Assessing Non-consumptive Recreational Needs and Opportunities in the Rio Grande River Basin

Final Report

Prepared for:

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Attn: Brandy Logan

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Prepared by: Hattie Johnson

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Introduction

Stakeholders in the Rio Grande Basin came together in 2017 to develop one of the largest, by number of river miles, Stream Management Plans (SMP) in Colorado. The scope included reaches of Saguache Creek and the Rio Grande and Conejos Rivers. The Rio Grande Basin Roundtable (RGBRT) reached out to American Whitewater to address data gaps related to streamflow needs for recreation. This report discusses that assessment on recreational needs and opportunities on segments of the Rio Grande and Conejos Rivers. The results of this project were included in as an appendix to the SMP. The project determined preferable flows for boaters, quantified the frequency of recreational opportunities, or boatable days, and assessed how changes in hydrology or physical obstacles affect those opportunities.

American Whitewater's Southern Rockies Stewardship Program represents recreation interests in the development of programs, policies, and cooperative management strategies that protect and enhance river health and recreational needs while balancing the needs of cities and farms. AW has conducted recreational flow studies in Colorado that have informed State and Federal water planning efforts, including the Colorado River Basin Study, State Water Supply Initiative, Non-Consumptive Needs Assessments and several Wild & Scenic River Alternative Management efforts.

The Flow Preference and Boatable Days Report (Appendix A), Climate Impact Report (Appendix B), and three bridge analyses (Appendix C) are all included as appendices to this document. Lotic Hydrological performed all analysis and the reports were coauthored with American Whitewater and with input from Rio Grande Headwaters Restoration Partnership (RGHRP) staff. The RGHRP was tasked by the RGBRT to manage the SMP process. A list of meetings and coordination is also included as Appendix D.

Background

The Non-consumptive Recreational Needs Assessment project was completed to help achieve goals outlined in Colorado's Water Plan (CWP), the state's Non-Consumptive Needs Assessment (NCNA) Toolbox, and the Rio Grande Basin Implementation Plan (BIP). Boating opportunities on the Rio Grande and Conejos are abundant, but the rural nature of the area leaves these opportunities less well-documented. It was important to stakeholders in the Basin to inventory these recreational resources to know begin to understand how they can be protected or enhanced. Using the Boatable Days Tool to assess the impact of future water supply projects on whitewater boating opportunities will help design beneficial multi-purpose projects, as outlined in Long-Term Goal #3 of the CWP. In addition to informing individual projects, using common methodologies for assessing recreational boating needs and opportunities in each basin is critical to improve inter-basin and intra-basin agreements and state-wide goals.

In 2015, Trout Unlimited and Dinatale Water Consultants completed a Boatable Days Study on four reaches of the Rio Grande main stem as a part of the Basin Implementation Plan. The RGBRT was interested in completing a more robust Boatable Days Study as part of a the Stream Management Plan project. This study investigated different craft types (e.g., rafts, kayaks, etc.) and additional river reaches, and to assess the impact of changes to physical obstacles or hydrological scenarios on existing whitewater boating resources.

The Non-Consumptive Recreational Needs Assessment focused on nine (9) sections of the Rio Grande River and three (3) sections of the Conejos River that are known to have existing recreational use. Colorado Water Plan and matching funds were used to support coordination with the RGBRT and local stakeholders, conduct recreational flow preference studies[1] on priority river reaches in the Rio Grande Basin, and complete the Boatable Days Study. The majority of Water Plan funding was used as a part of the detailed analysis of recreational opportunities and their sensitivity to hydrological and physical changes as well as report writing (Tasks 3-6). Matching funds from the Walton Family Foundation were more focused on coordination and survey implementation (Tasks 1-3).

Existing use patterns and descriptions in American Whitewater's National Whitewater Inventory[2] were used to define reach segmentation and corresponding stream gages (Table. 1).

Reach	River	Segment Description	Corresponding Stream Gauge/Simulation Node
1	Rio Grande	Rio Grande Reservoir to Mouth of Box Canyon	Rio Grande River at Thirty Mile Bridge Near Creede (RIOMILCO)
2	Rio Grande	Box Canyon to Deep Creek/Creede	Rio Grande River at Thirty Mile Bridge Near Creede (RIOMILCO)
3	Rio Grande	Creede to Wagon Wheel Gap	Rio Grande River at Wagon Wheel Gap (RIOWAGCO)
4	Rio Grande	Wagon Wheel Gap to South Fork	Rio Grande River at Wagon Wheel Gap (RIOWAGCO)
5	Rio Grande	South Fork to Del Norte (Hwy 112)	Rio Grande River Near Del Norte, Co (RIODELCO)
6	Rio Grande	Alamosa to Lasauses	Rio Grande River at Alamosa (RIOALACO)
7	Rio Grande	Lasauses to Lobatos Bridge	Rio Grande River Above Trinchera Creek Near Las Sauses (RIOTRICO)
8	Rio Grande	Lobatos Bridge to Lee Trail, NM	Rio Grande River Near Lobatos (RIOLOBCO)
9	Conejos	Platoro Reservoir to South Fork Conejos	Conejos River Below Platoro Reservoir (CONPLACO)
10	Conejos	S. Fork Conejos to Hwy 17 Bridge	Conejos River Below Platoro Reservoir (CONPLACO)
11	Conejos	Hwy 17 to Mogote Campground	Conejos River Near Mogote (CONMOGCO)

Table 1 River segments and corresponding streamflow measurement gages considered in this study

Historic streamflow time series for each gage identified in Table 1. was obtained from the SMP team. Their consultant, Wilson Water Group, had defined dry, average, and wet representative year types (Figure 1.) to be used in other flow needs assessments as a part of the SMP. Those representative hydrographs were used to quantify baseline recreational opportunities as a part of this study. The original Scope of Work for this project identified the use of four year types (dry, dry typical, wet typical, and wet) to be used for the Boatable Days analysis. Other flow analysis for the SMP utilized the three year types

[1] Stafford, E., Fey, N., and Vaske, J. J. (2016) Quantifying Whitewater Recreation Opportunities in Cataract Canyon of the Colorado River, Utah: Aggregating Acceptable Flows and Hydrologic Data to Identify Boatable Days. River Res. Applic., doi: 10.1002/rra.3049.

[2] https://www.americanwhitewater.org/content/River/view/river-index

provided by Wilson Water Group. For consistency, the Boatable Days study mirrored that hydrological data set.

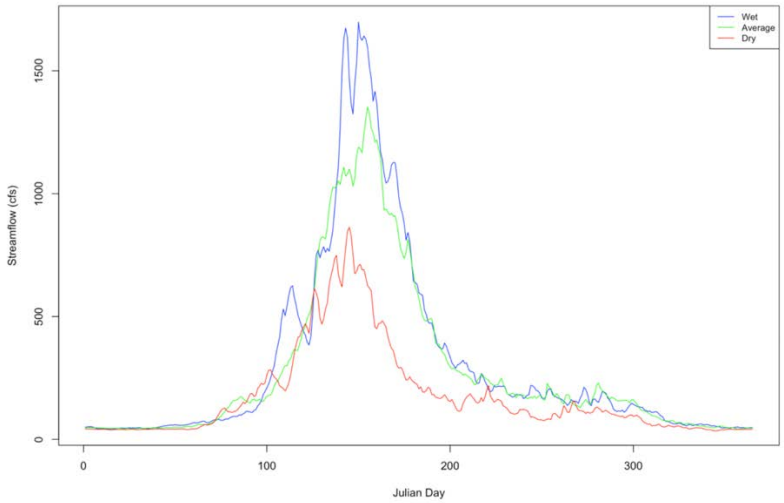

Figure 1 Representative hydrograph characterizing three hydrological year types in the assessment area. These streamflow time series were used in the Boatable Days analysis.

