RESTORING ACCESS TO FISH HABITAT THROUGH THE DESIGN AND CONSTRUCTION OF TWO FISHWAYS AT HUCKLEBERRY MINE


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ABSTRACT

Creek M is a short, high-gradient creek located on the south side of Tahtsa Reach in Ootsa Lake (Nechako Reservoir) near Houston, British Columbia. This creek was barren of fish until 1996, when Huckleberry Mines Ltd. implemented a habitat-compensation plan to offset prospective losses of fish habitat associated with mine development. The goal of this plan was to allow upstream passage of fish from Tahtsa Reach throughout the creek to a headwater pond located approximately 425 metres (m) upstream. Compensation structures within the creek consisted of three fishways comprised of log-steps (i.e., weirs) lined with geotextile and anchored with rock fill. Annual fish surveys documented the failure over time of many log-step structures, precluding fish passage. In 2012 and 2013, remedial works were undertaken to re-establish upstream fish passage for juvenile and adult rainbow trout in Creek M. New fishways were designed to be more robust, to function over a range of flows, and to meet specific requirements of migrating rainbow trout.

KEY WORDS

Fishway, fish passage, rainbow trout, habitat-compensation, migration.

INTRODUCTION

Creek M is a short, high-gradient creek located on the south side of Tahtsa Reach in Ootsa Lake (Nechako Reservoir) near Houston, B.C. Huckleberry Mines Ltd. (HML) implemented the Creek M compensation plan in 1996 to offset prospective losses of fish habitat in Creeks 2 and 4 as a result of mine development and operation. The goal of the compensation plan was to allow upstream passage of fish from Tahtsa Reach to a headwater pond located approximately 425 metres (m) upstream. Prior to the implementation of the compensation plan Creek M did not support fish populations as a result of two steep gradient reaches (10% to 20% slopes) which precluded fish passage. Compensation structures within Creek M consist of three fishways. Two of the fishways are located approximately 50 m and 300 m upstream the creek mouth while a third very small fishway is located immediately downstream the headwater pond (Figure 1). The original fishways were comprised of a series of log-steps (i.e., weirs) lined with geotextile and anchored with rock fill. Annual surveys conducted by Hatfield Consultants...
Partnership (Hatfield) from 2005 to 2011 documented the failure of several of the log-step structures whereby fish passage was precluded.

Annual surveys from 2001 to 2011 documented juvenile rainbow trout (*Oncorhynchus mykiss*) throughout the creek and adult rainbow trout within the headwater pond. The presence of juvenile fish may have indicated the downstream movement of juvenile trout, resulting from pond-resident trout entering the creek to spawn in spring, rather than fish moving upstream from Tahatsa Reach into upper Creek M. Juvenile fish numbers generally declined from 2008 to 2011, with record low numbers below the middle fishway in 2011. No other fish species have been observed or captured in this creek.

The decrease in juvenile trout is likely attributable to the failure of weirs in the lower and middle fishways. The uppermost fishway (comprised of two weirs) is still functioning as intended. Migrating adult rainbow trout either from Tahatsa Reach or the headwater pond were likely precluded from preferred spawning areas between the lower and middle fishways, while juveniles became stranded in isolated pools during the late summer and winter low flow seasons. The original weir design for each step-pool included a single log weir complete with low flow notch anchored into the banks of the creek. The weirs were installed perpendicular to the flow of the creek and lined with a geotextile fabric on the upstream face. The geotextile was anchored with native substrate at a depth suitable to form a pool above each weir. Weirs that extend across the stream at right angles to the flow tend to create short pools that extend across the channel making them less stable (Slaney and Zaldokas 1997). The majority of the weirs became undermined or blown out completely while the pools between each weir in-filled with gravel and cobble substrate. As a result, the majority of flow was conveyed subsurface and the original channel gradient reestablished (Figure 2). HML proposed to remediate the failed fishways during the summer low-flow period (i.e., August) in 2012 and 2013.
Figure 1. Creek M Fishways
FISH PASSAGE DESIGN RATIONAL

Riffles, pools and steps may be added to channels to change the local state of flow, increase access to floodplains, provide fish passage, reduce bed and bank erosion and create new habitats for fish (Newbury 2011). The objectives of the fishway remedial works in this case were to re-establish upstream fish passage for juvenile and adult rainbow trout between Tahtsa Reach and the Creek M headwater pond across a range of flows and extend the design life of the fishways. Design options were driven by the remoteness of the site, seasonal hydrology (i.e., spring freshet followed by an extended period of low flow), target species life-history and physiological capabilities, construction feasibility and budget.

