

Poudre Headwaters Project: Field Evaluation of Fish Passage at Prominent Rapids in the Big South Canyon of the Cache la Poudre River



Anglers collecting population data along the Big South section of the Cache la Poudre River.

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Executive Summary

The goal of this study was to evaluate the potential of naturally-occurring waterfall features in the Big South Canyon of the Cache la Poudre River to serve as a fish passage barrier for the Poudre Headwaters Project. We evaluated species composition and distribution through angling surveys and environmental DNA (eDNA) monitoring between identified waterfall features and conducted a field-based geomorphic assessment of each identified feature to gage height and hydraulic potential as it relates to fish passage. Preliminary evidence suggests that no single alternative waterfall identified is an absolute fish passage barrier; however, there some areas could be further evaluated. Genomics and mark-recapture approaches could be useful for determining if waterfall features restrict fish passage. Further study into the upper extent of brown trout could also be useful to improving our understanding of fish movement within the Big South Canyon. At this time, the findings from our preliminary study does not support a compelling argument to change the terminal barrier location of the Poudre Headwaters Project.



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Background

The Poudre Headwaters Project (PHP) is a large-scale, interagency effort to restore the federally-threatened greenback cutthroat trout to 37 miles of stream habitat and 106 acres of lake habitat in the upper Cache La Poudre River. The PHP arose from the environmental mitigation developed to offset impacts of Long Draw Reservoir and dam. The project sets forth a phased approach to preparing aquatic habitat for greenback cutthroat trout by removing non-native fish and establishing barriers that prevent re-invasion of non-native trout.