Through the project American Whitewater (AW) was in ongoing and close coordination with the RGHRP and Technical Advisory Team (TAT) for the SMP as well as a recreation specific stakeholder group. As project manager for the Stream Management Plan, RGHRP and the local stakeholders they convened made up AW's primary points of contact for this project. The coordination identified in Task 1 of the original scope of work is described as a part of the methods of the other tasks.

Methods

Task 2 – Partner with the Rio Grande Basin Roundtable to Conduct a Recreational Flow Evaluation Study to Establish Optimal and Acceptable Flow Criteria in the Basin.

To complete the Flow Preference study, AW coordinated with recreational stakeholders, RGHRP and the TAT to the SMP at key decision points. AW provided the team with relevant stream reaches based on the National Whitewater Inventory to be compared against the reaches as defined for other assessments. The TAT settled on the appropriate recreational reaches and associated gages (Table 1.).

Using these defined reaches, a web-based survey was developed to ask recreational users about streamflow conditions that support their preferred activities. An announcement of the survey was emailed to American Whitewater's members, posted on the AW and RGHRP website, distributed via American Whitewater's online newsletter, and shared through the Stream Management Plan email list.

Four types of questions were included in the survey. The first type of question captured demographic information about each participant's skill level, frequency of participation in river related recreation, etc. The second type of question allowed users to assign use-acceptability rankings to various streamflows. The third question type asked users to identify flows associated with niche trip types. The fourth type of question focused on participant perspectives on water management planning activities. The survey also

clearly defined which streamflow measurement gage to reference when assigning acceptability rankings for conditions on the reach.

The flow acceptability questions included in the user-survey are the principal focus of the flow preference assessment. These questions asked respondents to evaluate recreational use acceptability for a range of measured flows on each study segment using a five-point scale that included the following rankings: Unacceptable, Moderately Unacceptable, Marginal, Moderately Acceptable, and Acceptable. Each ranking in the scale was mapped to an integer value between -2 and 2 where an 'Unacceptable' ranking mapped to a value of -2, a 'Marginal' ranking mapped to a value of 0, and an 'Acceptable' ranking mapped to a value of 2. To further explore and characterize the relationship between flows and recreational use opportunities, the survey posed a series of open-ended questions about streamflows associated with distinct niche experiences. These niche experiences included: lowest navigable flow, minimum acceptable flow, technical but navigable flows, flows experienced during a standard trip, challenging high-water, and highest safe flow. Flow-acceptability rankings provided through the survey were used to describe preferences among recreational users for various ranges of streamflow.

This study utilizes the Potential for Conflict Index-2 to understand when there is a high degree of consensus among users regarding acceptable and unacceptable resource conditions. Briefly, computed PCI2 values range from 0 to 1.0 where the least amount of consensus (PCI2 = 1.0) occurs when responses are equally divided between two extreme values on a Likert response scale (e.g. 50% Highly Unacceptable and 50% Highly Acceptable). A set of responses with unanimous consensus among respondents yields a PCI2 value of zero. An example PCI curve is included in Figure 2.

American Whitewater's consultant, Lotic Hydrological, performed the analysis and prepared all the tables and figures included in this report. CWCB funds were used in part to complete the survey preparation portions of this task. Matching funds were used to disburse the survey and analyze the responses.

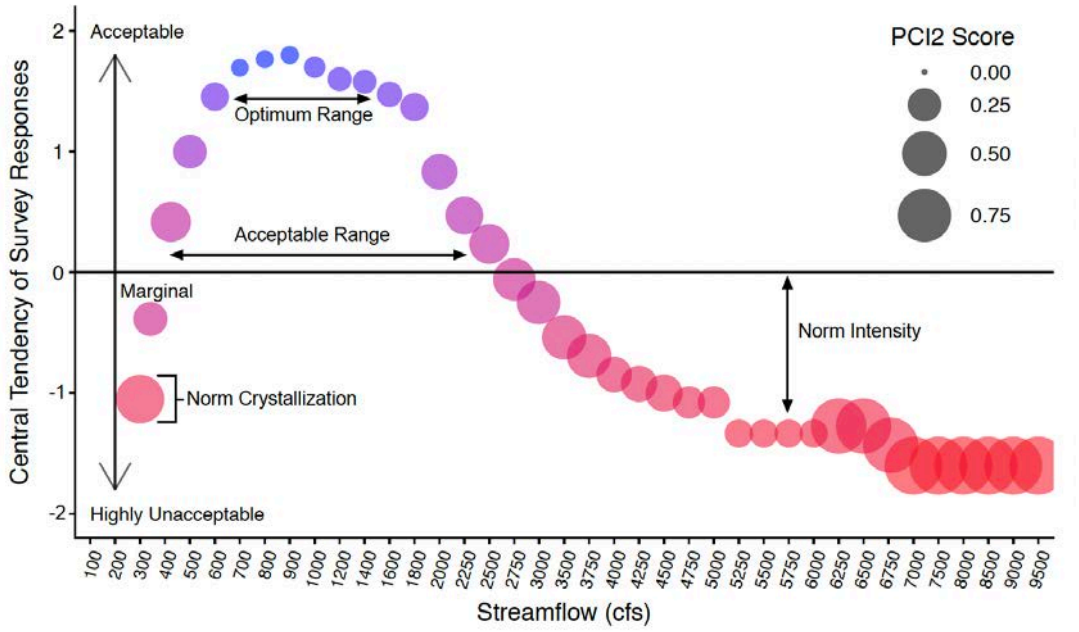

Figure 2 Example PCI-2 curve identifying preferable streamflow conditions for recreational boating.

Use acceptability curves, tabular data summaries, and responses to open-ended questions about niche conditions were used to delineate various normative streamflow characteristics. These characteristics included a minimum acceptable streamflow, a range of acceptable streamflow conditions, and a range of optimum streamflow conditions and are described more fully in the Results section. The upper and lower thresholds delineated for acceptable and optimal streamflow conditions were then compared to wet-year, average-year, and dry-year hydrological conditions to complete a Boatable Days analysis (Task 3).

Prior to moving into Task 3, American Whitewater presented preliminary flow preference results to stakeholders in the Basin with local knowledge of river use levels and patterns as well as water management. This coordination allowed for the adjustment of preferrable flow ranges that match realistic hydrology and was helpful in uncovering impacts to navigation, that were not uncovered in the survey data. Low bridges presented a significant hazard at certain streamflow that would otherwise provide boating opportunities. Access issues, safety and wayfinding signage, and hazards from diversion structures were all identified by locals as creating significant impacts to recreation outside of flow.

Task 3 – Assist the Rio Grande Basin Roundtable with completing a Boatable Days Analysis to Define Existing Whitewater Boating Opportunities in the Basin

The computation of Boatable Days is the dominant quantitative approach used by American Whitewater to characterize recreational use opportunities on rivers. The metric itself reflects the number of days in a given year that fall within certain defined flow ranges (i.e. lower acceptable flows, optimal flows, upper acceptable flows). The flow ranges used were those defined as a result of Task 2 for each of the 11 designated reaches. Those acceptable flow ranges were compared to the historic hydrology to quantify recreational opportunity. The Boatable Days analysis performed on reaches within the assessment area responded to the inter-annual natural and management-induced variability in streamflows by computing the number of Boatable Days that occur in each of three hydrological year types: wet, average and dry (Fig 1.). Typically, American Whitewater utilizes four year-types (i.e. wet, wet-typical, dry-typical, and dry), but the three year types was more consistent with other streamflow assessments completed for the SMP. An example hydrograph with preferable flow ranges is shown in Figure 3.

