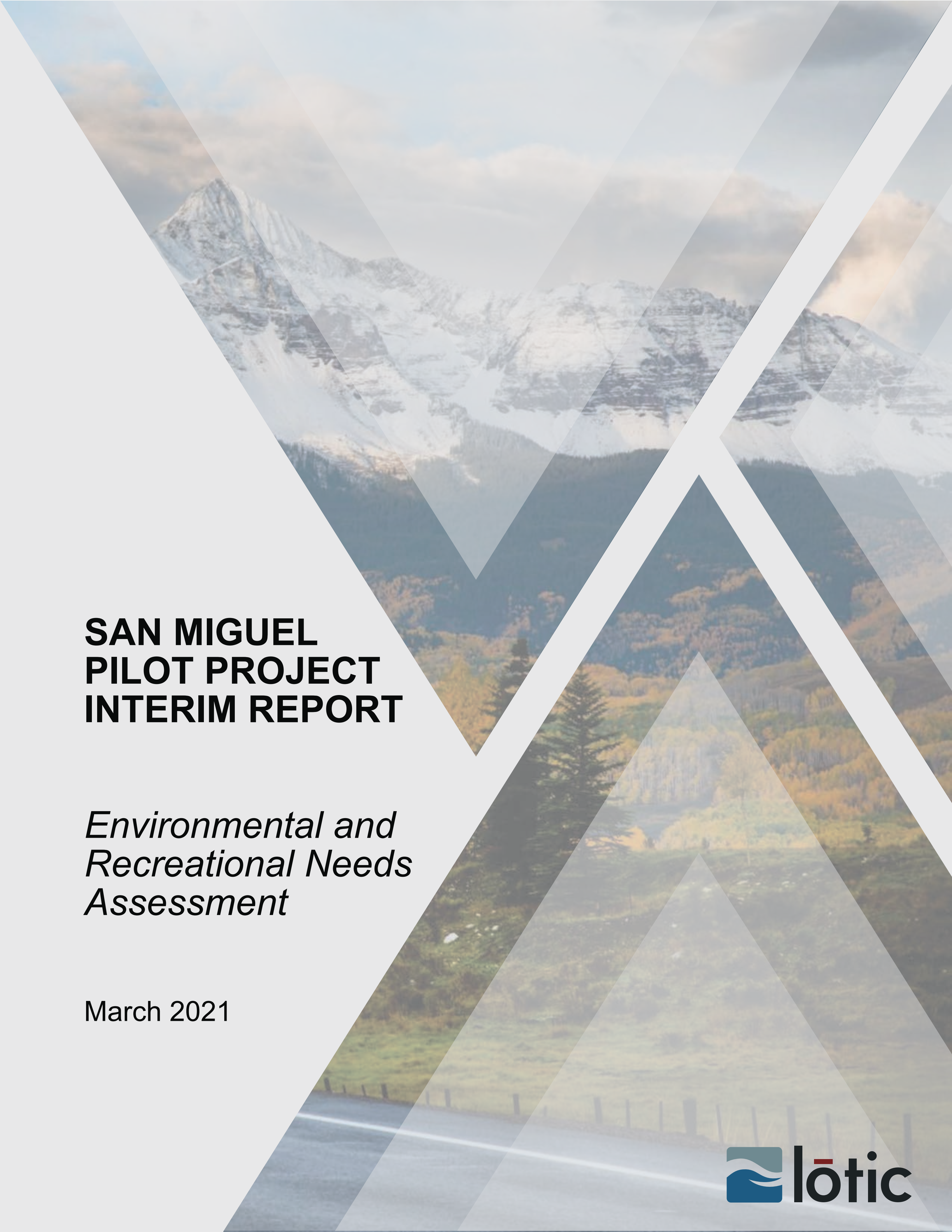

SAN MIGUEL PILOT PROJECT INTERIM REPORT

Environmental and Recreational Needs Assessment

March 2021

lōtic

PREPARED FOR

SAN MIGUEL WATERSHED COALITION

TROUT UNLIMITED

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

PREPARED BY

lōtic hydrological

ACKNOWLEDGEMENTS

This work was supported through grants by the Colorado Water Conservation Board and the Southwest Basin Roundtable. The San Miguel Watershed Coalition and Trout Unlimited performed critical coordination activities and numerous local individuals and organizations volunteered time to participate in presentations, discussions, and workshops.

DISCLAIMER

The San Miguel Pilot Project relies on high-level data collection and assessment to characterize gaps in E&R water supply needs. That information is summarized in this report. Collaborative stakeholder dialog is required to review this information, help resolve areas of potential conflict, prioritize management issues, and identify projects and processes that can improve management of water for the benefit of multiple uses.

This planning approach and its outcomes should not be used or viewed as an alternative to Colorado's water allocation system - the prior appropriation doctrine. Just as water supply planning in a municipal context defines needs and offers solutions, this Pilot Project does the same for E&R uses in the San Miguel watershed.

The methods and results presented here that assign numerical values to E&R needs should not be construed as minimum standards for meeting those needs during planning for future water supply projects etc. Future evaluations that contemplate the specific impact of a proposed project or altered hydrological condition will be better served through application of an incremental assessment approach [1] and more intensive site-specific investigations. Long-term monitoring and diagnostics may be required to further validate relationships identified between flow conditions and the various ecosystem and recreational attributes evaluated here.

[1] Cavendish, Mary G., and Margaret I. Duncan, "Use of the Instream Flow Incremental Methodology: A Tool for Negotiation."

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EXECUTIVE SUMMARY

This San Miguel Pilot Project is a demonstration planning effort for the Southwest Basin in Colorado that aims to bring together scientific and engineering evaluations and local stakeholder values/concerns to produce a list of high priority actions for meeting diverse water use needs. This effort specifically responds to the call for Environmental and Recreational (E&R) water use planning articulated by the Colorado Water Plan and the 2015 Southwest Basin Implementation Plan (SWBIP)[2]. Understanding E&R water use needs in the Southwest Basin is particularly challenging given the size of the basin and diversity of the nine major sub-drainages that it encompasses. In 2010, the SBRT completed a basin-wide E&R needs assessment as part of the Statewide Water Supply Initiative (SWSI)[3]. That assessment provided information about the type and geographic location of E&R water uses throughout the basin, but did not quantify water supply needs for those uses. Responding to this gap in E&R water needs data and planning, the SBRT supported an effort to assess E&R needs and gaps in the San Miguel watershed, with the hope that it could serve as a model for similar evaluation and planning efforts in the Southwest Basin.

Tight interrelationships between water, agriculture, recreation, tourism and industry create a complex template for understanding and optimizing management of limited water resources to support the diversity of water uses in the San Miguel watershed. Nonetheless, the San Miguel Pilot Project can promote collaborative learning about the system, help develop a shared understanding of tradeoffs involved in any given management action, and identify collaborative projects and processes to help optimize management of water for the full diversity of human and environmental needs. The assessment presented here builds upon decades of research, studies, water planning, and legal analysis focused on water resource issues in the basin.

The San Miguel Pilot Project aims to 1) characterize existing and historical conditions, 2) enhance understanding of timing and geographic patterns in E&R uses, and 3) identify opportunities for cooperative projects that support existing consumptive uses and enhance E&R needs. This effort relies on high-level data collection and assessment to characterize gaps in E&R water supply needs. Collaborative stakeholder dialog is required to review this information, help resolve areas of potential conflict, prioritize management issues, and identify projects and processes that can support multiple water uses. This planning approach and its outcomes should not be used or viewed as an alternative to Colorado's water allocation system - the prior appropriation doctrine. Just as water supply planning in a municipal context defines needs and offers solutions, this Pilot Project does the same for E&R uses in the San Miguel watershed.

The flows in the San Miguel River are largely unaltered compared to other western U.S. rivers. However, some segments of the mainstem and several tributaries are heavily utilized for municipal, industrial and agricultural purposes. The high-level analyses presented here indicate that E&R gaps do exist for maintenance of riparian and fishery health on some segments. Several other issues also appear to limit fishery health and recreational use. Reductions in stream network connectivity caused by irrigation diversions and road crossings may limit access to important habitat for some native and sport fish at some times of year. This appears particularly relevant on tributaries. Entrainment of fish in diversion canals and structures that impede upstream-downstream movement may negatively impact native fish populations. Several diversion structures on the San Miguel River near Naturita also present challenges to boat passage in their existing configuration, possibly limiting recreational use even when sufficient flows for boating are present.

[2] Oliver and Lile, "Southwest Basin Implementation Plan."

[3] Colorado Water Conservation Board, "Southwest Basin Nonconsumptive Needs Assessment: Environmental and Recreational."

The San Miguel Pilot Project considered these issues and others in an effort to identify projects, processes, and collaborative management opportunities (described here collectively as "*cooperative measures")* for meeting and protecting existing consumptive *and* E&R needs in the San Miguel watershed. Cooperative measures considered by stakeholders include market-based water use/conservation programs, water conveyance and application efficiency measures, water supply projects, and channel modifications, among others.

Ongoing stakeholders dialog will help ensure that planning activities remain well-aligned with local and regional perspectives. The planning process will continue to refine its focus and direction through community input on questions including, but not limited to, the following:

1. "What are our water use and management priorities?"

2. "What aspects of fishery and recreational use management are we most concerned about?"

3. "What kind of water future do we envision for our children growing up in the San Miguel watershed?"

The planning effort responded to high priority issues, attributes, and geographies that stakeholders believe warrant focused attention. Stakeholders helped articulate a set of management goals and objectives to guide the identification of cooperative measures. The planning process also engaged stakeholders to help evaluate the relative effectiveness and feasibility of each proposed cooperative measure. Notably, stakeholders in the San Miguel watershed wished to explore the local impacts of various hydrological futures presented in the 2019 Technical Update to the Colorado Water Plan. This view of potential future conditions assisted in prioritizing the implementation of cooperative measures over the short, medium and long-term.

The completion of the San Miguel Pilot Project yielded a list of projects, processes, and management actions that enjoy a broad base of community support, exhibit limited legal/political/administrative constraints, have identifiable champions for implementation, and present logical funding sources. This list of prioritized actions should help guide future action in the San Miguel watershed and may be used by the SWBRT to describe Identified Projects and Processes (IPPs) during the next update to the Southwest Basin Implementation Plan. Ultimately, compilation of a set of locally-defined IPPs under this planning effort will increase the likelihood that any one of those projects, processes, or management actions receives financial assistance from the State of Colorado under the funding mechanism set up under Proposition DD (2019) to support state water projects. Funding support from the state, in turn, greatly increases the chance that an IPP is implemented in the San Miguel watershed.