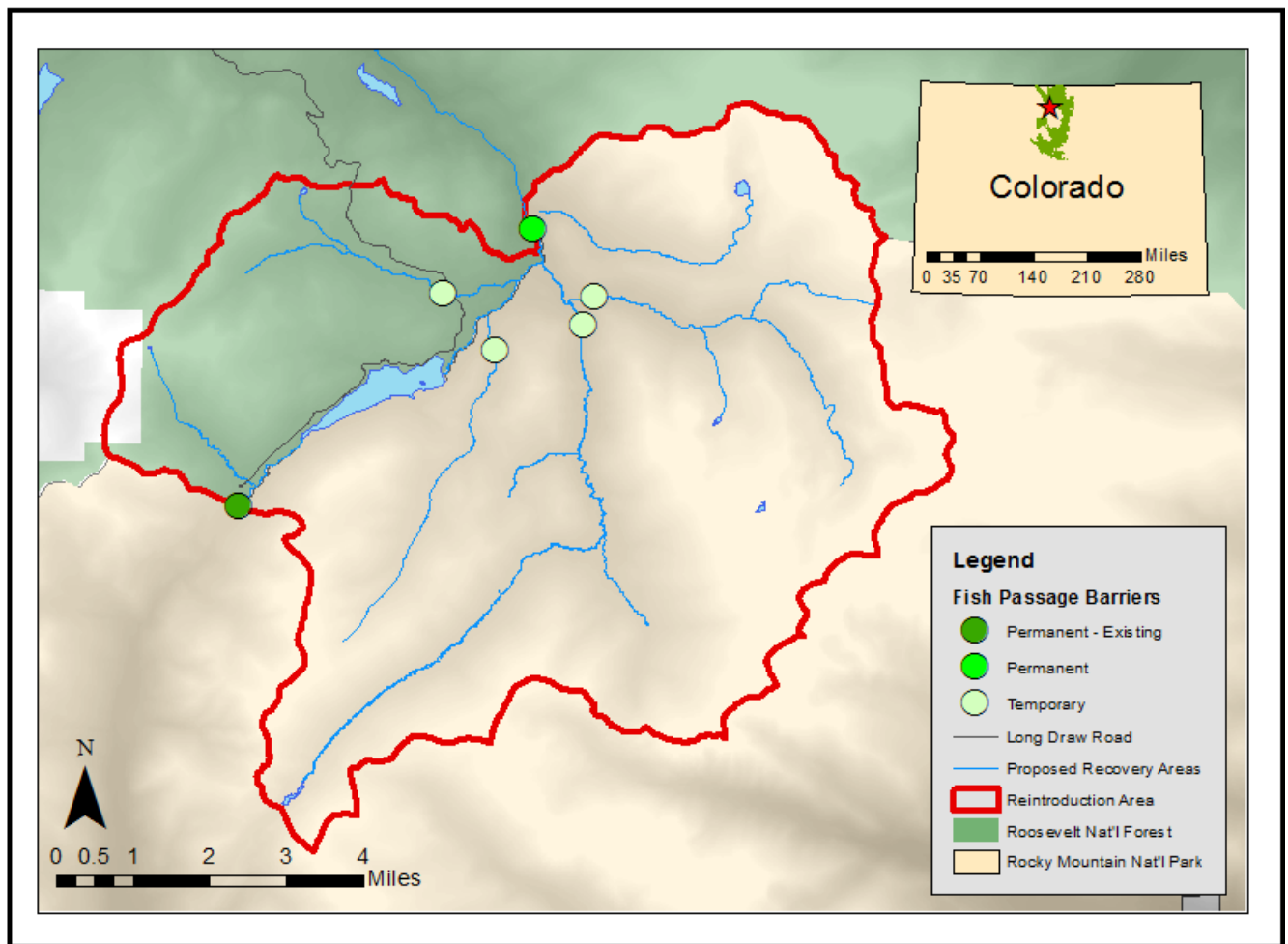


Figure 1. Proposed temporary and permanent fish passage barriers within the Poudre Headwaters Project conservation boundary.



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The project will rely on a total of six fish barriers throughout phases of the project: one existing barrier (Long Draw Dam), two permanent barriers to be built or established, and three temporary barriers to be built or established (Figure 1; USDA Forest Service 2009; National Park Service 2009; USDA Forest Service 2010; National Park Service 2011). The permanent barrier at the downstream end of the project area occurs on the Wild section of the Cache la Poudre Wild and Scenic River (WSR) and is the most critical barrier for the long-term success of the restoration effort and for the biosecurity of greenback cutthroat trout populations, once established. Barrier locations for the project were selected through an interagency process with the National Park Service (NPS) and the USDA Forest Service (FS) to identify the best candidate locations for the restoration project. Further, specific criteria were prescribed to ensure that barriers would be compatible with Wild & Scenic as well as Wilderness values, including:

- (a) mimicking normal, naturally occurring conditions,
- (b) not creating unusual hazards or substantially interfering with existing or reasonably anticipated recreational use of the river,
- (c) not interfering with naturally occurring events such as bank erosion, channel shifting, and bed load movement,
- (d) using construction materials with natural appearance,
- (e) placing materials in locations, positions, and quantities which mimic natural conditions, and
- (f) and installing anchoring materials, cables, rebar, etc., in such a manner as to be visually acceptable (USDA Forest Service 2010).

The lower permanent barrier site is located at a naturally-occurring bedrock waterfall and Class V rapid, named *Starter Fluid* (Figure 1). A fish passage study at *Starter Fluid* has revealed that the waterfall is only a partial barrier to non-native fish (USDA Forest Service unpublished data) and that physical modifications to the waterfall will be needed to establish a barrier robust to invasion across all flow levels.

The Cache la Poudre River was designated as a Wild and Scenic River in 1986 under Public Law 99-590 with four key values serving as the basis for the “Wild” segment of the river: (1) Hydrology – water is free-flowing with no diversions or dam structures and the shoreline remains primitive with no significant manmade modifications; (2) Water Quality – water volume and water quality; (3) Recreational – “Meaningful experience opportunity” and the river is accessible only by trail; (4) Scenic – there are no commercial developments & the area is entirely with Wilderness Areas or the National Park. Recent interest in the project and concern about impacts to the WSR arose from American Whitewater (AW) in late 2020. Specifically, they were concerned that as part of the PHP, the FS would be constructing a dam or otherwise diminishing the outstandingly remarkable values for which the river was designated.