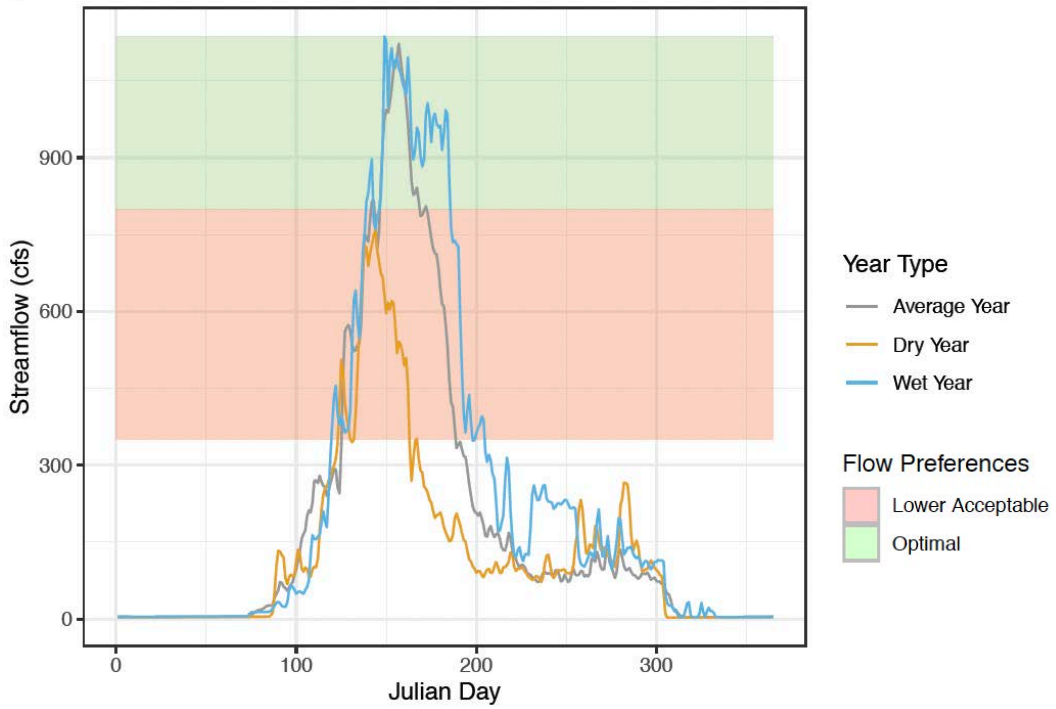

Figure 3 Flow acceptability ranges compared to typical wet, average, and dry year streamflow time series

Similar to Task 2, American Whitewater presented preliminary Boatable Days results to the recreation stakeholders and SMP team. Feedback from that presentation helped to identify a significant issue affecting navigation and recreational opportunities was the presence of low bridge crossings. The analysis showed that flows were preferable – and therefore days were considered 'boatable' – during times in which select bridge crossing required portage for most crafts. More discussion on the application of this coordination is in Task 5. The presence of Boatable Days in winter months (Dec-Mar) were shown in the preliminary analysis. Stakeholders identified that while flows may be adequate during that time, icing of sections of river and boat ramps do not allow users to take advantage of those boatable opportunities.

Task 4 – Assist the Rio Grande Basin Roundtable with Completing a Final Report Defining Existing Whitewater Boating Opportunities in the Rio Grande Basin

American Whitewater worked closely with our consultants, Lotic Hydrological, to complete the March 2020 *Assessment of Streamflow needs for Supporting Recreational Water Uses on the Rio Grande and Conejos River* (Appendix A). Lotic Hydrological compiled the report sections on study area, methods and results, discussion and conclusion, and all appendices, figures and tables. American Whitewater and RGHRP jointly authored the introduction and reviewed and provided edits for the body of the report. This task took multiple iterations of edits.

The final report was shared with local stakeholders to indicate how their feedback throughout the assessment process was incorporate. The final report added a new section identifying bridges that present navigation hazards and at which flows become impassable. The report also clearly indicated flows during winter months where boating opportunities are unavailable regardless of flow.

As mentioned above, coordination with stakeholders as a part of this project was critical in defining how to utilize the findings from the Boatable Days report in a way that was most useful. The Boatable Days study was finalized around the time the SMP process was wrapping up. Those working on the project identified a bit of data fatigue and a desire to use all the data that had been collected and analyzed to directly inform on the ground projects. The discussions around impacts from bridges stuck out to the project team as one that further study could be most helpful in quantifying the benefit to recreation of recently completed projects as well as identify ripe potential future projects.

Survey and analysis of the impacts of 2 new and one existing hazardous bridge were selected to be completed as a part of this task. The recreational stakeholder group provided key insight into the flows that make specific bridges unpassable, the crafts that typically utilize the stretch, and the clearance needed for each craft. This data was included in the boatable days study and can be used to identify projects that could improve recreational opportunities. Through coordination with RGHRP, local stakeholders and CWCB staff, the best path forward for Task 5 was to analyze impacts to boating opportunities from the bridges as well as from climate change modeling using projections of climate change impacts on regional hydrology.

Climate Impacts

Impacts to basin hydrology was made available for basins around the state of Colorado under the Technical Update to the Colorado Water Plan[3]. Unfortunately, the unique characteristics of the Rio Grande watershed make it difficult to accommodate the CWCB's traditional modeling frameworks and no climate change model was produced for the basin under the Technical Update. However, the Colorado Environmental Flow Tool (CEFT)[4] does provide streamflow simulation results associated with three climate change scenarios at a few discrete locations in the Rio Grande watershed. Two of these locations are relevant to the characterization of recreational use opportunities in the upper Rio Grande watershed: the Rio Grande at Wagon Wheel Gap and the Conejos River below Platoro Reservoir.

The climate assessment leverages outputs from the CEFT to synthesize sequences of future annual flow conditions under different climate scenarios. These sequences are used in conjunction with 20 years of historic daily flow data obtained from the Wilson Water Group's point flow model to predict changes in annual and monthly boatable days on eleven stream reaches (under three potential climate futures: a future resembling historical conditions ("Baseline"), a moderately warm and dry future ("In-Between"), and a significantly hotter and drier future ("Hot and Dry").

The year type sequences provided by the CEFT could not be directly applied to the data used in the Boatable Days Report. The simulation period included in the CEFT (1975-2010) and the period used to perform the boatable days analysis in the Boatable Days Report (1998-2017) do not completely overlap. Streamflow data utilized in the Boatable Days Report was sourced from a Rio Grande point flow model

[3] https://cwcb.colorado.gov/colorado-water-plan/technical-update-to-the-plan

[4] https://dnrftp.state.co.us/CWCB/Technical%20Update%20to%20Water%20Plan/2.%20Tools/EnvRec_Flow_Tool/Volume2-Section6_FlowTool.pdf

produced by Wilson Water Group and from U.S. Geological Survey stream gauges on the Conejos River. Outputs in the CEFT use different source data and are encumbered by a different set of assumptions. A choice was made to rely on the data from the Boatable Days Report for this effort wherever possible in order to maximize consistency in boatable days analysis results. A methodology was, therefore, required to map the streamflow time series used in the Boatable Days Report to the year type sequences produced by the CEFT.

