



United States Department of the Interior

NATIONAL PARK SERVICE

Water Resources Division

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Memorandum

To: Darla Sidles, Superintendent, Rocky Mountain National Park (ROMO)

Through: John Wullschleger, Acting Chief, Aquatic Systems Branch (ASB) **JOHN WULLSCHLEGER**

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Subject: Technical Assistance Report: Evaluation of Cub Lake Trail flooding, Rocky Mountain National Park

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Executive Summary

About 270 ft south of the trailhead the Cub Lake Trail frequently experiences high flows that inundate a side channel of the Big Thompson River and flood the trail as it approaches the Big Thompson bridge. This creates maintenance and visitor use problems. Reconnaissance level investigations were conducted on September 4 and October 17, 2019 to develop strategies to mitigate flooding of the bridge approach. During the assessment, an additional concern was identified where ongoing bank erosion threatens the north abutment of the bridge. A range of mitigation options were developed and evaluated, with a preliminary selection of rebuilding the approach with a robust boardwalk structure. This appears to be the most practicable treatment and should alleviate the trail flooding concern for all but extreme floods. This treatment will likely require secondary anti-scour measures at the bridge abutment and boardwalk piers.

Problem Statement/Issue Overview

On September 4 and October 17, 2019, Rocky Mountain National Park and NPS Water Resources Division staff visited the Cub Lake Trail to evaluate periodic flooding of the trail at the northern approach to the Big Thompson River bridge. The Cub Lake Trail trends south from the trailhead across the Big Thompson River valley through Moraine Park. The trail runs for about 270 ft. from the trailhead to the main channel of the Big Thompson River, and this section of the trail, north of the river, has four water conveyance structures that permit down valley flow. Two of the crossings, a small bridge over an abandoned channel (10 ft. span) and a small culvert (1 ft. diameter) in an overflow channel, are located between the trailhead and the area of concern. The main channel is spanned by a 25 ft long foot bridge, but this is only about 30-50% of the active channel width (Figure 2). The active channel is the width of stream that lacks perennial vegetation and is regularly modified by average floods. The rest of the active channel is spanned by a prism of fill with one large culvert (2.5 ft. diameter) at a side-channel location (Figure 3). During high flows the valley's cross-sectional water conveyance area is restricted by the trail, its prism of fill, and the inadequate size of the bridge opening and overflow culvert resulting in trail flooding and damage to the bridge approach.

The bridge approach north of the crossing is about 50 ft. long and built on a prism of fill raised about 2 ft. above the active channel and surrounding floodplain. Conveyance is adequate at low and medium flows, but during high flows the trail fill restricts flow across the width of the active channel and overbank, acting as a semi-permeable dam/dike. This is because the bridge constricts the main channel to about 1/3 to 1/2 the width of the active channel upstream and downstream (Figures 2, 3, and 4). The resulting constricted channel creates backwater that spreads across the floodplain. Some of this water diverts into a side channel at river left and passes through the larger culvert in the north bridge approach of the trail. However, the culvert provides only a small amount of additional flow capacity and is functional over a narrow range of discharges. Higher discharges flood the trail, creating maintenance and visitor access issues.

A potentially greater concern identified during the field visit is a cut bank on the main channel immediately upstream that is eroding and threatening the north abutment of the main bridge (Figures 2 and 5). Eventually, this erosion is likely to circumvent the abutment and compromise the north trail approach of the bridge. The resultant new side channel would likely develop into the main channel because of its steeper gradient. This scenario would render the bridge largely dysfunctional and necessitate re-design of the crossing or a major trail reconfiguration. The time frame of this channel migration is flow dependent and not readily predictable.

A longer-term concern that may exist is the potential for channel avulsion. In broad glacial valleys such as Moraine Park, multithreaded channels continually migrate, avulse, and reconfigure as a dynamic network of channels moves water down valley. That channel network has changed since the Cub Lake Trail and bridges were constructed perpendicular to historical Big Thompson flow paths, and it will continue to evolve in the future. The river-trail interface

will remain a dynamic environment with complex hydraulic and geomorphic processes. This will require occasional re-evaluation of the Cub Lake Trail.