Following discussions between the FS and AW, questions about whether or not other waterfall features in the Big South Canyon might already serve as an existing, complete barrier to fish passage led the FS to conduct a preliminary field evaluation of the WSR downstream from *Starter Fluid*. In 2021, we conducted field evaluations of waterfall features within the Big South Canyon downstream from *Starter*



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Fluid, the downstream boundary of the PHP as defined by the 2009 Final Environmental Impact Statement and Records of Decision issued by the FS and the NPS. In consultation with AW staff, waterfall features were identified for evaluation to determine the likelihood of a waterfall feature serving as a prospective fish barrier. This evaluation will help land managers determine the potential for fish passage and feasibility of relying on an alternate lower barrier site for the Poudre Headwaters Project.

Role of Barriers in Greenback Cutthroat Trout Conservation

The Poudre Headwaters Project will rely on natural and constructed barriers to exclude non-native fish from areas where greenback cutthroat trout will be reintroduced (Figure 1). Non-native trout pose a suite of threats to native cutthroat trout, making them particularly vulnerable to competition, predation, disease, and loss of genetic purity (Young 2009). In particular, young brook trout hold an ecological advantage over young greenback parr due to earlier spawning cycles of brook trout, resulting in larger fish of the same age class that can often outcompete young greenback for food and refuge (Petersen et al. 2004; Coleman and Fausch 2007). Additionally, brown trout are known potential carrier of *Myxobolus cerebralis*, the parasite that causes whirling disease and they have the potential to spread this disease to a conservation population (Bartholomew et al. 2005). Further, rainbow trout and other lineages of cutthroat trout are more closely related to greenback cutthroat trout and can interbreed causing genetic mixing or introgression (Weigel et al. 2003).

Establishing and confirming absolute fish passage barriers across the headwaters of the Cache la Poudre River will prevent non-native fish from invading into the conservation area and will confine reintroduced greenback cutthroat trout to their native range. The Grand Ditch Barrier, constructed December 2021, contains design elements (e.g., barrier height, limited pool depth) that prevent the passage of trout from La Poudre Pass Creek and Long Draw Reservoir from navigating into western slope waters, outside of the historic range of greenback cutthroat trout. Use of both permanent and temporary barriers within the Project will allow land managers to completely remove all the non-native fish within the area in phases. These barriers are essential for the lasting success of this conservation effort.

Study Objective

Our objective was to provide a preliminary assessment of fish passage potential at natural waterfall features in the Big South Canyon of the Wild & Scenic Cache la Poudre River downstream from the waterfall identified in the Final Environmental Impact Statement (FEIS) entitled Long Draw Reservoir Special Use Authorization (USDA Forest Service 2009). Ongoing fish passage studies that are being conducted at the identified downstream barrier within the project area are not included in this report. This analysis may be considered when evaluating proposed work on this section of the Cache la Poudre River as it applies to Wild and Scenic River standards and regulations.



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Methods

We used fish species composition and field geomorphic assessments to evaluate several alternate waterfall features known to the whitewater boating community as Class V rapids within the Big South Canyon downstream from the lower barrier site identified for the PHP. The primary features evaluated in 2021 were located upstream from Willow Creek and downstream from Cascade Creek within an approximate river length of 1.5 miles. AW staff provided confirmed locations for four known waterfall features. Colloquially known for being Class V rapids in the whitewater recreation community, the features had already been named and included: *Meltdown*, *Bonk*, *Cool World*, and *Fantasy Flight*, from downstream to upstream. Additionally, we evaluated the rapid *Double-Trouble* downstream from Peterson Lake in the lower segment of the Big South Canyon for fish species composition.

In all methods, measurements and observations were taken upstream and downstream from each waterfall feature to evaluate each feature's potential to serve as an absolute fish passage barrier. Waterfall features demonstrating strong preliminary evidence for potentially restricting fish passage (i.e., currently excluding brown trout from upstream reaches), then more thorough field studies could be warranted.