Streamflow data from the Boatable Days Report for two locations—Rio Grande at Wagon Wheel Gap and Conejos River below Platoro Reservoir—was classified into hydrological year types in a manner consistent with the CEFT. Annual flow volumes at each location were computed for each year in the 1998-2017 period and individual years were ranked accordingly. The maximum annual flow percentile thresholds provided by the CEFT were used to classify individual years into Drought, Dry, Average, Wet, and Flood years. The classification of year types at the Wagon Wheel Gap site was assumed relevant to all study reaches on the Rio Grande—a Drought year at Wagon Wheel Gap is expected to occur with a Drought year on the Rio Grande below Alamosa, for example. Similarly, the classification of year types on the Conejos River below Platoro Reservoir was assumed relevant to all study reaches on the Conejos River. This effort yielded a pair of tables indicating years in the Boatable Days Report data sets for the Rio Grande and Conejos River belonging to each hydrological year type (Table 2).

Year Type	Rio Grande	Conejos River
Drought	2002	2002
Dry	2000, 2003, 2012, 2013	2000, 2003, 2012, 2013
Average	1998, 2004, 2006, 2008, 2009, 2010, 2011, 2014, 2016, 2017	1998, 2001, 2004, 2006, 2007, 2009, 2010, 2014, 2015, 2016
Wet	2001, 2007, 2015	1999, 2008, 2011
Flood	1999, 2005	2005, 2017

Table 2 Year Type classes for Rio Grande at Wagon Wheel Gap (RIOWAGCO) and Conejos River below Platoro

The sequences of year types provided by the CEFT for each climate scenario were used to stochastically generate daily streamflow time series for each of the eleven study reaches covered in the Boatable Days Report. For example, if the first year in a given climate scenario sequence from CEFT was classified as “Dry”, then a year was randomly selected from the list of “Dry” years in Table 2. The random selection of years was repeated for each year in each climate sequence to produce an ensemble of ten, 35-year long sequences for each reach. A synthetic time series of daily flows was then produced for each reach under each climate scenario by simply retrieving and appending the appropriate daily flow record for each year in the sequence. The daily flow ensembles were used to characterize typical streamflow and boatable days conditions, along with several measures of interannual variability in recreational use opportunities.

The stochastically-generated streamflow time series for each reach were used to compute median daily (e.g. “typical”) streamflow conditions under each of the three climate scenarios considered here. These median daily streamflow values were then used to calculate total annual boatable day counts and the distribution of days falling into each of three recreational user preference categories—Lower Acceptable, Optimal, and Upper Acceptable—in each month of the year. Streamflow thresholds for each preference category change from reach to reach and reflect differences in reach characteristics, hydrology and suitability for varying forms of recreation.

Bridge Assessment

The Rio Grande Headwaters Restoration Project (RGHRP) indicated that quantifying the number of boating opportunities lost due to the inability to pass under 3 bridges would be the most effective use of the Boatable Days data. These being tangible issues on the river, AW was quick to agree with making this shift in analysis.

The methods employed to assess impacts to recreation from bridge crossings varied slightly with each analysis. Generally, bridge, bathymetric and floodplain survey was collected extending up and downstream of the bridge location to capture channel geometry, bridge low chord, and floodplain topography. For the Mountain Views bridge site, surveyors were not granted access to private property and so bridge design drawings and county GIS data were used in place of collected data. Two-dimensional hydraulic models were constructed in HEC-RAS.

Water surface elevations at the bridge site were modeled for the associated with a range of streamflow events noted in the Boatable Days Report for each relevant reach containing the bridges. Different bridge configurations were modeled (existing bridge layout, higher low chords, removal of select piers for Wagon Wheel Gap) at these streamflows. Four craft types were evaluated for safe passage through the bridge. Craft types included paddle rafts, rafts with oar frames, rafts with fishing frames, and fishing dories. RGHRP and AW staff determined that these four craft types are regularly used on this section of river. The minimum safe passage clearance heights for each craft with passengers on board were provided by RGHRP.

The modeled clearances at different water levels and bridge scenarios were compared to height of the different craft to understand which flows provided safe passage for a range of users. The impact of the existing bridges on users of paddle rafts, rafts with oar frames, rafts with fishing frames and fishing dories was assessed by computing the total number of Boatable Days in each year type that occur when flows are above the safe minimum pier clearance threshold.

Appendix C provides a much more thorough discussion as well as explains details of variables present at each site. For example, due to its angle across the river and the debris accumulation on pilings, the Wagon Wheel Gap railroad bridge presents an extreme navigation hazard at most flows. The two-dimensional modeling results provided a method for comprehensive evaluation of the velocity magnitude and direction patterns beneath the bridge across a range of flows.

CWCB funds were used in large part to complete this task. All the coordination to determine the optimal use of an assessment of impacts to boatable days was covered by CWCB funding. Matching funds were used to do the primary Boatable Days analysis. CWCB funding was used to perform climate impacts, bridge impacts and to complete reports and memos for each analysis.

Task 6 – Meet CWCB Reporting Requirements

American Whitewater provided the CWCB with progress reports and invoices every 6 months during the grant period. CWCB funding was used for the entirety of this task.

Results

Task 2 – Partner with the Rio Grande Basin Roundtable to Conduct a Recreational Flow Evaluation Study to Establish Optimal and Acceptable Flow Criteria in the Basin.

The web-survey captured responses from 136 recreational users. 63% of respondents indicated they were somewhat comfortable or very comfortable reporting flows, 52% of respondents identified themselves as advanced or expert paddlers, 84% identified as Class III or greater paddlers, and 44% recreate on streams and rivers at least 20 days per season (Figure 4). A wide range of preferred craft types were indicated, including oar frame rafts, kayaks, catarafts, canoes, dories, inner tubes, paddle rafts, skiffs, and stand-up paddle boards.

Use acceptability curves, tabular data summaries, and responses to open-ended questions about niche conditions were used to delineate various normative streamflow characteristics, including the ‘Minimum Acceptable’, ‘Minimum Optimal’, ‘Maximum Optimal’, and ‘Maximum Acceptable’ streamflow on each reach. Flow preferences reported by users for the Rio Grande were shown for each reach and can be found in Appendix A. Responses for the Wagon Wheel Gap to South Fork section of the Rio Grande are included in Figure 4.