GLOSSARY OF TERMS

1041 permit: The permitting authority granted to counties by the State of Colorado that gives county governments the ability to permit new water development projects (e.g. reservoir construction).

Alluvial: River segments characterized by broad floodplains and active lateral channel movement.

AW: American Whitewater

BLM: Bureau of Land Management

Boatable Days: A metric used to evaluate the number of days in a year or month that a stream segment can support recreational boating activities. The metric is based on user-defined relationships between patterns of streamflow and user preferences for various flow ranges.

CDWR: Colorado Division of Water Resources

Conditional water rights: Water rights that are decreed by the Colorado Water Court but are not currently in use.

Consumptive use: Uses of water that remove physical water from the system through evaporation, transpiration, or export from a basin. Agricultural and industrial uses are generally considered consumptive uses.

Cooperative Measures: Collaboratively-identified projects, processes, or management actions intended to support multiple water uses on the San Miguel River and its tributaries.

CPW: Colorado Parks and Wildlife

CWCB: Colorado Water Conservation Board

Decreed water rights: Water rights granted to users for beneficial use by the Colorado Water Court.

Demand shortages: The difference between the water available to support a given consumptive or non-consumptive use and the demand for that use.

E&R: Environmental and Recreational

Fishable Days: A metric used to evaluate the number of days in a year or month that a stream segment can support recreational fishing activities. The metric is based on user-defined relationships between patterns of streamflow and user preferences for various flow ranges.

Hydrograph recession: The period of falling streamflows that generally occurs in early summer as snowpacks become thinner.

Hydrological regime: The characteristic behaviors of streamflow observed or expected on a given segment of stream.

Invasive species: Plants or animals that are not native to a basin or stream. These organisms tend to disrupt local ecosystems and can, eventually, displace many native species.

IPP: Identified Project and Processes included in the Southwest Basin Implementation Plan

ISF water right: Instream Flow water rights held by the CWCB for the protection of aquatic species.

Prior appropriation doctrine: The system of water right allocations and administration in Colorado that gives older users in a system the first opportunity to use water in periods of scarcity.

R2Cross: An assessment methodology used by the CWCB to establish ISF water rights in many streams across Colorado.

Riparian zones: The vegetated areas adjacent to streams and rivers that tend to support high levels of biodiversity.

SBRT: Southwest Basin Roundtable

StateMod: The simulation model used by the CWCB to simulate hydrology and water rights administration in basins across Colorado.

SWBIP: Southwest Basin Implementation Plan, a component of the Colorado Water Plan.

SWSI: Surface Water Supply Initiative conducted by the CWCB.

Trans-basin diversion: Diversion of water across a watershed divide.

USFS: United States Forest Service

USGS: United States Geological Service

Water supply gaps: The amount of water required to make up the difference between the water available to support a given consumptive or non-consumptive use and the demand for that use.

1. BACKGROUND AND PURPOSE

The Colorado Water Plan left environmental and recreational water (E&R) needs planning to local stakeholders.[4] The Plan quantified municipal, industrial, and agricultural water supply gaps, but noted the knowledge gaps and lack of common metrics for E&R flows prevented a similar statewide analysis. To bring the State's understanding (and methods for understanding) of E&R needs on par with consumptive needs, the State set a goal that E&R planning (i.e. "Stream Management Planning) should occur on 80 percent of locally prioritized rivers by 2030. Local stakeholders retain control in deciding which rivers to prioritize and management objectives to pursue.

The San Miguel Pilot Project responds to the call for E&R water use planning for the San Miguel Basin articulated by the Colorado Water Plan and the 2015 Southwest Basin Implementation Plan (SWBIP) [5]. Similarly, the Southwest Basin Roundtable (SBRT) identified a significant gap in information necessary to understand E&R water needs in the basin during development of the SWBIP.

> "With respect to the Southwest Basin's Environmental and Recreational values and water needs, the Roundtable recognizes that there are significant gaps in the data and understanding regarding the flows and other conditions necessary to sustain these values. The Roundtable also recognizes that the tools currently available to help maintain those conditions are limited."[6]

Understanding E&R water uses in the Southwest Basin is particularly challenging given the size of the basin and diversity of the nine major sub-drainages that it encompasses. In 2010, the SBRT completed a basin-wide E&R needs assessment as part of the Statewide Water Supply Initiative (SWSI) [7]. That assessment provided information about the type and geographic location of E&R water uses throughout the basin, but did not quantify water supply needs for those uses. Responding to this gap in E&R water needs data and planning, the SBRT supported this effort to assess E&R needs and gaps in the San Miguel watershed, with the hope that it could serve as a model for similar evaluation and planning efforts in the Southwest Basin.

Colorado water planners and engineers have quantified consumptive use needs for a century: the methodologies for determining an agricultural producers existing need or a city's future need are well understood and extensively practiced. Water demand has exceeded water supply when a senior water right holder places an administrative call. On streams without instream flow rights or recreational instream diversion water rights, it is less clear when an environmental need goes unsatisfied. A single or universal approach for characterizing E&R use needs in streams and rivers across the state does not exist. This is largely a result of the complexity and dependence between a river's hydrological, hydraulic, biological, and chemical components. Environmental needs depend on a river's physical attributes (e.g., width, depth, gradient) and the community of plants and

[4] Planning is distinguished here from the Colorado Water Conservation Board's ongoing appropriations of water for instream flow. *See* Colorado Water Plan §§ 5-15, 6-18, and 6-167.

[5] Oliver and Lile, "Southwest Basin Implementation Plan."

[6] Id.

[7] Colorado Water Conservation Board, "Southwest Basin Nonconsumptive Needs Assessment: Environmental and Recreational."

animals present. Recreational needs depend on river structure and user preferences for various streamflow conditions (e.g., what water levels are too low or too high to float), aesthetics, opportunities for access, and other factors. To capture that complexity, a somewhat comprehensive approach was required for assessing E&R needs and gaps across the San Miguel watershed.

The assessment presented here provides a platform for understanding the diversity of water use needs in the San Miguel River basin. This effort builds upon decades of research, studies, water planning, and legal analysis focused on water resource issues in the basin. Parties responsible for completing past investigations include state and federal resource management agencies, academic institutions, private consultants and attorneys, non-profit organizations and others. The following is a sample of the existing literature foundational to the development of this assessment effort:

- San Miguel Watershed Plan [8]
- San Miguel River Instream Flow Assessment [9]
- Ecological Health of the San Miguel Watershed [10]
- San Miguel Watershed Report Card Update [11]
- Non-consumptive Needs Assessment: Southwest Basin [12]
- San Miguel Tamarisk Monitoring [13]
- State of the San Miguel Watershed [14]
- Southwest Basin Implementation Plan [15]

These references provide a rich set of functional characterizations and articulate goals and expectations for ecosystem behavior and recreational use opportunities on the San Miguel River and its major tributaries. An annotated bibliography of relevant studies and reports is included as Appendix A. Maps relevant to this effort are compiled in Appendix B.

[8] San Miguel Watershed Coalition, "San Miguel Watershed Plan: A Collaborative Management Framework for the San Miguel Basin."

[9] Bureau of Reclamation, "San Miguel River Instream Flow Assessment."

[10] "2005 Report Card: The Ecological Health of the San Miguel River Watershed."

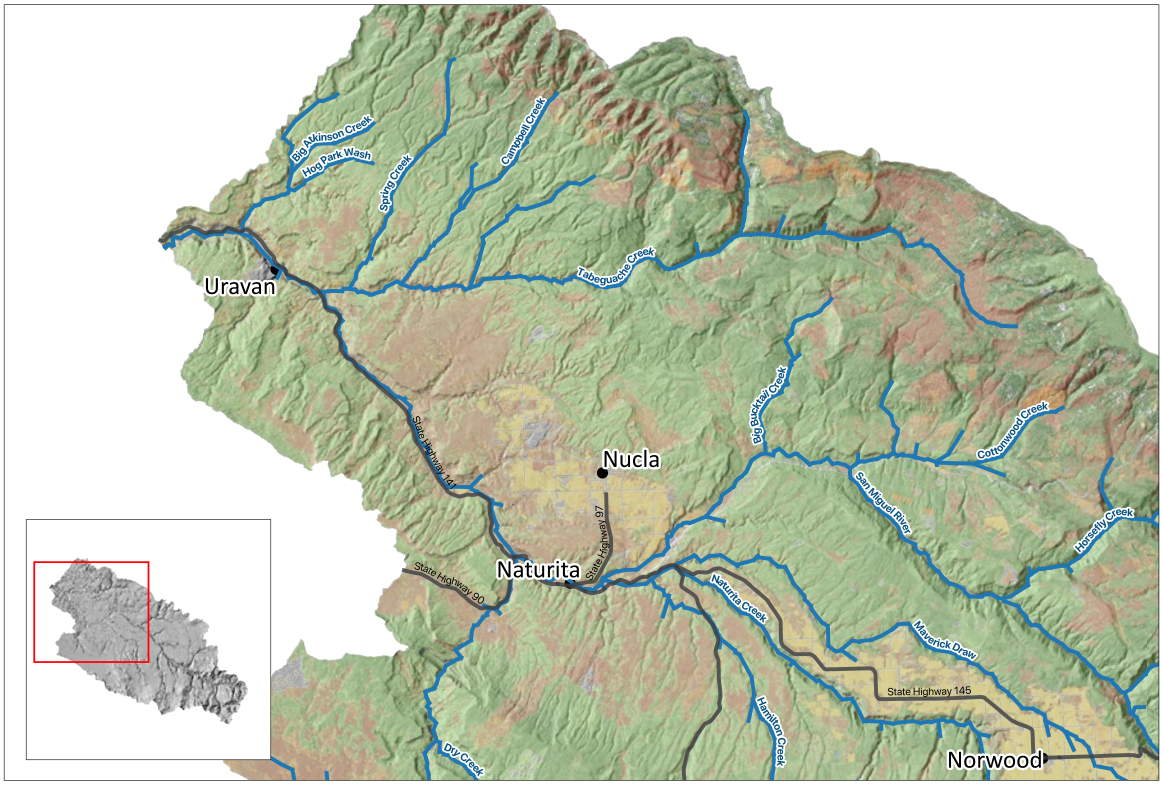
[11] "2006 Report Card Update: San Miguel River Watershed."