Angling Survey – Species Composition

Angling surveys were conducted to identify waterfall features that restrict the distribution of brown trout in the Big South Canyon. Brown trout currently co-occur with brook trout in the Cache la Poudre River near the Big South trailhead, whereas upstream portions of the river near *Starter Fluid* are not occupied with brown trout (USFS, unpublished data). Through a multi-day effort with Rocky Mountain Flycasters, teams of volunteer anglers were deployed to targeted river reaches upstream and downstream of waterfall features to determine species composition and relative abundance of species. Angling was chosen as the fish collection method over more traditional methods (i.e., electrofishing) due to the remoteness of the sites, the moderate discharge of the Cache la Poudre River at the time of surveys, (120 – 140 CFS [USFS, unpublished gauge data]), and untenable wading conditions near waterfall features (i.e., water depths > 5 feet). Flyfishers captured trout on four consecutive days from August 16 - 19, 2021. ARP Fisheries staff supervised the collections, determining the hours of fishing effort per day (i.e., angler hours), identifying trout species, recording length (nearest mm) and weight (nearest 0.1 g) measurements of captured fish, and scanning fish for PIT (Passive Integrated Transponder) tags that may have moved downstream from a fish passage study area near *Starter Fluid*. Fish caught were held in mesh baskets in the stream for 5-30 minutes until they could be measured and recorded.

eDNA – Presence/Absence of species

Environmental DNA (eDNA) present in the river water can provide information on the presence or absence of a species or group of species when water filters are analyzed in reference to known DNA markers for select species (Carim et al. 2016). In this study, we collected eDNA samples to test for the presence of brook trout and brown trout eDNA using standard procedures established by the Forest Service Rocky Mountain Research Station (Carim et al. 2016). To reduce the chance of contamination, we collected samples from downstream to upstream on two separate days: August 19, 2021



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[downstream from *Meltdown* and *Cool World*]; and September 5, 2021 [upstream and downstream from *Double Trouble*] The filtered samples were preserved in silica beads and kept frozen until they were shipped to the National Genomics Lab for analysis.

Geomorphic Assessment

Field assessments were performed on August 16-17, 2021 to examine waterfall features in a geomorphic context in order to characterize jump heights and side channels accessible at higher river stages for each of the features. Brook trout and other trout species are limited in their ability to jump/leap upstream through waterfall features of specific heights. Laboratory studies indicate 3 factors should be considered in evaluating natural features as potential barriers: (1) size of fish (2) depth of plunge pool [limits acceleration of fish]; and (3) height of waterfall feature [trout have limits on the heights they can jump] (Myrick and Kondratieff 2006). Large mature brook trout and athletic individuals are capable of making single leaps that exceed 3.3 feet (Myrick and Kondratieff 2006). In circumstances where natural waterfall features are a series of cascade drops, some fish are capable of making multiple leaps up connected features. ARP Fisheries staff visited the four rapids (i.e., *Meltdown*, *Bonk*, *Cool World*, and *Fantasy Flight*) making observations about jump heights, number of drops through the rapid, presence of side channels, and other factors relevant for making a preliminary determination about fish passage. Natural, cascading waterfall features can be difficult to evaluate due to the amount of turbulent flow, eddies, and small resting areas found along the margins of rocks and bedrock. For these reasons, our approach was to provide an informed estimate of the potential for fish passage at each rapid.