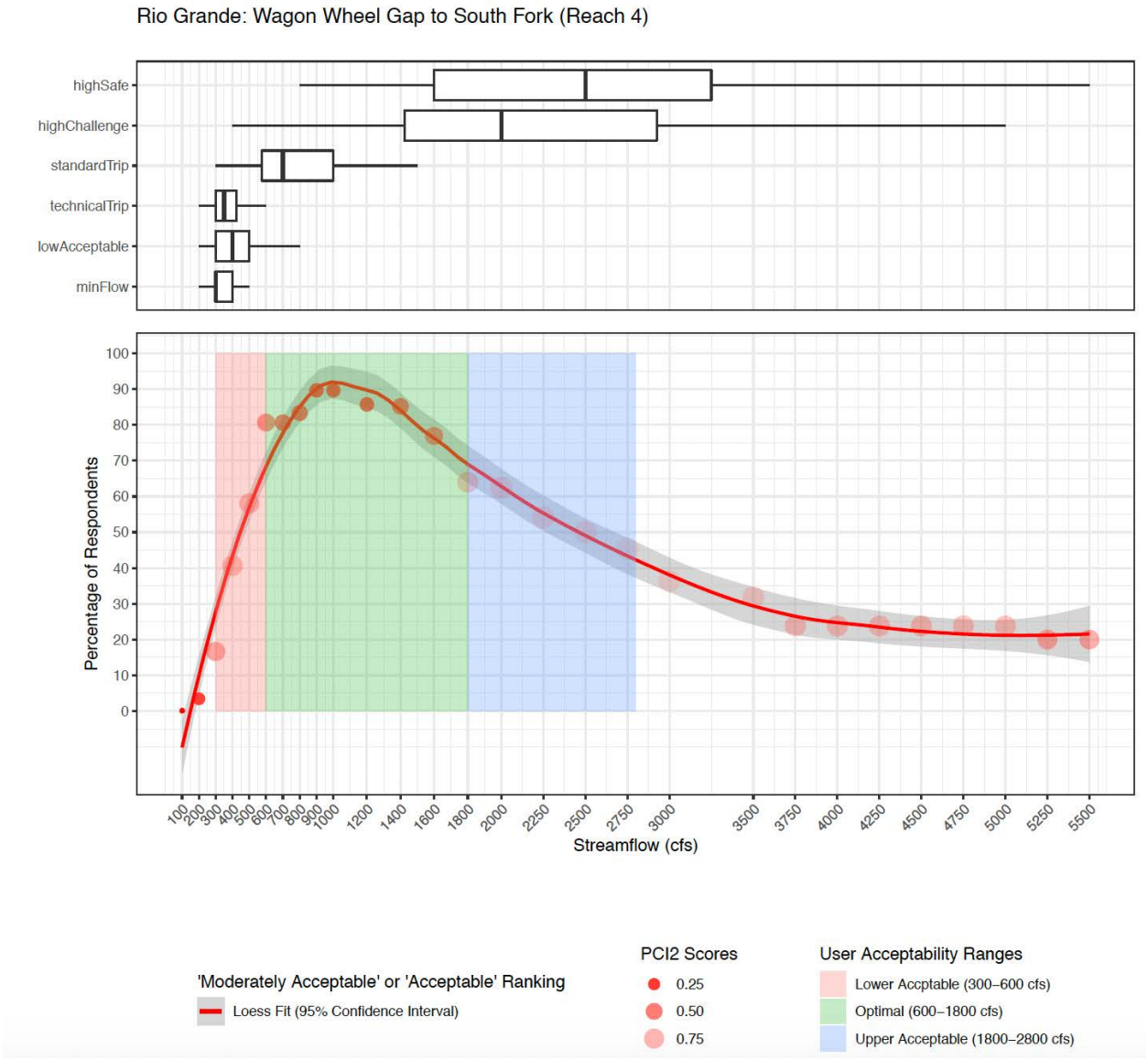

Figure 4 (Top) Boxplot of responses to open-ended questions about different categories of flow. (Bottom) PCI2 analysis results overlaid on the percentage of respondents that ranked a given flow as "Moderately Acceptable" or "Acceptable". The percentage of respondents in those categories across the full range of flows was fit with a Loess curve to support visualization of flow acceptability ranges.

Minimum acceptable flows on the Rio Grande generally range between approximately 350-400 cfs, optimal flows range between approximately 600-2000 cfs, and the upper acceptable flows range between ~2000-3000 cfs. No clear flow preference patterns exist for the Conejos River reaches. Variability in flow thresholds between reaches can be attributed to different user groups recreating in different locations, the unique geomorphic or hydraulic characteristics of each reach, and/or variability in the sample size of respondents providing flow rankings on each reach and for each listed streamflow. The ranges of preferable flows are included in Table 3 below.

Reach	River	Reach Description	Min. Acceptable	Min. Optimal	Max. Optimal	Max. Acceptable
1	Rio Grande	Rio Grande Reservoir to Mouth of Box Canyon	350	800	1400	2250*
2	Rio Grande	Box Canyon to Deep Creek/Creede	350	550	1400	2000
3	Rio Grande	Creede to Wagon Wheel Gap	400	600	2100	2750
4	Rio Grande	Wagon Wheel Gap to South Fork	300	600	1800	2800
5	Rio Grande	South Fork to Del Norte (Hwy 112)	350	500	2000	3000
6	Rio Grande	Alamosa to Lasauses	200	500	1000	3000
7	Rio Grande	Lasauses to Lobatos Bridge	300	600	2000	3500
8	Rio Grande	Lobatos Bridge to Lee Trail, NM	300	600	2000	3250
9	Conejos	Platoro Reservoir to South Fork Conejos	150	300	600	1200
10	Conejos	S. Fork Conejos to Hwy 17 Bridge	150	300	550	800
11	Conejos	Hwy 17 to Mogote Campground	300	550	2100	2700

*The maximum safe release from Rio Grande Reservoir was 1200 cfs throughout the 1998 to 2017 period.
** Flows never reached this max acceptable threshold during the study period, in part due to mandatory flood mitigation measures triggered by a flow of 2300 cfs or greater at the Mogote stream gauge.

Table 3 Flow preference thresholds delineated for each reach in the assessment area. All values are reported in cubic feet per second

Task 3 – Assist the Rio Grande Basin Roundtable with completing a Boatable Days Analysis to Define Existing Whitewater Boating Opportunities in the Basin

Flow preference thresholds were used to compute the number of Boatable Days associated with different hydrological conditions on each reach in the assessment area. Results were summarized graphically and in tabular form. See Appendix A for all Flow Preference and Boatable Days results. Boatable Days totals falling within the range of "Upper Acceptable" flows never exceed zero on several reaches of the Rio Grande. This is due, in some locations, to the lack of a discernible upper bound on the range of "Optimal" flows identified by recreational users. In other locations, the streamflow time series supplied by Wilson Water Group, LLC to characterize dry, average, and wet year types never exceeded the upper bound of user-defined "Optimal" flows. A different representation of hydrological year types will result in different Boatable Days totals. The number of Boatable Days in all segments across the three year types is in Table 4.

Reach	River	Description	Acceptability Category	Dry Year	Avg. Year	Wet Year
1	Rio Grande	Rio Grande Reservoir to Mouth of Box Canyon	Lower Acceptable	38	38	40
			Optimal	0	25	43
			Upper Acceptable	0	0	0
			Total Days	38	63	83
2	Rio Grande	Box Canyon to Deep Creek/Creede	Lower Acceptable	17	11	24
			Optimal	21	52	59
			Upper Acceptable	0	0	0
			Total Days	38	63	83
3	Rio Grande	Creede to Wagon Wheel Gap	Lower Acceptable	43	62	31
			Optimal	56	80	59
			Upper Acceptable	0	17	21
			Total Days	99	159	111
4	Rio Grande	Wagon Wheel Gap to South Fork	Lower Acceptable	101	111	82
			Optimal	54	67	48
			Upper Acceptable	2	30	35
			Total Days	157	208	165
5	Rio Grande	South Fork to Del Norte (Hwy 112)	Lower Acceptable	54	56	74
			Optimal	119	127	87
			Upper Acceptable	12	26	19
			Total Days	185	209	180
6	Rio Grande	Alamosa to Lasauses	Lower Acceptable	47	146	204
			Optimal	0	1	45
			Upper Acceptable	0	0	0
			Total Days	47	147	249
7	Rio Grande	Lasauses to Lobatos Bridge	Lower Acceptable	0	39	74
			Optimal	0	0	47
			Upper Acceptable	0	0	0
			Total Days	0	39	121
8	Rio Grande	Lobatos Bridge to Lee Trail, NM	Lower Acceptable	7	137	141
			Optimal	0	46	95
			Upper Acceptable	0	0	2
			Total Days	7	183	238
9	Conejos	Platoro Reservoir to South Fork Conejos	Lower Acceptable	53	56	44
			Optimal	0	17	31
			Upper Acceptable	0	0	0
			Total Days	53	73	75
10	Conejos	S. Fork Conejos to Hwy 17 Bridge	Lower Acceptable	53	56	44
			Optimal	0	17	31
			Upper Acceptable	0	0	0
			Total Days	53	73	75
11	Conejos	Hwy 17 to Mogote Campground	Lower Acceptable	29	30	40
			Optimal	29	59	64
			Upper Acceptable	0	0	0
			Total Days	58	89	104

Table 4 Boatable Days falling within each acceptability category calculated for reaches within the assessment area for typical dry, average, and wet hydrological year types.