Treatment options evaluated to address trail flooding

Flood mitigation of the bridge approach may be addressed through a range of options including:

Option 1: No action. The trail will continue to flood during high flows and visitor access will be periodically restricted. Routine repair and maintenance will likely be required. This may be a reasonable option, as it has no initial financial or time investment beyond repair and maintenance. This option would allow for more detailed analyses and monitoring to inform a future solution that could accommodate the dynamic fluvial system as it evolves through time.

Option 2: Increase the culvert conveyance capacity near where the prism of fill constricts the active channel and side channel. This is a relatively low-cost solution that would reduce flooding of the trail to some degree. One option is that the culvert could be increased from one culvert to multiple culverts, increasing the width of the channel network. For example, adding two more 2.5' culverts might increase the effective channel width (main bridge plus main culvert) from 27.5' to 32.5'. This solution would be effective under a limited range of discharges, but would reduce the frequency of trail flooding.

Option 3 (preferred): Replace the north bridge approach with a boardwalk structure. The boardwalk would complete the span over the active channel at about the same elevation as the bridge and extend a reasonable distance into the floodplain meeting natural grade at an ADA compliant slope. Its construction would enable removal of the prism of fill that supports the current trail and dams flows that occur during both normal annual runoff and extreme events. This option would allow the river to re-occupy most of its modern active channel. A boardwalk would alleviate most of the damming and an appreciable amount of backwater. The boardwalk will accommodate stock animals and be ADA compliant. Anti-scour measures must be taken to prevent undermining of the base of the boardwalk, whose piers would be subject to erosion. Current constriction from the cement bridge abutments will still affect hydraulics and create some backwater in the main channel, and its north abutment may necessitate anti-scour measures.

Option 4: Add an additional bridge section that spans the active channel. This is likely the costliest option and would require hydraulic analysis/modeling, engineering design and a greater level of compliance. Also, this option would be undertaken with the assumption that the main channel will maintain its current location and not avulse into a different part of the river valley. This is uncertain, especially with an unknown future that could include things such as beaver recolonization.

Future cutbank migration

Construction of a boardwalk that spans the northern section of the active channel (Option 3) is the preferred treatment for alleviating trail flooding, but it would exist in an environment vulnerable to future cutbank migration toward the boardwalk and bridge abutment. If the advancing cutbank is not artificially armored, it is likely to progress toward and circumvent the north bridge abutment. This process would represent the river reclaiming active channel on both sides of the north abutment, which is a natural result of dynamic fluvial processes. Despite the loss of some of the vegetated bank, this scenario would be a positive condition for the riparian system and hydraulic environment. However, the north bridge abutment and any boardwalk piers in the active channel will be subjected to substantial hydraulic pressure, and anti-scour measures such as boulders could be used to protect them.

Further Investigation

More detailed study could inform immediate and future management decisions regarding the long-term geomorphic stability of this river reach. Specifically, the ongoing possibility of mainstem channel avulsion and continued channel migration could create a need for future trail realignment, at which time we would assess which options are the most practicable and cost effective. WRD will be available to provide consultation and technical support to staff at ROMO in addressing this issue.



Figure 1. Evolution of the Big Thompson River near the Cub Lake Trail, 1990-2016. The water conveyance structures are labeled in the middle panel and are the small bridge, small culvert, main culvert, and main bridge (1,2,3, and 4). A side-channel that was possibly the former main channel supported surface flow in 1990 (A1) but was completely disconnected by 2016 (A2). The main channel had a relatively straight approach to the bridge in 1990 (B1), but increased sinuosity and a wider active channel developed by 2016 (B2). Increasing sinuosity near the bridge partially resulted from an upstream channel cutoff (C) that steepened the flow gradient and increased energy available downstream. The cut bank at B2 is likely to migrate downstream and compromise the north bridge approach in the future.