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Results

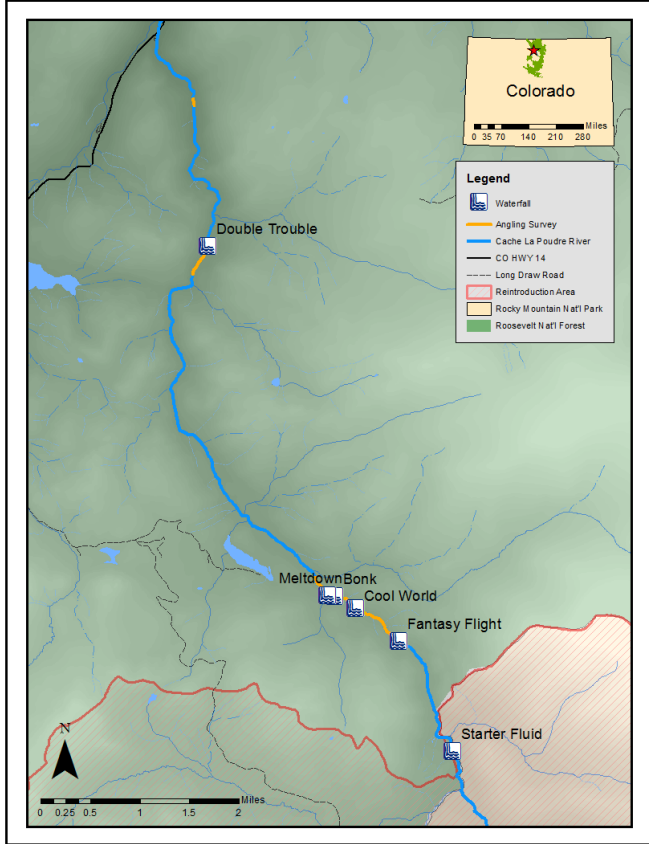


Figure 2. Study area along the Big South stretch of the Cache la Poudre River. The orange reaches indicates the extent of the 2021 angling survey. The six waterfall features were identified as established rapid features and potential fish passage barriers.

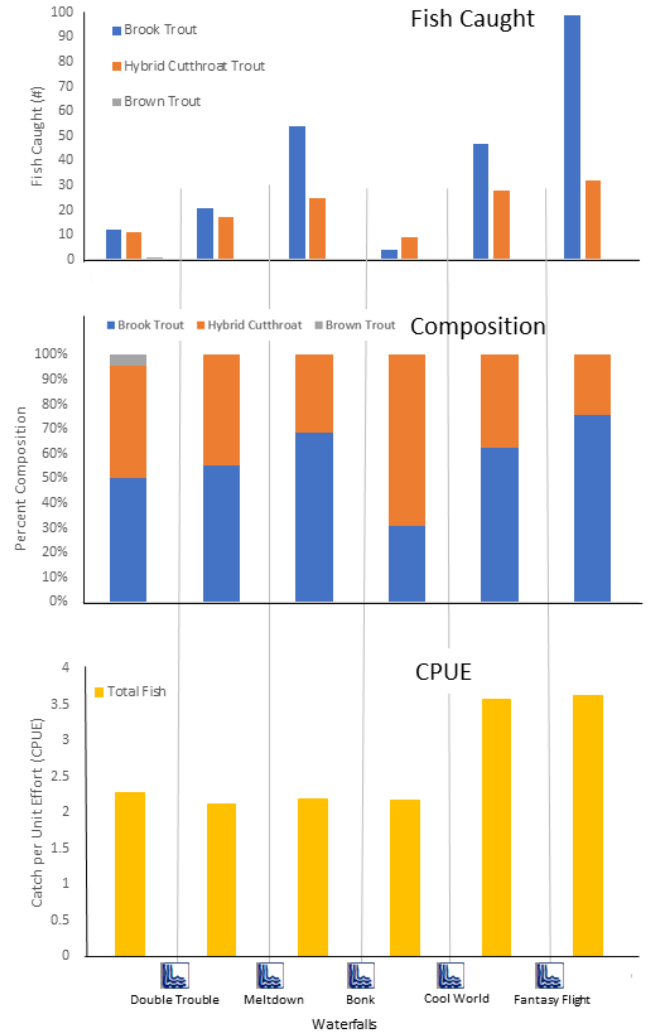


Figure 3. Angling results represented as reaches between waterfall features. Fish caught (top), composition (middle), and CPUE (bottom).