Boatable Days in each reach were represented graphically and tabularly in the report. Below Figure 5 shows the flow preferences and boatable days for the Rio Grande from Wagon Wheel Gap to South Fork.

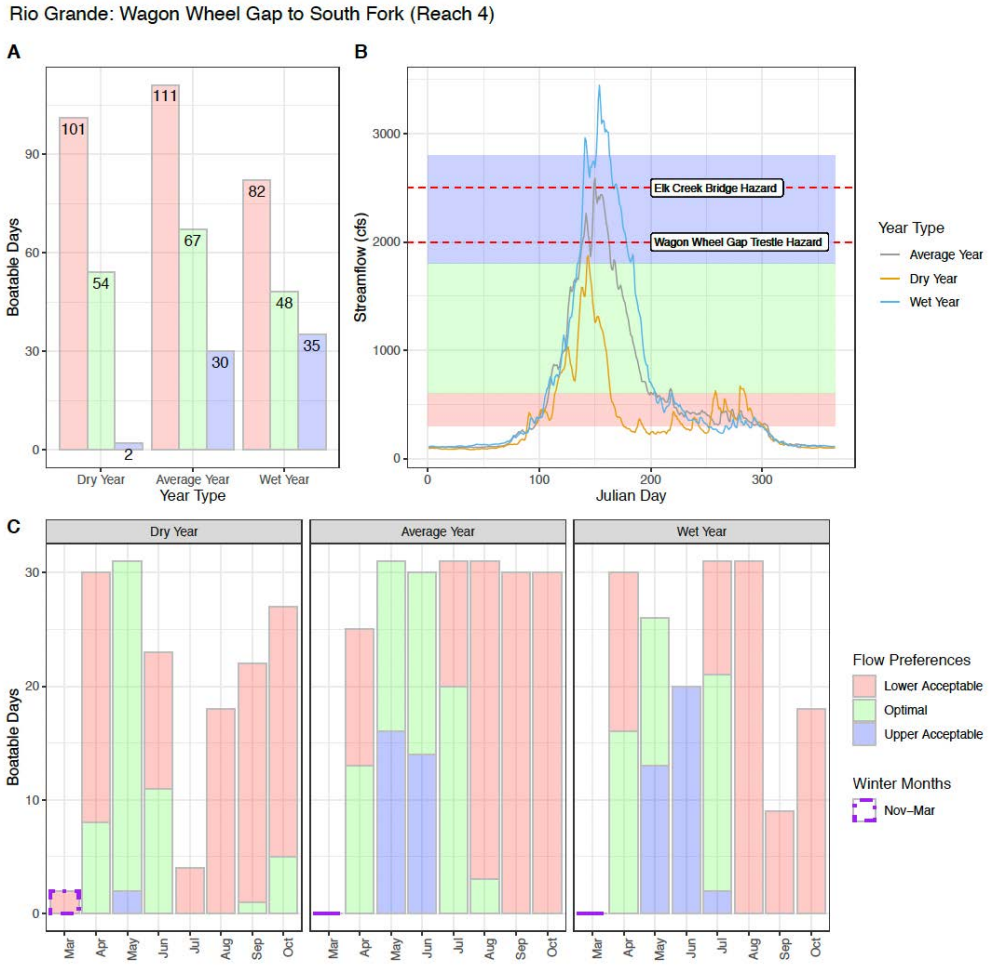

Figure 5 (A) Annual Boatable Days totals summarized by hydrological year type. (B) Flow preference ranges mapped to representative streamflow time series for wet, average, and dry years. Flows associated with specific navigational hazards are labeled. (C) Monthly Boatable Days totals summarized by hydrological year type

Task 4 – Assist the Rio Grande Basin Roundtable with Completing a Final Report Defining Existing Whitewater Boating Opportunities in the Rio Grande Basin

The recreational use assessment presented in this report provides important baseline information relating streamflows and recreational use. This body of work directly supports the Rio Grande Headwater Restoration Project's Stream Management Planning[5] efforts. The report was incorporated into the SMP and is included as Appendix A to the Plan.

Task 5 – Coordinate with the Rio Grande Basin Roundtable to Assess the Impact of Future IPPs and Hydrological Changes on Existing Whitewater Boating Opportunities in the Rio Grande River Basin

[5] https://riograndeheadwaters.org/stream-management-plans

Climate modeling results for the Rio Grande and Conejos River indicate a shift towards drier year types (Table 5). Proportions of Flood, Wet and Average year types all decline in the Hot and Dry scenario relative to the Baseline condition. Proportions of Dry and Drought year types both increase along both rivers with respect to Baseline conditions. Similar patterns are observed for the In-Between scenario with the exception that, along the Rio Grande, proportions of wet and drought years do not decrease relative to the Baseline scenario. Median daily streamflows are generally lower under the In-Between scenario as compared to the Baseline condition on all reaches. Daily streamflows tend to be lowest under the Hot and Dry scenario but do not depart strongly from the In-Between scenario.

Median daily streamflow hydrographs were used to complete a boatable days analysis. Results were summarized on an annual and monthly basis. Annual boatable days totals were lower at the majority of reaches under the In-Between scenario relative to Baseline and were lower on all reaches under the Hot and Dry scenario (Table 5). Optimal days declined under both scenarios on all reaches. Days falling into the Lower Acceptable streamflow range also declined. However, Reaches 3-5 experienced gains in Lower Acceptable days under the In-Between scenario. Only Reach 5 exhibited more Lower Acceptable days under the Hot and Dry scenario relative to Baseline conditions. Upper Acceptable days, only observed in Reaches 3-5 in the Baseline condition, declined under future climate scenarios on Reaches 3 and 4 but increased on Reach 5.

Reach	River	Description	Flow Preference	Baseline	In Between	Hot & Dry
1	Rio Grande	Rio Grande Reservoir to Mouth of Box Canyon	Lower Acceptable	31	23	20
	Rio Grande	Rio Grande Reservoir to Mouth of Box Canyon	Optimal	30	19	19
	Rio Grande	Rio Grande Reservoir to Mouth of Box Canyon	Total Days	61	42	39
2	Rio Grande	Box Canyon to Deep Creek/Creede	Lower Acceptable	17	15	12
	Rio Grande	Box Canyon to Deep Creek/Creede	Optimal	44	27	27
	Rio Grande	Box Canyon to Deep Creek/Creede	Total Days	61	42	39
3	Rio Grande	Creede to Wagon Wheel Gap	Lower Acceptable	36	39	19
	Rio Grande	Creede to Wagon Wheel Gap	Optimal	65	53	54
	Rio Grande	Creede to Wagon Wheel Gap	Upper Acceptable	14	7	3
	Rio Grande	Creede to Wagon Wheel Gap	Total Days	115	99	76
4	Rio Grande	Wagon Wheel Gap to South Fork	Lower Acceptable	86	101	74
	Rio Grande	Wagon Wheel Gap to South Fork	Optimal	49	43	42
	Rio Grande	Wagon Wheel Gap to South Fork	Upper Acceptable	30	17	15
	Rio Grande	Wagon Wheel Gap to South Fork	Total Days	165	161	131