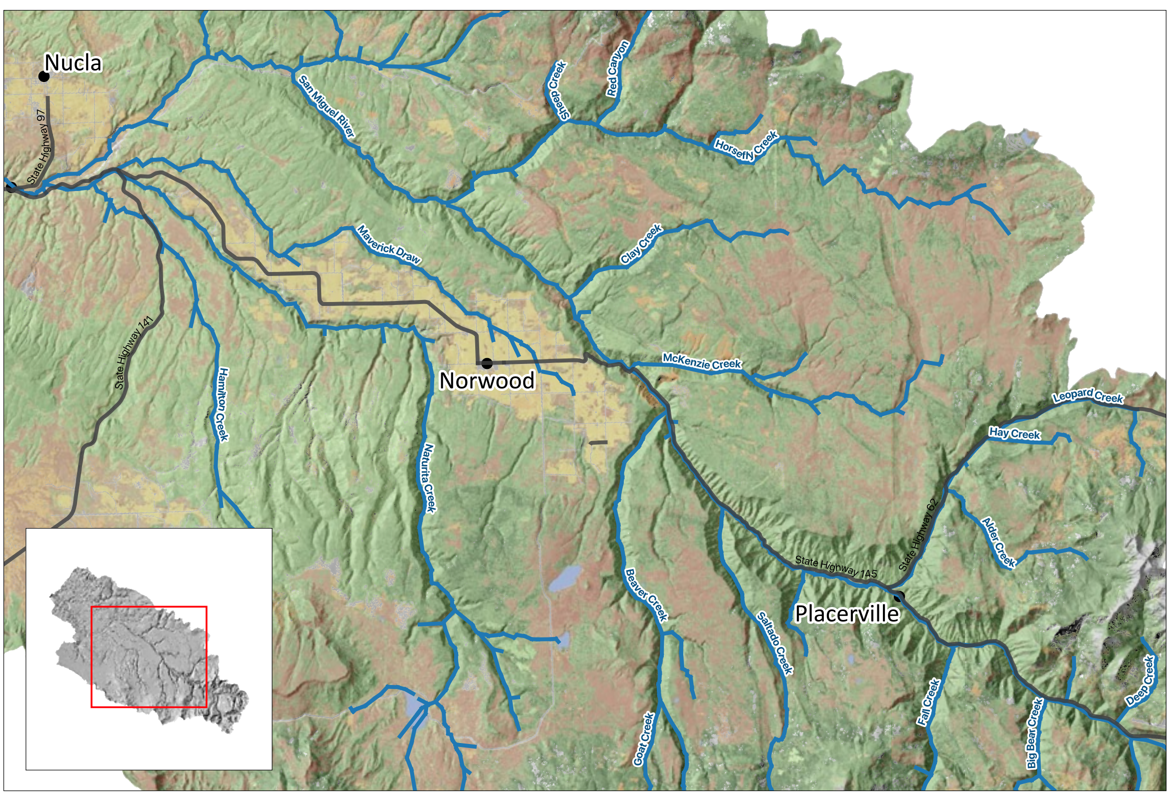
[12] Colorado Water Conservation Board, "Southwest Basin Nonconsumptive Needs Assessment: Environmental and Recreational."

[13] The Nature Conservancy, "Save the Native: San Miguel Tamarisk Monitoring Update 2014."

[14] "State of the San Miguel Watershed 2014."

[15] Oliver and Lile, "Southwest Basin Implementation Plan."


Uravan
Nucla
Naturita
Norwood
Big Atkinson Creek
Hog Park Wash
Spring Creek
Campbell Creek
Tabeguache Creek
Big Bucktail Creek
Cottonwood Creek
San Miguel River
Horsefly Creek
State Highway 141
State Highway 97
State Highway 90
Naturita Creek
Maverick Draw
State Highway 145
Hamilton Creek
Dry Creek


Nucla
Norwood
Placerville
State Highway 97
San Miguel River
Sheep Creek
Red Canyon
Horsefly Creek
Maverick Draw
Clay Creek
McKenzie Creek
State Highway 141
Hamilton Creek
Naturita Creek
Leopard Creek
Hay Creek
State Highway 62
Alder Creek
State Highway 145
Beaver Creek
Saltado Creek
Goat Creek
Fall Creek
Big Bear Creek
Deep Creek

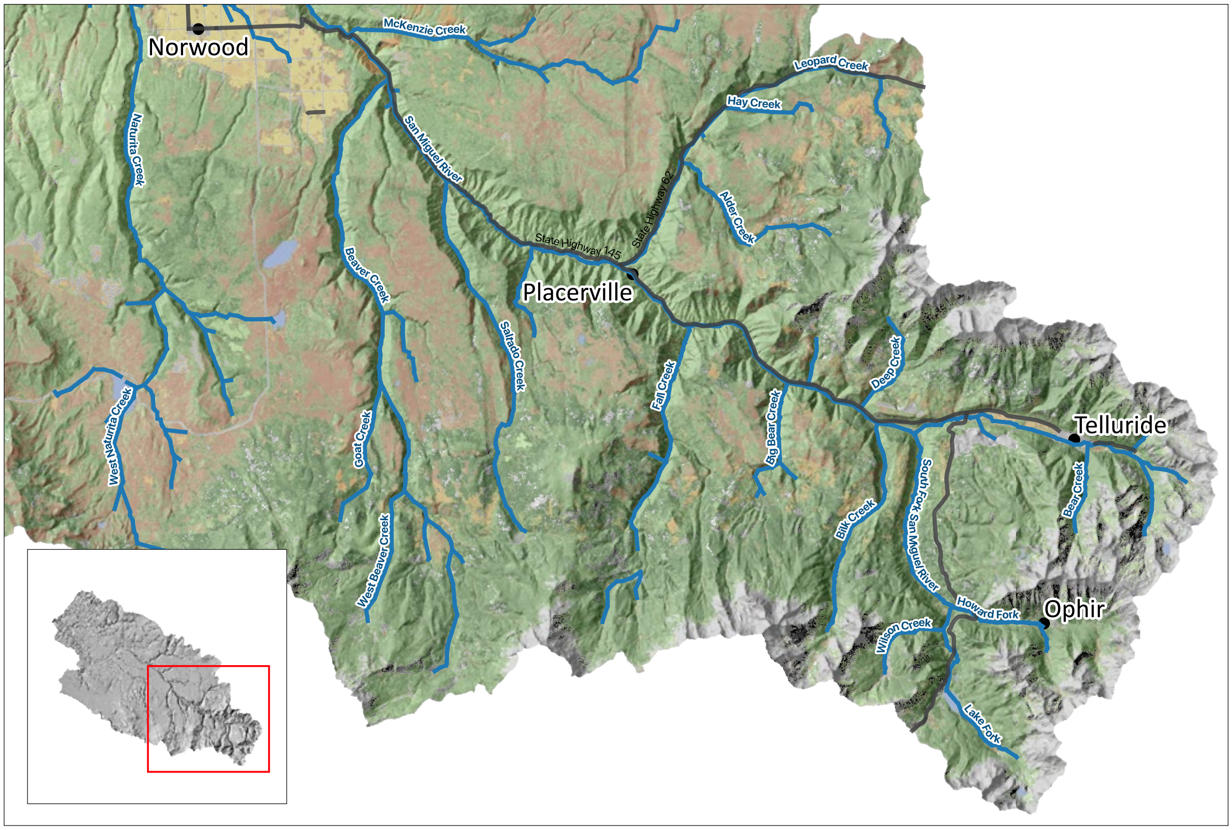


Figure 1. Streams and rivers in lower (first panel), middle (second panel) and upper (third panel) San Miguel watershed.

Tight interrelationships between water, agriculture, recreation, tourism and industry create a complex template for understanding and optimizing management of limited water resources to support the diversity of use needs in the San Miguel watershed. Nonetheless, comprehensive water management decision making supported by the San Miguel Pilot Project can promote collaborative learning about the system, help develop a shared understanding of tradeoffs involved in any given management action, and identify projects and processes to help optimize management of water for the full diversity of needs.

1.1 Water and the Economy

The San Miguel region is sparsely populated--fewer than 6,000 people reside in the entire basin. Similar to other Western Slope areas, the region continues to experience a gradual transition from an economy dominated by agriculture, mining, and logging to an economy driven by tourism and recreation. However, the economies in the east and west ends of the basin remain distinctly different. The economies of Nucla, Naturita, and Norwood rely on agricultural production and, until recently, the operation of a small coal power plant. Placerville, Sawpit, and Ophir are bedroom communities supporting the recreation and tourism economy in Telluride. Telluride is the most populated community in the watershed, supporting a permanent population of approximately 2,300 people. Other towns have 700 or fewer residents each. Population in the San Miguel basin increased quickly over the last 40 years, with most new growth concentrated around Telluride. While the economies that support each community differ, each is intimately tied to the use and management of water in local streams, rivers, lakes and reservoirs.

Mining played a significant role in the history of the basin, but drastically receded in recent decades. Most hard rock mining took place in the upper basin, while the middle and lower basin saw extensive placer mining along rivers and streams. An abandoned uranium mill on the San Miguel's banks near Uravan is now a Superfund site. Early water development projects in the upper watershed supported the mining industry. Mines operating in the mountains near Telluride relied on surface water from local streams to support extraction activities. Extensive mining activities now create a legacy of physical streambed modifications from diversions, impoundments, and placer mining. Drainage from the abandoned mill and tailings piles continues to present challenges to local communities concerned with water quality.

Power production in the upper and lower basin contributes to the economic viability at both ends of the watershed. The Smuggler-Union Hydroelectric Plant above Telluride, the Ames Hydroelectric Plant near Ophir and the Nucla Station coal power plant provide energy and employment to local communities. The Nucla station is slated for closure. All three power-generating stations rely on water from the San Miguel River and its tributaries for continued operation.