Angling Survey

Over the four days of sampling, six reaches were surveyed by 47 total anglers, capturing 364 trout from nearly 1.5 miles of the Cache la Poudre River (Figure 2). Overall, catch rates were moderately productive, with nearly 3 (+/- Std Error = 0.30) fish per angler hour of effort. Brook trout and hybrid cutthroat trout were observed at each survey reach, while only a single brown trout was caught downstream from the rapid Double Trouble (Figures 2 and 3). The largest number of fish were caught between *Cool World* and *Fantasy Flight* (Figure 3) likely because the river channel is more wide and relatively flat in comparison to other reaches, which allowed anglers to easily fish through a larger proportion of the reach in comparison to other reaches. The reach between *Meltdown* and *Bonk*



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(Figure 2) was the shortest of all the reaches sampled, covering less than 0.1 mile in a steep canyon section of the river, contributing to the low number of fish caught in this section. Brook trout were the most commonly captured fish species across all survey reaches (Figure 3). Although the percent composition of fish species varied somewhat across sites, the overarching theme for the fish community based on the angling survey is that species composition is fairly similar among the river reaches from Willow Creek upstream through the rapids *Meltdown*, *Bonk*, *Cool World*, and *Fantasy Flight*. Species composition in the *Meltdown* to *Bonk* reach are most dissimilar from the other reaches, but this reach had less fishing effort and fewer fish caught in comparison to others and likely represents either higher probability of capturing the larger hybrid cutthroat trout or that the areas anglers could reach in the confined reach were disproportionately occupied by cutthroat trout over brook trout. Based on these findings, we did not find evidence that the waterfall features *Meltdown*, *Bonk*, *Cool World*, or *Fantasy Flight* serve act as any significant barrier to fish passage in the Big South Canyon of the Cache la Poudre River. Further downstream, brown trout were caught exclusively downstream from the Double Trouble waterfall feature. Angler data suggests that Double Trouble may in fact function as a barrier to fish passage, at least for brown trout.

Environmental DNA

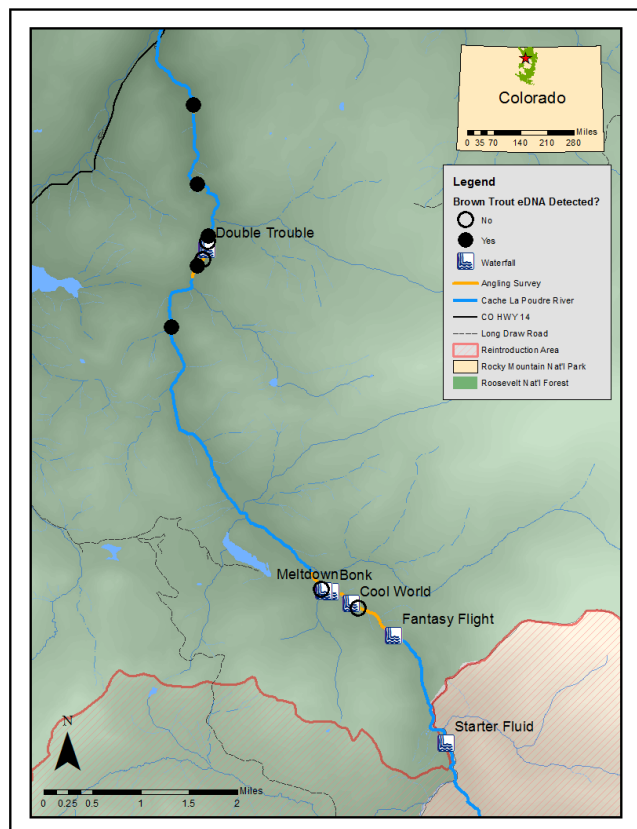


Figure 4. The presence/absence of Brown Trout eDNA detected in the study area. Filled-in circles indicate a positive detection. Samples were taken above and below waterfalls thought to restrict brown trout populations.