5	Rio Grande	South Fork to Hwy 112 at Del Norte	Lower Acceptable	65	84	70
	Rio Grande	South Fork to Hwy 112 at Del Norte	Optimal	90	82	64
	Rio Grande	South Fork to Hwy 112 at Del Norte	Upper Acceptable	20	23	28
	Rio Grande	South Fork to Hwy 112 at Del Norte	Total Days	175	189	162
6	Rio Grande	Alamosa to Lasauses	Lower Acceptable	74	56	40
	Rio Grande	Alamosa to Lasauses	Total Days	74	56	40
7	Rio Grande	Lasauses to Lobatos Bridge	Lower Acceptable	42	19	13
	Rio Grande	Lasauses to Lobatos Bridge	Total Days	42	19	13
8	Rio Grande	Lobatos Bridge to Lee Trail	Lower Acceptable	113	56	41
	Rio Grande	Lobatos Bridge to Lee Trail	Optimal	9	4	0
	Rio Grande	Lobatos Bridge to Lee Trail	Total Days	122	60	41
9	Conejos	Platoro Reservoir To South Fork Conejos	Lower Acceptable	62	51	52
	Conejos	Platoro Reservoir To South Fork Conejos	Optimal	6	3	2
	Conejos	Platoro Reservoir To South Fork Conejos	Total Days	68	54	54
10	Conejos	S. Fork Conejos to Hwy 17 Bridge	Lower Acceptable	62	51	52
	Conejos	S. Fork Conejos to Hwy 17 Bridge	Optimal	6	3	2
	Conejos	S. Fork Conejos to Hwy 17 Bridge	Total Days	68	54	54
11	Conejos	Hwy 17 to Mogote Campground	Lower Acceptable	30	21	27
	Conejos	Hwy 17 to Mogote Campground	Optimal	54	36	27
	Conejos	Hwy 17 to Mogote Campground	Total Days	84	57	54

Table 5 Boatable Days within each flow preference category calculated for reaches within the assessment area for Baseline, In-Between and Hot and Dry scenarios.

Results up to this point have only considered the median of simulated daily streamflows, reflecting the central tendency of conditions occurring under each scenario. This approach neglects to consider the effects of year-to-year variability in streamflow on boatable days availability. Examination of the monthly boatable day distributions produced under each stochastically generated-streamflow time series helps illustrate this variability.

These distributions of monthly boatable days demonstrate that, on the majority of reaches, years with high boatable day counts in May or June still occur under future climate scenarios, albeit less frequently than under Baseline conditions (Figure 6). Correspondingly, the occurrence of years with very low boatable day counts in summer months is prevalent under the two future climate conditions considered here. Planning for the future of recreation along these reaches, thus, needs to consider both shifts in the median behavior of summertime recreation opportunities and the increasing likelihood of sequential years with reduced recreation opportunities.

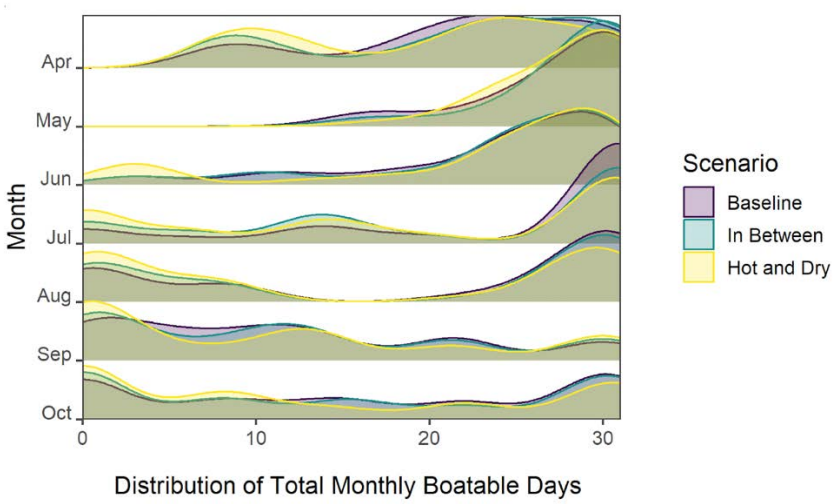

Figure 6 Relative distriburitons of total monthly boatble days acress the entire streamflow simulation ensemble for each climate scenario on Reach 4 (Wagon Wheen Gap to South Fork)

Bridge Assessments

Wagon Wheel Gap Bridge

The Flow Preference study identified the that acceptable flows exist between 300-600 cfs for the Rio Grande flowing between Wagon Wheel Gap and South Fork . Optimal flows were found to exist between 600-1,800 cfs. Maximum acceptable flows were found to exist between 1,800-2,800 cfs. Local outfitters do not attempt passage of this bridge if flows are greater than 1,800 cfs to 2,000 cfs. These flow thresholds were used to complete a Boatable Days analysis described above.

The impact of the existing bridge on users of paddle rafts, rafts with oar frames, rafts with fishing frames and fishing dories was assessed by computing the total number of Boatable Days in each year type that occur when flows are above the safe minimum pier clearance threshold of 2,000 cfs. The resulting totals represent the number of days in each year type where the existing and modified Wagon Wheel Gap bridge is expected to limit opportunities for recreational use in various crafts.

	Total Available Boatable Days			Days Reduction Due to Bridge Piers			Days Reduction Due to Bridge Deck			% Reduction Due to Bridge Piers			% Reduction Due to Bridge Deck		
Craft Type	Dry Year	Average Year	Wet Year	Dry Year	Average Year	Wet Year	Dry Year	Average Year	Wet Year	Dry Year	Average Year	Wet Year	Dry Year	Average Year	Wet Year
Paddle Raft	157	208	165	0	21	26	0	0	0	0%	10%	16%	0%	0%	0%
Raft + Oar Frame	157	208	165	0	21	26	0	0	0	0%	10%	16%	0%	0%	0%
Raft + Fishing Frame	157	208	165	0	21	26	0	21	26	0%	10%	16%	0%	10%	16%
Dory	157	208	165	0	21	26	0	7	17	0%	10%	16%	0%	3%	10%

Table 6 The impact of the Wagon Wheel Gap bridge piers and the bridge deck was assessed by computing the total number of Boatable Days in each year type (dry, average and wet) when flows were above the safe minimum clearance thresholds of 2,000 cfs and 2,800 cfs respectively.

Antlers Lodge Bridge

The impact of the historic bridge on users of rafts with fishing frames was assessed by computing the total number of Boatable Days in each year type that occur when flows are above the safe minimum clearance threshold of 250 cfs. The impact on users with dories and rafts with oar frames were assessed in the same manner, except using a safe minimum clearance threshold of 450 cfs and 500 cfs respectively. A

safe minimum clearance threshold of 800 cfs was used to assess impacts on safe passage for paddle boats. The resulting totals represent the number of days in each year type where the historic Antlers Lodge bridge was expected to limit opportunities for recreational use in various crafts (Table 7).

The impact of the bridge modifications on users of rafts with fishing frames was assessed by computing the total number of Boatable Days in each year type that occur when flows are above the safe minimum clearance threshold of 900 cfs. The impact on users with dories and rafts with oar frames were assessed in the same manner, except using a safe minimum clearance threshold of 1,350 cfs and 1,450 cfs respectively. A safe minimum clearance threshold of 2,000 cfs was used for paddle boats. The resulting totals represent the number of days in each year type where the new Antlers Lodge bridge was expected to limit opportunities for recreational use in various crafts (Table 8).