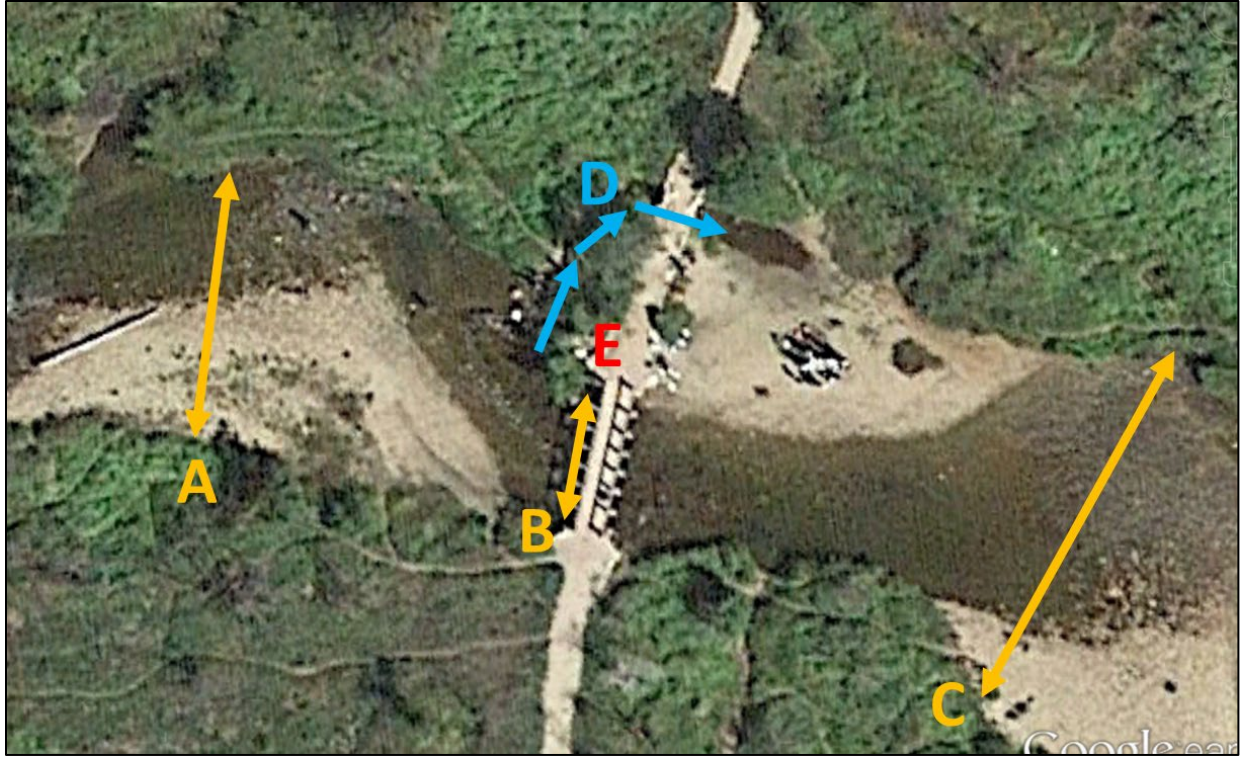


Figure 2. Mainstem Big Thompson River near the main bridge of the Cub Lake trail. The active channel widths upstream and downstream of the bridge (A, C) are about 59 and 75 ft., respectively. This is 2-3 times wider than it is at the bridge (B), which is only about 30 ft. The constriction causes backwater that enters a secondary channel and flows through the culvert (D) or onto the trail. The bank loss that is threatening north bridge abutment is located at (E).



Figure 3. Upstream view of the Cub Lake trail, the bridge over the mainstem Big Thompson River, the prism of fill, and the culvert on the side-channel. The fill acts as a barrier to in-channel and overland flow at higher discharges. Note the large boulders that could serve as point protection riprap. NPS, 2019.



Figure 4. Downstream view of the Big Thompson River. The active channel width (i.e., bankfull width) is much wider than the bridge opening. The cut bank at left of the bridge will probably migrate downstream reclaiming the active channel width. This will surround the north bridge abutment and likely necessitate anti-scour measures. NPS, 2019.



Figure 5. Downstream view of the main channel and its advancing cut bank that threatens the bridge abutment. The small side channel leading to the culvert extends to the left immediately below the researcher at left. This whole section of bank will likely become active channel and be spanned by the proposed boardwalk. NPS, 2019.

CC:

IMR: Weeks

ROMO: Bromberg, Fedorchak, Nydick, Parker, Reis, Yost

WRD: Ellsworth, Harvey, Noon, Wagner