Environmental DNA (eDNA) was collected at 9 sites between the proposed barrier alternatives to provide additional data for determining the presence/absence of brown trout distribution in relation to the waterfall features being evaluated and to corroborate results from the angler survey (Figure 4). Due to the lack of brown trout captured during angler surveys, only two of the samples were collected between the waterfall features within the focal area of this study. Specifically, these samples were collected between the rapids *Meltdown* and *Bonk*, and the rapids *Bonk* and *Cool World*. Neither of these samples detected brown trout eDNA. The remaining seven samples were collected longitudinally along 3 miles in the lower segment of the Big South Canyon of the Cache la Poudre River. These samples returned positive detections of brown trout eDNA not only downstream from the rapid *Double Trouble*, but also upstream from the waterfall and more than 1 mile upstream from the waterfall. These eDNA results are counter to the results of the angler survey and bring to question both angler and eDNA data. It is possible that brown trout in



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fact do occur upstream from Double Trouble and the angler catch simply missed capturing this species. Alternately, the eDNA methods can produce false positive results due to contamination and poor adherence to procedure. Contract crews were responsible for collecting the eDNA samples in lower Big South Canyon and there is a possibility that waders or sample collection gear caused filters to get contaminated with eDNA not present from the actual collection site.

Geomorphic Assessment

Field assessment of waterfall features revealed that several, large and valley-wide bedrock-formed channel constrictions were present within the focal area of our study. At baseflow conditions these waterfall features contain some jumps that may potentially restrict fish passage; however, there are side channel areas that likely carry water through less arduous pathways at higher river stages (Table 1). The rapids Meltdown, Bonk, Cool World, and Fantasy Flight likely limit fish passage for smaller fish and at certain river stages. Of these waterfall features, Cool World seemed most likely to restrict fish passage. The rapid Double Trouble was added to our survey area after our initial scoping and was not included in the 2021 geomorphic assessment. The following photos and physical assessments were collected in the field around each waterfall feature and are presented from downstream to upstream.

Table 1. Summary of geomorphic assessment and fish passage factors for Class V rapids in a segment of the Wild & Scenic Cache la Poudre River.

Table with 6 columns: Feature, Jump Height, Number of Drops, High Flow Side Channels, Areas of Turbulence for Fish Movement?, Resting Areas Present? and 6 rows of data for different rapids.

Meltdown

The waterfall named as the rapid Meltdown occurs in a bedrock gorge with sheer rock walls on both banks. As a result, the area was difficult to examine the waterfall feature. The feature consists of 3 sharp grade drops of varying heights, 3 ft to 7 ft, with areas of high turbulence and conditions that are likely to allow fish passage because the feature does not contain a continuous drop across the entire valley width. Access for crews and equipment is very difficult.



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Figure 5. Images from the left. (1) Overhead view of Meltdown looking downstream. (2) Cross-section of the head of the rapid. (3) Panorama taken from the bottom of the rapid.

Bonk



Figure 6. Images from the left. (1) Overhead view of the rapid looking upstream. Rapid located by large boulder on the right bank. (2) Overhead view of the rapid looking upstream with person for scale (in yellow hat on the left bank).

The cascade feature named as the rapid *Bonk* drops the elevation of the river over a 200 ft segment with one notable constriction with a bedrock protrusion from the valley bottom that forces the river into distinct chutes with steep, but not vertical drops of 4 to 6 feet. Flow paths along the right bank that were present even at the low to moderate flows at the time of assessment likely provide easy passage for fish. Log jams and turbulence in along the right bank likely create adequate resting areas for non-native fish to jump upstream through this feature.