In the early days of settlement, headwaters towns developed around resource extraction, while in the western half of the watershed, towns sprang up around opportunities for agricultural enterprise. Irrigation of previously dry mesas continues to support hay, alfalfa, small grain, and barley production. Colorado Department of Natural Resources estimates approximately 37,000 acres of land in the watershed remains under agricultural production [16]. Agricultural production relies on water sourced from the San Miguel River, Beaver Creek, Naturita Creek, and other tributaries.

Recreational tourism is a noteworthy contributor to the economy of Telluride, and by extension, the bedroom communities that support the resort services industry. Recreational opportunities across the watershed abound and include: skiing, fishing, camping, hiking, biking, hunting, and rafting. Visitors to the area, largely attracted by the local scenery and opportunities to participate in these activities, spend approximately $100 million in local businesses each year [17]. The high quality of life enjoyed by local residents is similarly bound to the area's recreational opportunities. Many recreation and social values are directly tied to the biological and physical condition of local rivers, streams, and lakes. Miramonte Reservoir is an important recreational amenity for the communities of Norwood, Nucla, and Naturita. Residents and visitors in the headwaters areas enjoy whitewater boating, bank and wade fishing on the San Miguel River and some major tributaries.

1.2 Existing Patterns of Water Use

Legal administration of water use on the San Miguel River allocates water among multiple users according to Colorado's water law and the prior appropriation system. Rights are decreed in a seniority system. In periods of scarcity, senior rights are fulfilled first and junior rights may receive a portion or none of their decreed amount. Water from the San Miguel River and its tributaries supports agricultural production, municipal water

[16] "2010 Irrigated Parcels, Division 4."

[17] Blevins, J., "Telluride Crushing Summer Business for Third Consecutive Year."

use, several power plants, and a number of minimum instream flow rights (Figure 2), all administered to deliver water to the oldest existing uses in priority before newer uses [18].

1.2.1 Municipal Use

The communities of Telluride, Nucla, Norwood, Naturita, Redvale, Placerville, Sawpit, and Ophir supply local residents with treated drinking water from surface stream diversions or from wells tapping alluvial aquifers. Adjudicated surface water diversion rights decreed for municipal use across the watershed total approximately 529 cfs; however, the amount currently used by municipalities is much lower. Absolute storage rights decreed for municipal use total 9,100 acre feet and conditional storage rights approach 37,729 acre feet. Existing water rights and developed water sources are generally considered adequate to accommodate future population growth in the Telluride area. Several potential water development projects, conditional water rights, and anticipated water transfers, are considered viable approaches for meeting future water demands in the western watershed.

1.2.2 Agriculture

Agricultural production occupies a significant position in the history, culture, and economy of the San Miguel basin. Approximately 37,000 acres of irrigated agriculture [19] occupy the terraces and benches around Norwood, Redvale, Nucla and Naturita (Figure 3). These farms and ranches contribute to the vibrancy of local economies and to the scenic nature of the landscape. Agricultural rights in the middle and lower basin are among the most senior on the river. Numerous agricultural diversion structures exist on the mainstem of the San Miguel River and adjoining tributaries. Several large reservoirs in the Beaver and Naturita Creek drainages capture runoff during peak snowmelt periods to provide reliable supply throughout summer and early fall. Agricultural production in the San Miguel watershed is supported by active decreed water rights totaling approximately 2,718 cfs.

1.2.3 Trans-Basin Diversions

A single trans-basin diversion moves water out of the headwaters of Leopard Creek and into the Dallas Creek drainage to the north. This 21 cfs surface water diversion is a relatively junior right and only diverts flow during spring runoff. It generally does not affect water availability for other uses in the San Miguel watershed.

1.2.4 Instream Flows

The Colorado Water Conservation Board (CWCB) holds a total of 590 cfs of junior instream flow (ISF) rights and 30 acre-feet of absolute storage rights on the San Miguel River mainstem and its tributaries (Figure 4). ISF rights are intended to provide some measure of environmental use benefit under the prior appropriation system. Many of these ISF rights go unmet during moderate and severe drought conditions in late summer and early fall due to water availability constraints and their relatively junior priority.

1.2.5 Power Production and Mining

A portion of early water rights development supplied mining operations and power production facilities throughout the basin. Upper basin development grew around hard rock mining, while middle and lower basin activities focused on placer deposits, and later, uranium mining. Though most mining operations have ceased

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[18] "San Miguel River: Legal and Institutional Analysis."

[19] "2010 Irrigated Parcels, Division 4."

production, the legacy companies still control a portion of original water rights. In recent history, active gravel and aggregate mining occurred on limited portions of the San Miguel floodplain but operations are generally limited to the region around Telluride today. Water rights totaling approximately 52 cfs are decreed for industrial uses like mining. Absolute surface water rights totaling 19 cfs and absolute storage rights totaling 2,371 acre-feet support power production at the three plants in the basin: Smuggler-Union Hydroelectric Plant above Telluride, the Ames Hydroelectric Plant near Ophir and the Nucla Station coal-fired power plant. Conditional surface water rights totaling 954 cfs and conditional storage rights totaling 17,902 acre-feet are also decreed for power production within the basin [20].

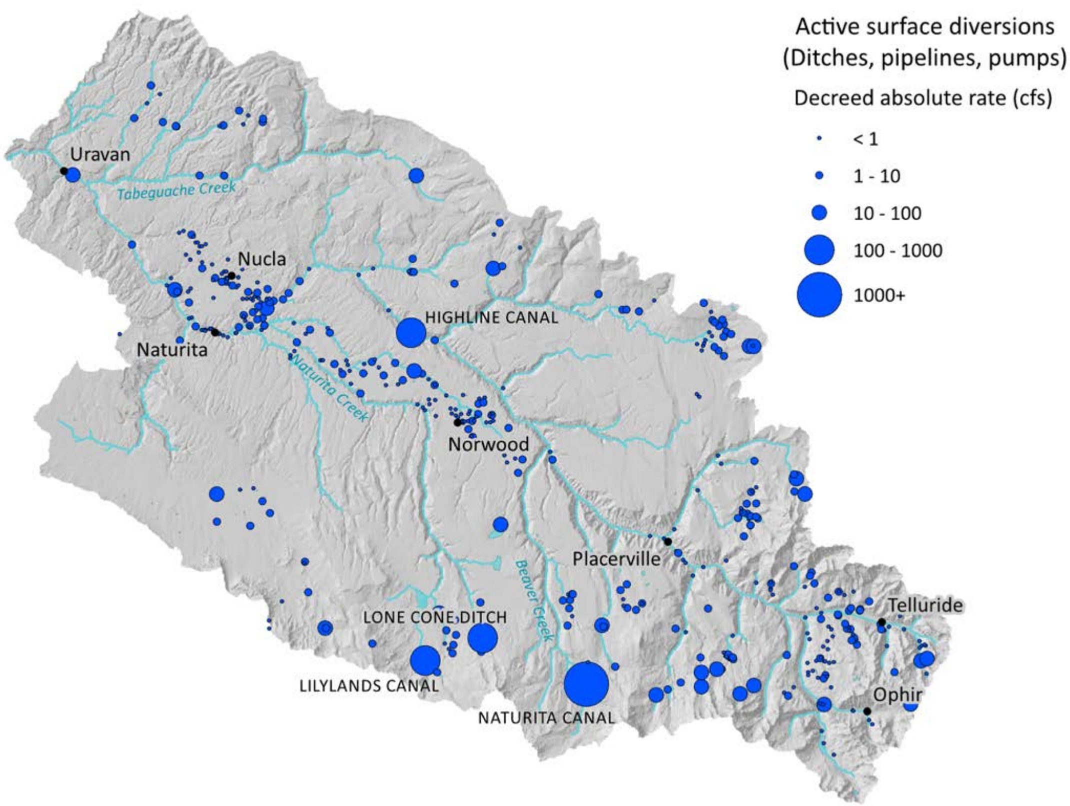

Figure 2. Surface water diversion rights in the San Miguel watershed [21]

