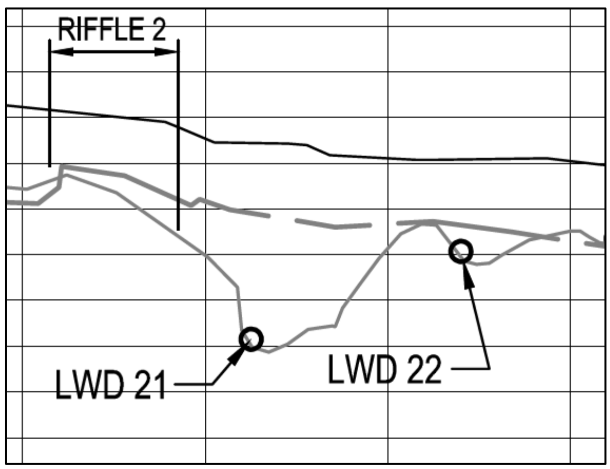


**Figure 6. Longitudinal profile plot of the 2016 and 2019 thalweg in association with LWD 21 (Refer to Figure 4 for axis scale: x-axis = 20 m grid; y-axis = 0.5 m grid).**

## Fish Use Effectiveness Monitoring

On September 7, 2017 the snorkel crew completed drifts at downstream and upstream portions of the Fording River Habitat Rehabilitation near Concrete Arch Bridge site. Fish observations were made for fish greater than 200 mm fork length. The downstream section had 105 fish over 0.923 km, supporting 113.76 fish/km. The upstream section covered 0.377 km and had 148 fish observed, supporting 392.57 fish/km. Combined, this produced a density of 194.61 fish/km within the rehabilitation site. The selected control sub-section was snorkelled for 1.30 km with 26 fish observed, producing 20.00 fish/km. Comparison of fish abundance between treated and control subsections found the observed abundance to be 9.73 times greater in the rehabilitated section than in the control section.

# CONCLUSION

The objectives of the Fording River Habitat Rehabilitation near Concrete Arch Bridge project were to improve connectivity and overwintering opportunity within the Fording River watershed. Preconstruction conditions documented an overwidened channel that lacked pool habitat necessary for fish to successfully migrate through this section of the river. While not a physical barrier, this approximately 1 km long section of the Fording River was considered to be a migratory obstacle where fish would be forced to migrate without holding pools and suitable overhead cover; putting them at increased risk to predation. The monitoring results suggest that the rehabilitation treatments have been successful in the first three years to increase the abundance and quality of pool habitat in this reach. Pool habitat was shown to have increased by percentage of available habitat and by spacing. The quality of pools was also shown to have improved by deepening the thalweg and increasing the amount of LWD cover in pools. Migration through this section of the Fording River, and therefore connectivity with the Fording River watershed is considered to have been improved. This same deep pool habitat with abundant LWD cover has also been shown to be preferred overwintering habitat for Westslope Cutthroat Trout (Cope et al. 2016).

Fish use data suggest that habitat suitability has indeed improved in the rehabilitation section. Summer rearing density for Westslope Cutthroat Trout was nearly an order of magnitude higher in the rehabilitated section than the next kilometer of the Fording River immediately downstream in the first year post-rehabilitation. Fish use monitoring is scheduled to be repeated in fall 2019 to investigate if this trend continues. The complete habitat and fish use effectiveness monitoring program will be repeated again in 2021 and 2026 if not flow triggered on any given year. Result will be used to assess the ongoing success of this rehabilitation project.

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