Cool World

The waterfall features within the rapid named *Cool World* occur within an incised bedrock gorge. The feature consists of 2 drops within a 400 ft segment of channel. The lower feature is a bedrock shelf that spans the valley bottom. The jump height is approximately 5 ft tall; however, the left bank portion cascades from the bedrock with several small pools reducing the height to less than 2 ft per jump. The upper feature is 25-ft wide channel constriction in bedrock with an ~ 10 ft drop; however, there is a great deal of roughness in the rock surface and micro-eddies that may serve as resting areas for fish to traverse the waterfall feature at certain flows. Additionally, water surface elevations in the pool at the upper constriction are likely to rise significantly at higher river stages and reduce the jump height to much less than 10 ft. This site was observed at medium stage flows (120-140 CFS on 8/17/2021). At peak flows of 720 CFS or flood stage flows (>1500 CFS) natural waterfall features must still contain adequate jump heights or current speed limitations to still serve as fish passage barriers for native



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cutthroat trout reintroduction projects. Of the four waterfall features examined in this geomorphic assessment, the *Cool World* rapid, may be most likely to limit fish passage for large portions of the annual hydrograph.



Figure 7. (1) *Cool World* looking downstream. (2) *Cool World* looking upstream from south bank. Site difficult to access due to large rock features on banks.

Fantasy Flight

The waterfall feature named as the *Fantasy Flight* rapid is a single drop where the river pours through an incised section of bedrock. A harder portion of bedrock remains in place forming a Y-shaped waterfall feature that splits the flow into either 2 or 3 chutes depending on the river stage. The floodplain is more accessible for higher streamflow upstream and downstream of this feature relative to the others, which may provide more fish passable flow paths in flows approaching peak flows and flood stage flows. The area is easier to access because the river is not within a bedrock gorge. An additional feature was located ~ 800 ft upstream from *Fantasy Flight*. This feature is similar to *Fantasy Flight* and presents an overbank area that when inundated could provide opportunity for fish passage. The surrounding area is unstable due to recent wildfire and soil instability from the heavy monsoon season of 2021.



Figure 8. (1) *Fantasy Flight* looking upstream from south bank. Large pools and slow flow just upstream of barrier. (2) Looking downstream from above the feature; note the person on the left bank for scale and the high burn intensity on both sides of the river. (3) Below the lower drop of the feature. (4) Downstream looking up at the feature.



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Conclusions

The goal of this study was to evaluate the potential of naturally-occurring waterfall features in the Big South Canyon of the Cache la Poudre River to serve as a fish passage barrier for the lower extent of the Poudre Headwaters Project. Of the Class V rapids evaluated in our study, only *Cool World* and *Double-Trouble* provided some evidence of restricting fish passage. Our approach of relying on a detectable shift in species composition upstream of waterfall features has limited ability to fully test the four rapids *Meltdown*, *Bonk*, *Cool World*, and *Fantasy Flight* because brown trout distribution does not extend upstream to this segment of the river. The rapid *Cool World* seemed most likely restrict fish passage across extend periods of the hydrograph; however, this is only based on a coarse assessment of the waterfall. The rapid *Double Trouble*, the largest waterfall in the study, showed some evidence that brown trout were restricted by this waterfall; however, detection of brown trout eDNA above and below *Double Trouble* either casts doubt on the angler data or indicates some samples were compromised. Although brown trout were not detected around the upstream rapids, the geomorphic evaluation provided clues to the possibility of fish passage across these features. Additional monitoring could be completed to determine the upper extent of brown trout in the Big South Canyon and to characterize the geomorphic features of the *Double Trouble* rapid. Further, more in-depth examination of brook trout geneflow within the entire Big South Canyon could be pursued to determine if there are barriers to upstream geneflow. Such a study would likely involve much greater expense than the FS invested in this preliminary study.

It is our recommendation that the species composition among other rapids or waterfall features in the lower segment of the river be assessed further to determine the upper extent of brown trout and if other features are linked to abrupt changes in species composition. There was no clear evidence that a single rapid feature had the capacity to act as an absolute fish passage barrier without modification to account for different flows over the year. A study of brook trout geneflow could help to identify if waterfalls or series of waterfalls preclude the upstream movement of reproducing brook trout; however, such studies would require additional investment of time and financial resources. The evaluation of alternate waterfalls will help the Forest Service in consider a wholistic view of the resources as it applies to the management within the Wild and Scenic River.

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