[20] *Hydrobase.*

[21] *Id.*

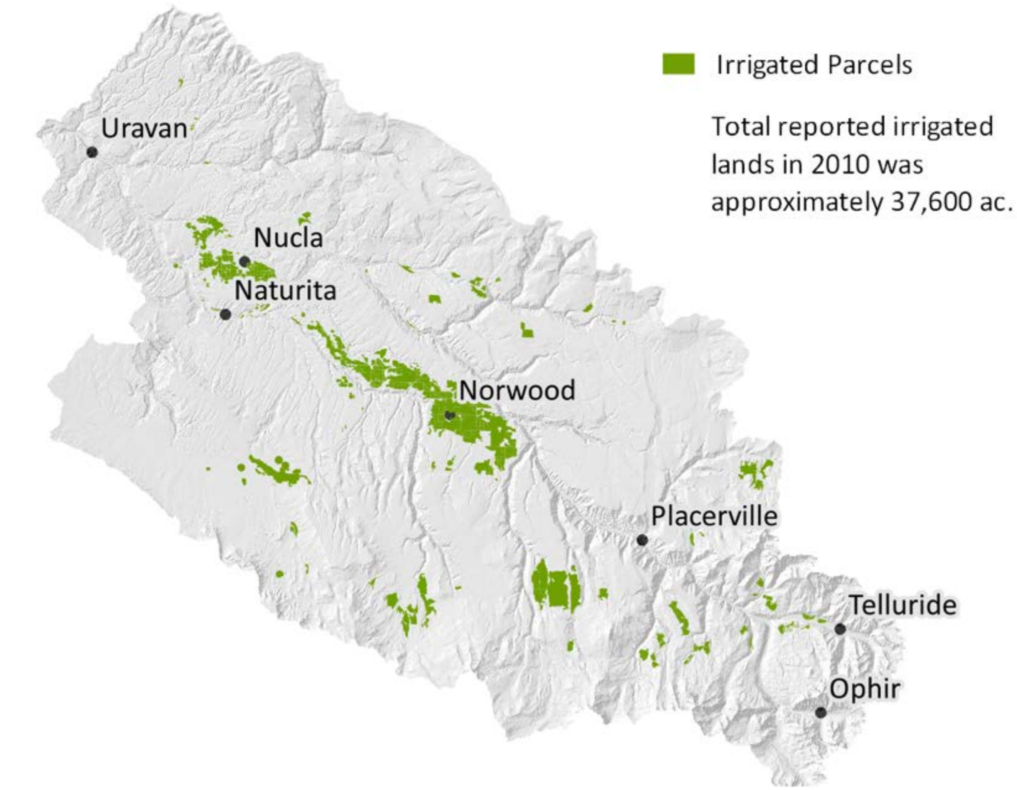

Figure 3. Irrigated parcels in the San Miguel watershed

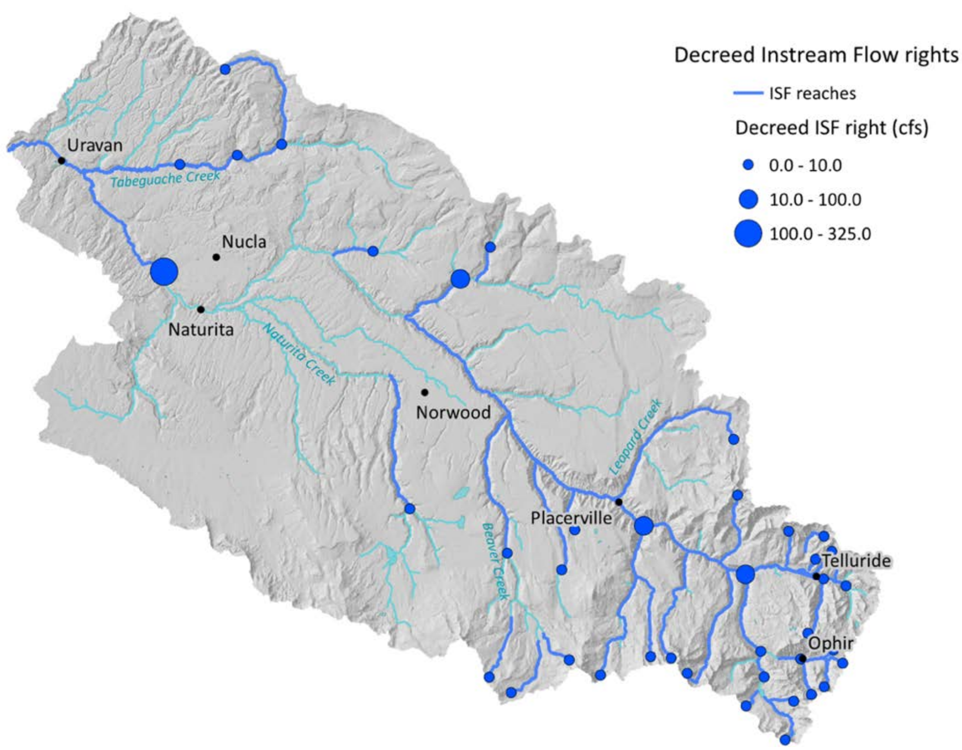

Figure 4. Instream Flow rights and protected stream reaches in the San Miguel watershed

1.3 Planning Objectives

The San Miguel Pilot Project aims to 1) characterize existing and historical conditions, 2) enhance understanding of timing and geographic patterns in E&R uses, and 3) identify opportunities for cooperative projects that support existing consumptive uses and enhance E&R needs. This project specifically responds to recommendations included in the 2015 Southwest Basin Implementation Plan:

> "1. Evaluation of environmental and/or recreation gaps is planned to be conducted for improvement of non-consumptive resources and/or in collaborative efforts with development of consumptive IPPs. The evaluations may be conducted by a subgroup of the Roundtable or by individuals, groups, or organizations with input from the Roundtable. The evaluation may utilize methodologies such as the southwest attribute map, flow evaluation tool, R2 Cross, and any other tools that may be available.
>
> 2. Where environmental and/or recreational gaps are identified, a collaborative effort will be initiated to develop innovative tools to protect water identified as necessary to address these gaps."[22]

The San Miguel Pilot Project relies on high-level data collection and assessment to characterize gaps in E&R water supply needs. That information is summarized in this report. Collaborative stakeholder dialog is required to review this information, help resolve areas of potential conflict, prioritize management issues, and identify projects and processes that can improve management of water for the benefit of multiple uses. The San Miguel Pilot Project implemented a stepwise planning process (Figure 5) as the fundamental structure for guiding the schedule and focus of different deliverables and stakeholder dialogs.

The San Miguel Pilot Project did not attempt to include each of the planning steps indicated in the figure above. Rather, the planning effort began with a Definition of Purpose and Scope and progressed through to an Evaluation and Prioritization of Actions. The implementation, monitoring, and adaptive management of these actions is expected to occur once the planning effort is complete. It is worth noting here that this planning approach and its outcomes should not be used or viewed as an alternative to Colorado's water allocation system - the prior appropriation doctrine. Just as water supply planning in a municipal context defines needs and offers solutions, this Pilot Project does the same for E&R uses in the San Miguel watershed. Each step presented below required thoughtful design and execution and careful consideration of the need for stakeholder input.

[22] Oliver and Lile, "Southwest Basin Implementation Plan."

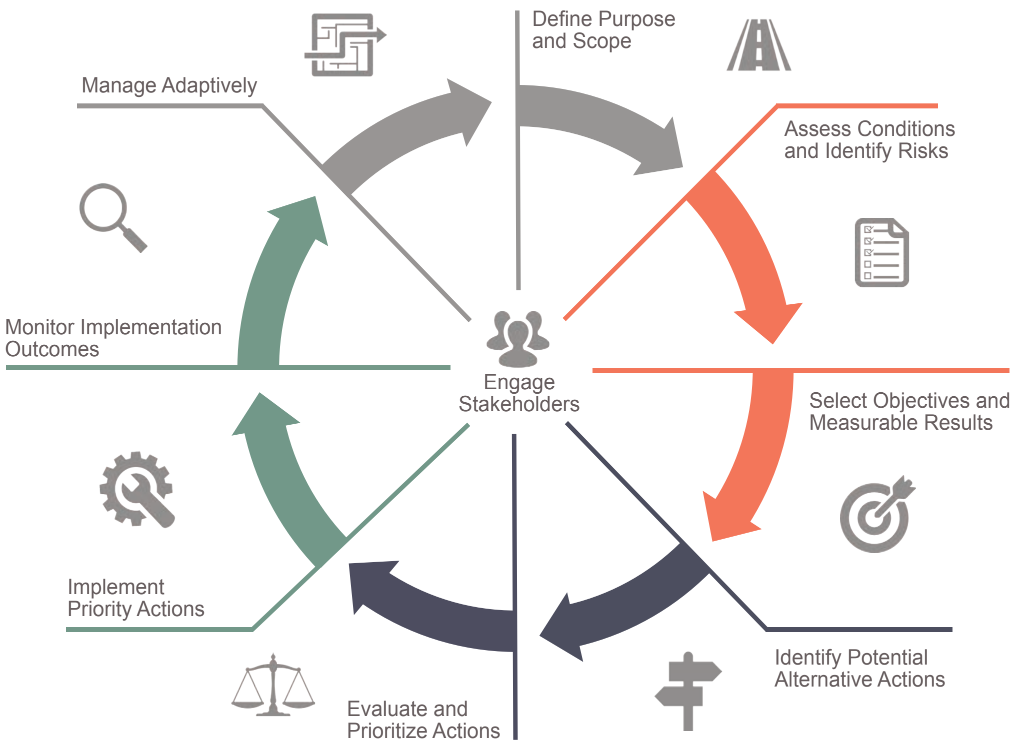

Figure 5. The multi-phase planning process guiding the San Miguel Pilot Project.

1.3.1 Step 1: Engage Stakeholders

Engaging stakeholders is central to every step of the planning process, including preliminary decision making about whether or not to pursue planning at all. A local organization or institution with a history of engagement in water conservation, use and/or management is generally best suited to stakeholder engagement and outreach tasks. In the San Miguel, the San Miguel Watershed Coalition initially adopted this role. As time progressed and in response to the preferences expressed by local stakeholders, lead coordination of the San Miguel Pilo Project shifted to an ad-hoc group of individuals representing the diversity of water uses and interests across the watershed. This group coordinated the efforts of the technical team and guided interactions between the technical team and members of the community. Facilitated dialog was orchestrated by a professional mediator.

1.3.2 Step 2: Define Purpose and Scope

Defining the overarching planning purpose and scope is a critical early step in the process and requires some reflection on the foundational motivation—the catalyst—for planning. Recognizing the nature of the motivation for planning and reflecting on where that motivation intersects with the conceptual model presented previously should help stakeholders develop a clear purpose and scope for subsequent planning steps. The purpose of the San Miguel Pilot Project is to yield a list of projects, processes, and management actions that enjoy a broad base of community support, exhibit limited legal/political/administrative constraints, have identifiable champions for implementation, and present logical funding sources. This list of prioritized actions will guide future action in the San Miguel watershed and may be used by the SWBRT to describe Identified Projects and Processes (IPPs) during the next update to the Southwest Basin Implementation Plan. Ultimately, compilation of a set of locally-defined IPPs under this planning effort will increase the likelihood that any one of those projects, processes, or management actions receives financial assistance from the State of Colorado under the funding mechanism set up under Proposition DD (2019) to support state water projects. Funding support from the state, in turn, greatly increases the chance that an IPP is implemented in the San Miguel watershed.

1.3.3 Step 3: Assess Conditions and Identify Risks

It was critical that the San Miguel Pilot Project be rooted in a robust understanding of physical conditions and ecological processes as well as constraints posed by human needs, including water rights and consumptive uses. A wide variety of methodologies for linking water management to environmental and/or recreational use appear in the scientific literature and in common practice. Approaches to environmental flow assessment in the San Miguel Pilot Project focused on aquatic species habitat, water quality, riparian function, and channel processes. Characterization of the relationship between ecological conditions and the services that communities receive from streams and rivers, such as agricultural irrigation and recreational opportunities, helped clarify tradeoffs and make the decision-making space more relevant and approachable for a diverse, non-technical audience.

1.3.4 Step 4: Select Objectives and Measurable Results

The information generated in the previous step allowed stakeholders to consider the risks posed to environmental and recreational water uses due to historical water management practices and future changes in hydrology driven by changing climate and growing populations. This phase of the planning effort required stakeholders to identify specific planning objectives that responded to some issue revealed through assessments of existing conditions and characterization of the risk to those conditions imparted by a change to the system. An example ecological objective might involve decreasing the number of days where flows are below an identified low-flow threshold for trout habitat on some reach. Other ecological objectives might deal with peak flows critical to sediment transport and fish passage or overbanking conditions related to the health of riparian vegetation.