Remedial works included the replacement of degrading and failed weirs (Figure 2) with new milled cedar timber and/or rock and mortar weirs. The new weirs were configured in an upstream-V orientation, reinforced with rebar and lined with a nonwoven geotextile fabric on the upstream face. The milled cedar weirs were constructed two timbers thick whereby one timber was completely buried in the substrate to prevent undermining. The geotextile was anchored to the weirs with large wood screws and washers and along the channel bottom upstream of the weir with native cobble substrate below the invert of the upstream pool. Timber weirs were substituted with rock weirs (of similar configuration) when bedrock substrate prevented anchoring of the timber and non-woven geotextile. Rock interstices were filled with mortar to increase stability.
and provide a seal to the channel bottom. The modified design is more stable than the existing weirs. The upstream-V configuration also promotes scour of the downstream plunge pool during both high and low flow conditions (Figure 3). The upstream V has the strength inherent in an arch design and tends to concentrate the current and subsequent scour in the middle of the channel and away from adjacent stream banks (Slaney and Zaldokas 1997). The weirs were anchored into the stream banks with rock ballast or fastened with rock anchor bolts and aircraft cable. Each weir crest was designed to slope down from the stream bank to the upstream point of the weir to confine the main flow to the middle 1/3 of the stream creating a type of low flow notch (Figure 3). These timber or log type weirs should only be used in small streams with an average channel width of less than 5 m. Larger streams with average gradients exceeding 0.4% typically have stream power or energy during floods that result in structural failure or burial of structures by excess bed load (Slaney and Zaldokas 1997).

Each weir was replaced starting from the downstream end of the fishway to ensure channel grade control and pool-jump specifications were achieved for the target life-stages of rainbow trout. For each weir the depth of the plunge pool should be a minimum of 1.25 times the height of the jump (Adams and Whyte 1990) and the height of the jump should not exceed 0.3 m to permit passage of juvenile rainbow trout (Slaney and Zaldokas 1997).
Figure 3. Typical weir sections for the Creek M fishway
CONSTRUCTION METHODOLOGY

Given the remoteness of the site (i.e., boat access only) cedar timbers and geotextile were imported via helicopter to a predetermined drop zone outside the creek riparian area; remaining construction materials were imported by boat. A fish salvage was conducted prior to the commencement of works within the work area using a backpack electrofisher. Full-span stopnets were installed at the upstream and downstream ends of the work area prior to commencing the fish salvage. The electrofishing crew fished wetted portions of the work area until fish were no longer captured. All captured fish were enumerated, weighed and measured for fork length then relocated to a pool upstream the work area. Flows were conveyed around the work area with a sandbag headwall and four-inch pipe such that the work area was isolated from flowing water. Installation of the weirs occurred from the downstream extent of each fishway and progressed upstream. The stream banks of each fishway were armored with rock salvaged from the removal of the original fishway and channel excavation (completed by hand). Large construction machinery (e.g., excavator) was not used during construction due to access restrictions.

Creek M, downstream view of lower fishway construction (August 2012).

Figure 4. Creek M fishway construction photographs
Figure 5. Creek M fishway construction photographs (Cont.)
MONITORING

Site inspections of the fishways were completed in June 2013 and 2014 to evaluate the pool-depth and jump-heights of each step-pool within the fishways during spring freshet and rainbow trout spawning season. Rainbow trout are spring spawners and typically migrate from overwintering habitat to spawning grounds in the spring when temperatures reach between 10.0 and 15.5 °C (Scott and Crossman 1979) depending on geographic location. Assessments of hydraulic function and physical stability were also assessed during the spring inspections. With the exception of three weirs in the lower fishway all pool-depth to jump-height ratios have increased from what was observed during the as-built survey and meet the design criteria for migrating adult and juvenile rainbow trout. The structural integrity of the fishways was upheld and evidence of erosion, weir undermining or pool in-filling was not observed. As part of the mines environmental effects monitoring (EEM) program fish sampling in Creek M is conducted annually in mid-August. In 2013 a total of 39 rainbow trout were captured in Creek M, all of which were young-of-year (YOY) fish. This is the largest number of YOY fish observed in Creek M since 2008. All fish were captured between the lower fishway and the middle fishway within isolated pools as a result of low water levels. It should be noted that remedial works within the middle fishway were underway at the time of the 2013 fish sampling program. A comprehensive assessment of both remediated fishways in the context of fish distribution and relative abundance will be completed in August 2014. Monitoring and remediation if required will continue for five years post-construction.
Downstream view of the lower fishway (June 2014).

View of lower fishway from top of canyon bank (June 2014).

Figure 5. Photographs of the Creek M fishways in operation (Cont)
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REFERENCES