	Dry Year				Average Year				Wet Year			
Flow Preference Category	Paddle Raft	Oar Frame	Fishing Frame	Dory	Paddle Raft	Oar Frame	Fishing Frame	Dory	Paddle Raft	Oar Frame	Fishing Frame	Dory
Lower Acceptable	0	6	17	10	0	6	11	8	0	2	24	4
Optimal	0	21	21	21	25	52	52	52	43	59	59	59
Total Days	0	27	38	31	25	58	63	60	43	61	83	63

Table 7 Reduction in Boatable Days due to minimum safe passage clearance issues at the historic Antlers Lodge bridge.

	Dry Year				Average Year				Wet Year			
Flow Preference Category	Paddle Raft	Oar Frame	Fishing Frame	Dory	Paddle Raft	Oar Frame	Fishing Frame	Dory	Paddle Raft	Oar Frame	Fishing Frame	Dory
Lower Acceptable	0	0	0	0	0	0	0	0	0	0	0	0
Optimal	0	0	0	0	0	0	16	0	0	0	34	0
Total Days	0	0	0	0	0	0	16	0	0	0	34	0

Table 8 Reduction in Boatable Days due to the minimum safe passage clearnace issues at the renovated Antlers Lodge bridge.

Boatable Days totals for this reach of the Rio Grande were compared to the number of Boatable Days reduced by bridge clearance issues for all craft types. Calculations for Total Available Boatable Days were based on flow conditions only and were assumed to apply equally across craft types. Changes in the calculated Boatable Days reductions due to the Antlers Lodge bridge renovations indicate beneficial impacts from renovations can be expected in dry, average and wet year types for all four craft type (Table 7-8). The most significant changes are relevant to paddle rafts and rafts with oar frames. Dories continue to see some constraints on Boatable Days but they are limited to wet years. Rafts with fishing frames also continue to see some impact due to the bridge in average and wet years but conditions are much improved following bridge renovation.

For the reach of the Rio Grande flowing between Deep Creek and Wagon Wheel Gap, minimum acceptable flows for boating uses were found to exist between 400-600 cfs. Optimal flows were found to exist between 600-2100 cfs. Maximum acceptable flows were found to exist between 2100-2750 cfs. The Boatable Days assessment framework provides a means for characterizing the potential impact of the Mountain Views RV Park bridge on recreational boating use. The analysis presented here used the same model-generated streamflow time series for characterizing dry, average, and wet year types for this

section of the Rio Grande as the AW report referenced previously. The choice to use modeled flows rather than gauge records to develop the representative year types was intended to ensure fidelity to previously published Boatable Days results for the Rio Grande. The impact of the bridge on users of rafts with fishing frames was assessed by computing the total number of Boatable Days in each year type that occur when flows are above the safe minimum clearance threshold of 1,800 cfs. The impact on users with dories and rafts with oar frames were assessed in the same manner, except using a safe minimum clearance threshold of 2,400 and 2,500 cfs, respectively. The resulting totals represent the number of days in each year type where navigation beneath the Mountain Views RV Park bridge becomes a limiting constraint on recreational use in various crafts (Table 9).

	Dry Year			Average Year			Wet Year		
Flow Preference Category	**Fishing Frame**	**Dory**	**Oar Frame**	**Fishing Frame**	**Dory**	**Oar Frame**	**Fishing Frame**	**Dory**	**Oar Frame**
Lower Acceptable	0	0	0	0	0	0	0	0	0
Optimal	2	0	0	13	0	0	11	0	0
Upper Acceptable	0	0	0	17	7	2	21	15	12
Total Days	2	0	0	30	7	2	32	15	12

Table 9Expected reductions in Boatable Days due to minimum safe passage clearance issues at the Mountain Views RV Park bridge.

Conclusion and Discussion

Variable streamflow conditions were found to impact use opportunities on all reaches. The total number of Boatable Days generally increase throughout the assessment area as hydrological conditions transition from dry to average to wet. On most reaches, typical daily streamflows rarely exceed the upper flow acceptability threshold.

The assessment followed recommendations in the State of Colorado's Basin Implementation Plan guidance documents for quantifying non-consumptive recreational needs. In addition to completing a quantitative Boatable Days analysis, results from open-ended recreational user survey questions were evaluated. Responses to these questions provide insights into the recreational community's views on environmental, regulatory, and infrastructure management issues affecting reaches within the planning area. High priority issues identified by multiple users included the following:

- Coordinated reservoir releases and consistent flows for fishing and boating on the Rio Grande
- Removal or mitigation of boating hazards (fencing, diversions, bridges, etc.)
- River access improvements

Survey respondents also indicated which reaches they considered priorities for recreational paddling improvements. The sections of the Rio Grande between Texas Creek and South Fork ranked highest. The section between Lasauses and Lobatos Bridge ranked lowest. Rankings for the Conejos River segments were not requested in the survey. The desire for improvements on high-priority reaches may or may not be flow-based.

In general, the climate impact analysis recognized that moving from Baseline conditions to In-Between and/or Hot and Dry conditions resulted in a decrease in median daily streamflow across all reaches. This

trend was particularly pronounced when comparing Baseline to Hot and Dry streamflow. In addition to a general decrease in flow, we also observed lower and earlier summer peak flows.

These alterations to streamflow regimes resulted in attendant changes in the availability of boatable days on the focus reaches. Fewer boatable days were available under increasingly warm and dry climate scenarios. Some exceptions were observed. For example, an increase in Lower Acceptable flow conditions was observed in some reaches at some times of year. This illustrates the point that the changes to boatable day patterns as a result of changing climate and streamflow may not be linear. Some days falling into specific flow preference classes (Lower Acceptable, Optimal, Upper Acceptable) may be affected differently on disparate reaches and those effects may be more or less apparent at different times of year.

As previously mentioned, the assessment of different potential impacts to boatable days did not originally envision the bridge analysis completed. However, this analysis has already made marked difference to recreational opportunities on the Rio Grande. In general, we found that higher low chord elevation of bridges would increase the number of boatable opportunities on the Rio Grande at the bridge sites analyzed. The Mountain Views bridge analysis was provided to the US Army Corps of Engineers in their review of the new bridge and helped to lead to a request for it to be rebuilt higher off the water.

The primary lesson learned as a result of this project is that it is important to closely and careful communicate with your project proponent. AW built a good working relationship with the RGHRP and were able to discuss different options for impact analysis that would be most useful to the steam management planning team and broader stakeholder group. More in-person coordination with stakeholders in the basin would have been beneficial and helped AW in making decisions around what analysis of Boatable Day impacts would be most useful. We ended up with a great result, but more conversation on site would have likely gotten us to that decision more quickly.

We met with recreational stakeholders multiple times throughout the process to present our results and get their feedback. These meetings initially sparked the bridge analysis discussion because we learned from those people who know the river best, what the biggest impediments are to recreation.

American Whitewater has performed Flow Preference and Boatable Days studies across the state of Colorado. Their results have been included in many management plans and used in a variety of ways. The breadth of use of this study in the Rio Grande Basin opened new opportunities to how this data can be utilized.

Additionally, the relationship built with the Rio Grande Headwaters Restoration Partnership and local stakeholders has provided and opportunity to continue working together past the end of this project working on other recreation issues. The Boatable Days and associated assessments provide a valuable framework and identification of the recreational opportunity in the basin. Other issues, such as, access or dangerous low head dams, can be better addressed by understanding the importance of the recreational resource.

AW intends to continue working with RGHRP on improving recreational access and opportunity. Currently, AW is supporting a project to improve a portage route around a diveresion to the Rio Grande Canal. There have also been discussions of following up the Boatable Days study with an economic impact analysis in a few years. The methodology for the economic analysis is something that is currently being vetted.