1.3.5 Step 5: Identify Potential Alternative Actions

The planning process yielded a set of candidate alternative actions that respond to the planning objectives. In their initial conceptualization, not all alternatives were assumed immediately achievable; rather, that they were grounded in reality and not contingent upon benevolent supporting actions of outside players. Alternative actions contemplated in the San Miguel Pilot Project included, but were not limited to: physical modifications of stream beds, water leasing, water conveyance system efficiency upgrades, water application system efficiency upgrades, water diversion infrastructure modification to promote fish and/or boat passage, and reservoir development.

1.3.6 Step 6: Evaluate and Prioritize Actions

Stakeholders in the San Miguel reflected on information illustrating the different dimensions of effectiveness (at meeting project objectives) and feasibility (of implementation) of each alternative. The evaluation of alternatives simultaneously considered the potential impact of each on ecological conditions, recreational use opportunities, and the ability of a stream or river to serve the other needs and desires of local communities (e.g. municipal drinking water, productive agriculture, etc.). While use of structured approaches are often advantageous, trade-offs for some intangible services that rivers provide to communities will likely be evaluated through simple dialog and subjective analyses with local stakeholders. Several factors were assessed when considering the relative feasibility or effectiveness of each alternative. These considerations included legality, total capital cost, ongoing maintenance and operations costs, property ownership and accessibility, and institutional capacity. This exercise culminated in the assignment of relative priority or "ripeness" levels for the alternative the projects, processes, and management actions. Each alternative was described and formatted as an IPP for inclusion in the SWBRT BIP and included an identification of project champions, the availability of funding sources, the required technical or legal resources, and approximate implementation timelines.

2 WATERSHED CHARACTERISTICS

Planning for optimized water use and management begins with development of a shared understanding of existing conditions. To this end, this section provides a brief summary of watershed geography, geology, hydrology—the physical and biological template upon which all management decisions are made.

The 1,550 square mile San Miguel watershed extends northwest from headwaters above Telluride down to the Dolores River near Uravan and the Utah state line. Land ownership is split between federal land (Bureau of Land Management: 27% & U.S. Forest Service: 35%), private ownership (35%) and state and local governments (2%) (Figure 6) [23]. The San Miguel River runs for 85 miles, starting near 14,000 ft. in the San Juan Mountains, carving into the Colorado Plateau region around the southern flank of the Uncompahgre Plateau, and ending at its 4,800 ft. confluence with the Dolores River. The river is one of the few larger rivers in the upper Colorado River basin without a mainstem dam. Diverse climate and geological characteristics create a rich mosaic of stream and river types, vegetation communities, and aquatic and riparian ecosystems throughout the river corridor.

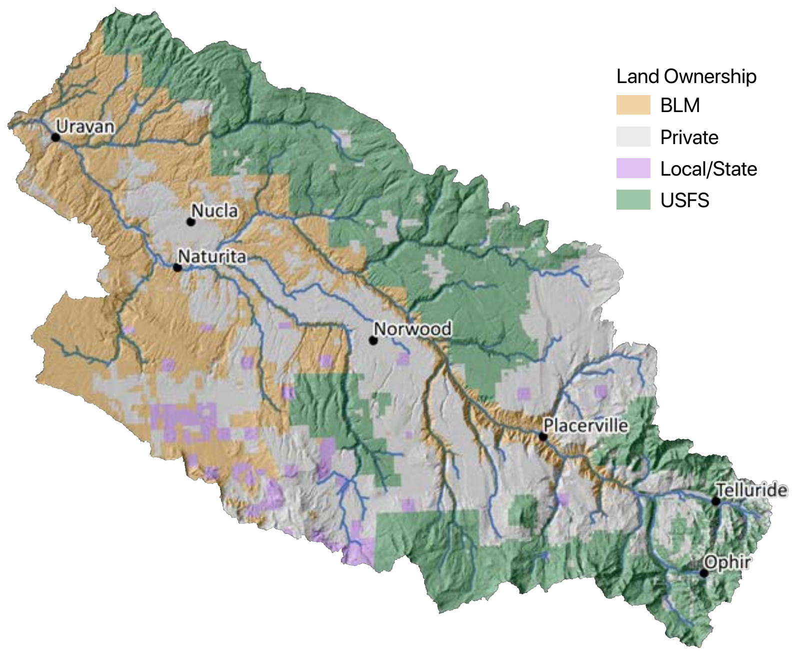

Figure 6. Land ownership in the San Miguel watershed.

2.1 Geology, Climate and Hydrology

Surficial rock and soils vary widely in the watershed, owing to the variety of geological processes at work (Figure 7). The same Tertiary volcanic rocks that are common across the San Juan Mountain Range dominate in high elevation headwaters tributaries. These rocks, formed between 66 and 2.6 million years ago, are frequently

[23] "2005 Report Card: The Ecological Health of the San Miguel River Watershed"; "San Miguel Watershed Rapid Assessment."

underlain by Mancos Shale. Descending from the San Juan Mountains, streams enter the Colorado Plateau physiographic province, incising narrow, deep canyons into the sandstone, siltstones and shales common in the middle watershed. Resistant sandstone layers prevent erosive siltstone and shale embedded within from crumbling, maintaining steep canyon walls along many valleys. In the lower basin, streams flow through sedimentary rocks of the Jurassic and Triassic Age.

Side-slope processes largely control patterns in fluvial geomorphology across the watershed. Heavy glaciation during the Pleistocene (2.5 million to 11 thousand years ago) left the upper basin vulnerable to landslides, evidenced by large debris flow deposits in the steep tributary channels. Where the San Miguel River canyon is the deepest and narrowest near Placerville, frequent alluvial fans and colluvial slide deposits dictate channel location on the valley floor, as well as local channel geometry and erosion/aggradation processes. Alluvial fan size and frequency decreases where the canyon widens near Nucla. Planform channel dynamics are most apparent near Uravan, where the channel has actively migrated across the valley floor during the last 50 years [24].

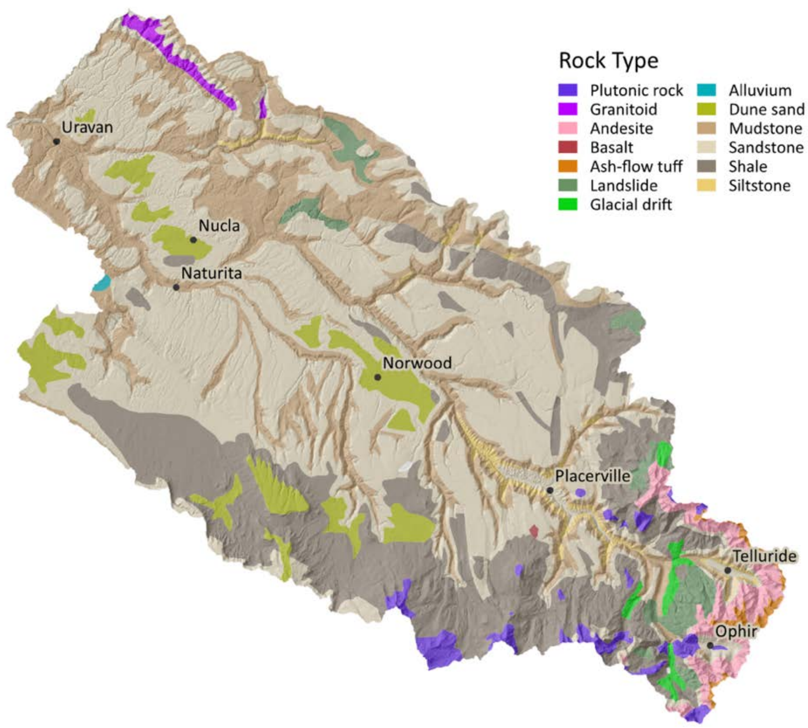

Figure 7. Surficial geology of the San Miguel watershed

Large elevation gradients contribute to significant differences in climatic characteristics between the headwaters and the lower basin. Climatic patterns parallel elevation patterns. The headwaters receive almost five times as much precipitation as the lower basin. The northern flank of the basin borders the Uncompahgre Plateau and receives an intermediate amount. Precipitation falls mainly as winter snow in the upper basin and late summer

[24] Allred, Tyler M. and Andrews, "Hydrology, Geomorphology, and Sediment Transport of the San Miguel River, Southwest Colorado"; Madole and VanSistine, "Geology and Recent History of the San Miguel River Valley, Southwestern Colorado."

rain in the lower basin. Higher elevations near Telluride are significantly colder than the western portion of the watershed, with the mid-basin retaining a moderate temperature regime. Maximum and minimum average temperatures vary predictably along an elevation gradient moving northwest from the headwaters to the Dolores River confluence (Figure 8).

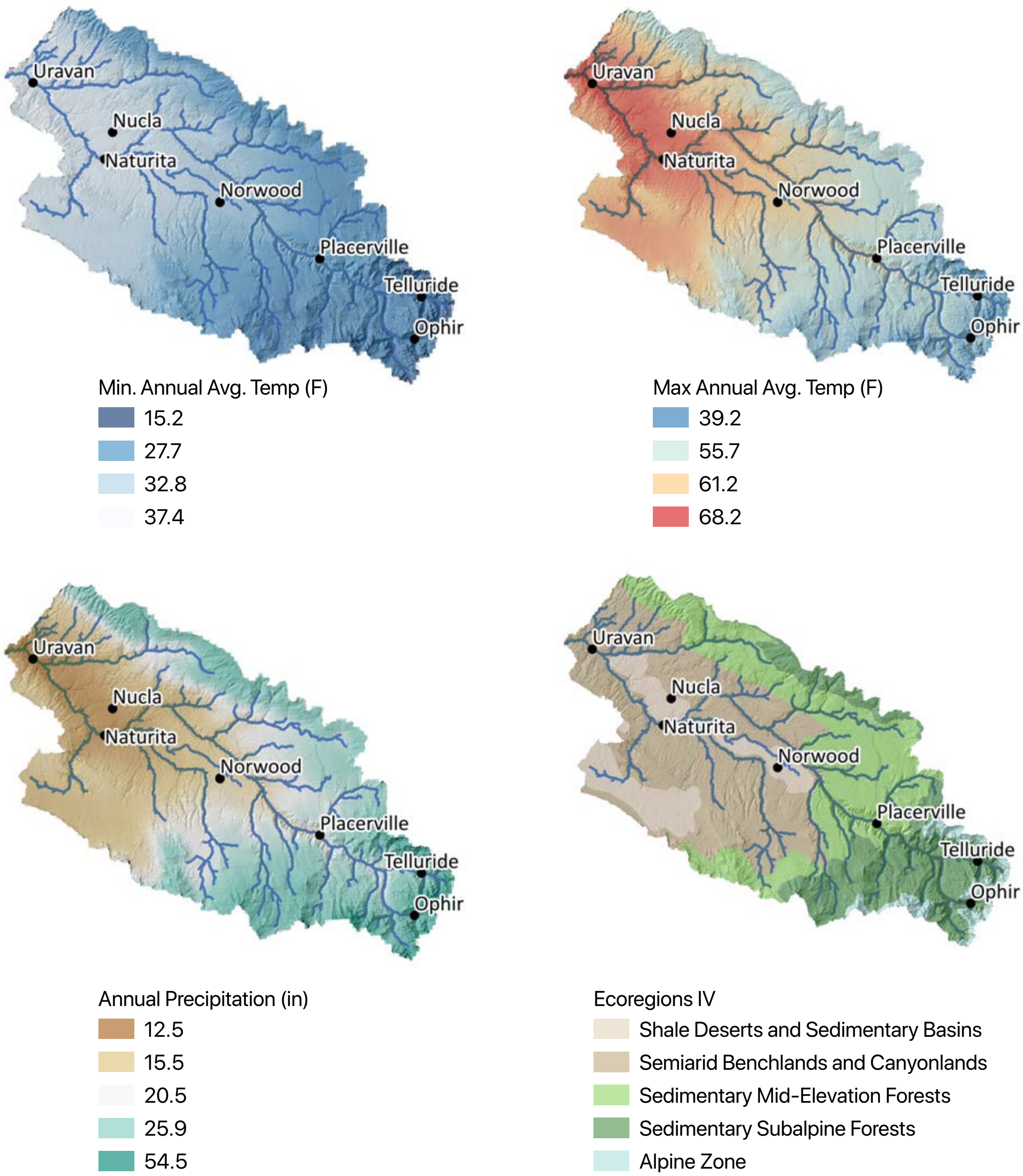

Figure 8. Climate patterns and dominant vegetation communities in the San Miguel watershed.

2.2 Land Cover and Land Use

Vegetation type, extent, and density also provide controls on hydrological regime. Changes to land cover or land use may produce cascading effects on local hydrology, geomorphology, and ecology. Dominant cover types in the upper basin transition from barren rock near the divide to denser forests interspersed with shrubs as elevations decreases. In the lower and western watershed, tree cover becomes sparse, while shrubs and grasses dominate. Large swaths of dense shrub and grass cover exist on the elevated northern flank of the basin where valley hillslopes meet the Uncompahgre Plateau. Similar vegetation patterns exist in major tributary basins such as Dry Creek Basin, in areas around Naturita, and to the northwest of Nucla (Figure 9).

The remote, sparsely populated nature of the San Miguel watershed is reflected in patterns of land use. Although urban areas comprise less than 1% of total watershed area, development in the upper basin is concentrated in valley bottoms, creating outsized impacts to streams. Development in the lower basin, though still relatively minimal, is sometimes concentrated on the floodplain and other times on terraces and mesas near the San Miguel River. Rangeland and grassland cover 90% of the basin and irrigated cropland accounts for 4% of total acreage [25]. Agricultural activity is concentrated near Norwood, Redvale, and Nucla.

The San Miguel watershed hosts a robust vegetative community. Plant communities in the lower basin are composed predominately of native species, with an increasing presence of non-native species in rangeland and developed areas [26]. In total, the basin is home to 29 globally rare plant communities and 12 globally rare plants [27]. While riparian zones account for less than 1% of total watershed area, these zones host several rare and significant plants.

Ecoregions represent areas characterized by similar ecosystem and natural resource characteristics. Their delineation synthesizes similarities between spatial patterns in geology, climate, land use, vegetation, physiography, and soils. Identification of ecoregions in the context of water use planning is important as it helps land and water managers understand how the physical landscape, climate, and resource use interact to govern local channel dynamics, hydrological regime behavior, and the response of local ecosystems to each of the former. Additionally, mapping ecoregions can facilitate approximation of dominant characteristics and landforms in different areas of the landscape, the streams and rivers they contain and prediction of how each may respond to changes in climate, management, or land cover. The San Miguel basin exhibits five EPA Level IV Ecoregions [28] (Figure 8).

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[25] San Miguel Watershed Coalition, San Miguel Watershed Rapid Assessment.

[26] San Miguel Watershed Coalition, State of the San Miguel Watershed (2014)

[27] Lyon and Sovell, "A Natural Heritage Assessment: San Miguel and Western Montrose Counties, Colorado."

[28] Chapman et al., "Ecoregions of Colorado."

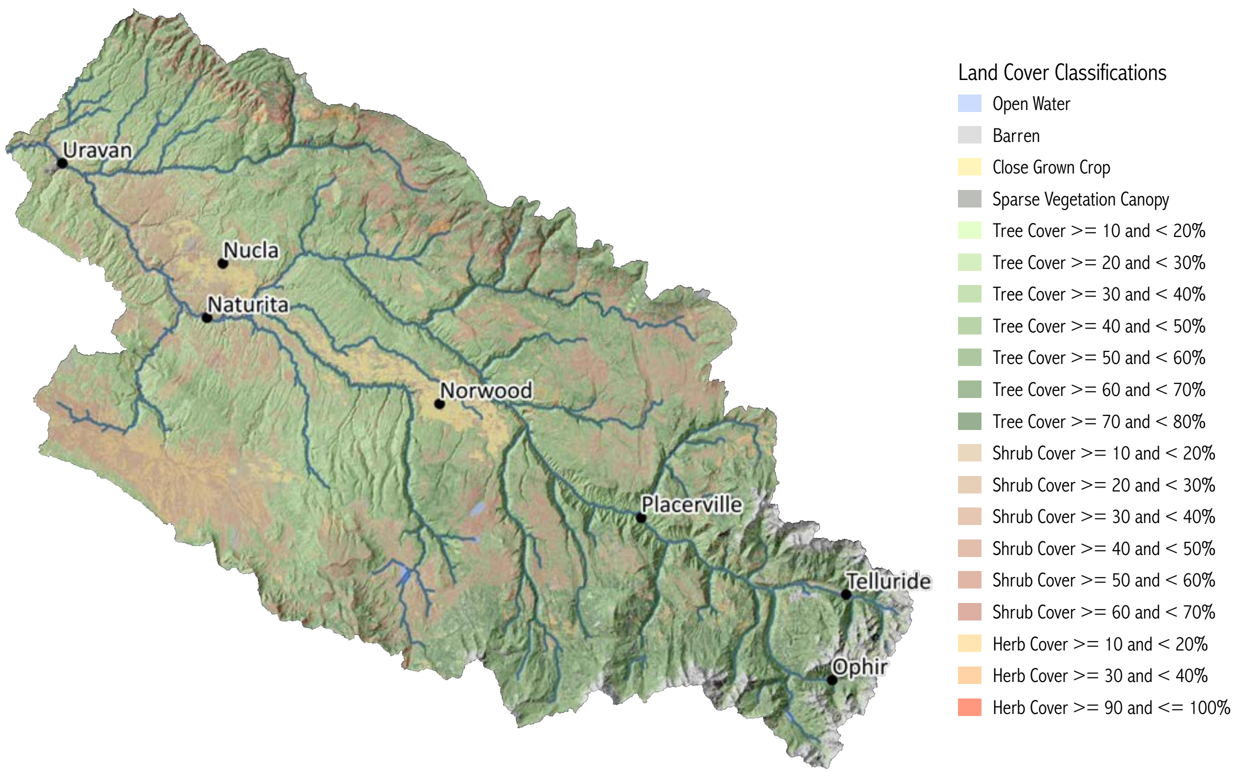

Figure 9. Land cover characteristics in the San Miguel watershed.

2.2.1 Shale Deserts and Sedimentary Basins

These low-relief areas of the Colorado Plateau are characterized by basins, valleys, benches, rounded hills and badlands. Soils derive from Mancos shale or a mixture of limestone, sandstone, shale and gypsum. Mancos shale-based soils in the Dry Creek valley are vulnerable to high selenium levels. Similar to the nearby Gunnison basin, this can be problematic for crop health and natural contamination of groundwater where irrigated agriculture is practiced. The arid environment is sparsely vegetated by saltbush, sagebrush, grasses, and desert scrub. Floodplain areas support seepweed, shadscale and greasewood, while badland areas have almost no vegetative cover. Land use is limited to range- and pastureland, dryland and irrigated forage, wheat and grain crops, and shrubland. Due to lesser snow cover and more moderate temperatures, this zone offers important wildlife winter habitat.

2.2.2 Semiarid Benchlands and Canyonlands

Escarpments separating broad benches from slickrock mesas and canyons characterize this area of the Colorado Plateau, creating alternating high and low relief. Extreme relief changes cause differential precipitation accumulation throughout: Lower elevations receive 10-18 inches, while some higher zones receive up to 25 inches annually. This zone is slightly wetter than the shale deserts and sedimentary basins zone. Deep wind-deposited sandy soils on mesa tops and benches are covered in grasses, Mormon tea, winterfat, sagebrush and saltbush. Pinyon-juniper forests grow in shallower, stony soils. Higher elevation bench areas host sparse clumps of Gambel's oak. Rangeland grazing dominates land use, with irrigated agriculture development on floodplains and terraces where water can be transported from nearby perennial streams. Mining and oil/natural gas extraction are supported as well.

2.2.3 Sedimentary Mid-Elevation Forests

Occupying the lowest elevation band of the Southern Rockies (sub-9,000 ft.), this partially glaciated area is characterized by low ridges, hillslopes and moderate to high gradient perennial streams. Precipitation is moderate, falling more as rain than snow, and temperatures are slightly warmer than higher zones. Sedimentary limestone, siltstone, shale and sandstone are the predominant surficial geology. Soils weathered from underlying limestone are fine-textured and alkaline. Ponderosa pine, Gambel's oak, pinyon pine, aspen, and a shrub-grass understory make up forests. Land uses range from recreation and wildlife habitat to timber production, grazing, and hard rock metals mining.

2.2.4 Sedimentary Subalpine Forest

Occupying a slightly higher elevational band than Mid-Elevation Forests (up to 10,000 ft.), this region continues many of the same trends found lower. Landforms include glaciated peaks, rocky outcrops, and steep streams. Vegetation is mostly forest of subalpine fir, Engelmann spruce, and lodgepole pine interspersed with aspen, with an understory of berry shrubs, sedges and forbs. Annual precipitation increases in both total amount and the ratio of snow to rain. This zone provides a perennial water source for lower elevation arid regions. Soils originate from the same sedimentary geologies of the Mid-Elevation Forest. Land uses include recreation, hunting, wildlife habitat, timber production, and limited hard rock mining.

2.2.5 Alpine Zone

Occurring mostly above treeline, this high relief zone is known for glaciated peaks, exposed rocky outcrops and alpine meadows. Streams are steep with boulder, cobble, and bedrock channel substrate. Vegetation in this harsh environment of the transitional tundra is limited to sparse *krummholz* (dwarfed trees) of spruce, fir, and pine. Sedges, wildflowers, shrubs, and cushion plants fill alpine meadow areas, with willow thickets in wet meadows. The 35-70 inches of annual precipitation fall mostly as snow and are a major water source for lower, more-arid ecoregions. Land use is confined to wildlife habitat and recreation, with relics of legacy hard rock mining activities.

2.3 The Hydrological Template

The structural form and functional integrity of a riverine system is described by a suite of hydrological, physiochemical, biological, geomorphological, and hydraulic processes. Complex bi-directional interactions occur between each process, complicating evaluation of any one component of the system in isolation from the others. However, the overall form and function of a river is primarily influenced by its natural hydrology. In turn, fluvial ecologists often treat flow regime as the "master variable" exerting the largest influence on riverine ecosystem form and function [29]. The Natural Flow Paradigm [30] postulates that hydrology represents the key driver of riverine structure and function.

The daily, seasonal, and inter-annual variations in a stream's flows make up its *hydrologic regime*. Changes in the timing and magnitude of various elements of the hydrological regime can produce cascading effects—or

[29] Poff et al., "The Natural Flow Regime."

[30] Id.

positive feedback loops—between: 1) the availability and quality of aquatic habitat, 2) the condition and extent of riparian zones, and 3) the dynamics and evolutionary trajectory of channel structure. Broad patterns of precipitation and topography largely determine a river's flow regime. River systems subject to hydrological change due to changing climate or human management are vulnerable to shifts in the composition and resiliency of both structural and biological components of the ecosystem.

Hydrological regimes exhibited by streams in the San Miguel watershed reflect dominant climatological drivers. High elevation headwaters flow from zones of significant winter snowfall. These streams exhibit a typical snowmelt hydrology for the Rocky Mountains, with peak flows driven by melting snowpack occurring between April and June. Low flow periods extend from September through March, punctuated by occasionally significant summer and fall storms (Figure 10). While most streams in the basin are affected by late season monsoonal moisture, impacts are strongest in the lower watershed where sandy soils and sparse vegetation promote quick runoff and rapid spikes in streamflow following heavy late season rains. Gauge records in the upper watershed show the highest natural flows during spring runoff, while the largest peak flood pulses measured near Uravan occurred in the late summer or early fall.

Activities that deplete or augment streamflow have the potential to impact important regime characteristics, including: total annual volume, magnitude and duration of peak and low flows, and variability in timing and rate of change. Changes to total annual volume and peak flows may impact channel stability, riparian vegetation, and floodplain functions. Impacts to base flows frequently alter water quality and the quality and availability of aquatic habitat. Alterations to natural patterns of flow variability (e.g. the frequency and timing of floods) impact fish, aquatic insects and other biota with life history strategies tied to predictable rates of occurrence or change [31].

[31] Johnson, Beardsley, and Doran, "FACStream Manual 1.0: Functional Assessment of Colorado Streams."

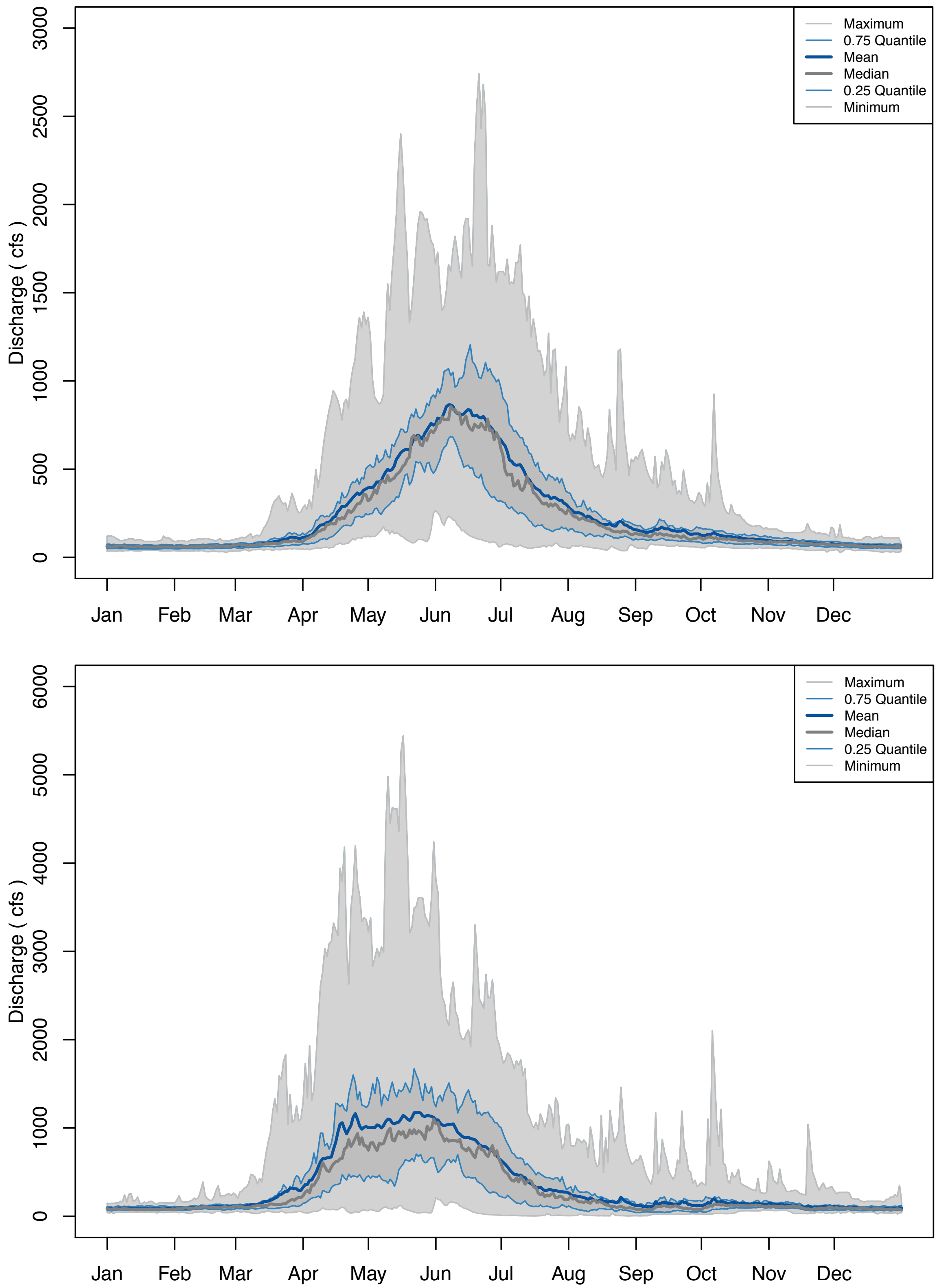

Figure 10. Hydrological regime plots for the San Miguel River at Placerville in the upper basin (top), and the San Miguel River near Uravan in the lower basin (bottom).

3 NEEDS ASSESSMENT

The environmental and recreational needs assessment approach employed here investigated the intersection between hydrology, channel hydraulics, the processes and conditions most relevant to aquatic and riparian biota, and recreational user preferences. Implementation of this framework resulted in a collection of loosely coupled hydrologic, hydraulic and statistical models to 1) predict and simulate rainfall-runoff processes contributing streamflow to the San Miguel watershed, 2) allocate and account for 'paper' and 'real' water along the San Miguel River according to Colorado water law, 3) estimate spatially distributed water surface elevations, stream depths and velocity profiles corresponding to a range of hydrological conditions, 4) quantify the morphological and ecological effects of incremental increases/decreases in streamflow on adjoining reaches of the river, and 5) calculate potential for two types of recreational use: whitewater boating and river angling.

The evaluation of E&R needs and potential gaps presented here can be divided into two methodological categories: numerical evaluations and narrative assessments. The E&R Subcommittee to the SWBRT requested identification of numerical needs and gaps through application of threshold or standard-setting assessment methods. For example, SWBRT requested evaluation of fishery health needs through application of the R2Cross methodology [32]. This method relates streamflow thresholds to habitat quality at specific locations in the watershed. R2Cross results do not provide any information about things like local or regional stream network connectivity. This may be problematic in locations where network connectivity, not streamflow, is the primary limiting factor for fishery health. Additional investigations were performed fill these important information gaps. Results from this type of investigation do not lend themselves to computation of numerical water supply gaps and are, instead, provided in narrative form. Narrative assessments accompany the numerical characterizations in several of the sections below to provide additional context for future planning activities. Results produced through this approach should allow stakeholders and resource managers to efficiently evaluate the current functional condition of the riverine ecosystem and provide a foundation for investigating the ecological benefits realized by any proposed projects or alternative resource management strategies.

3.1 Computing E&R Needs and Gaps

The diversity of, and competition among, various water uses in the San Miguel watershed produces gaps between existing supply—both in time and in place—and the supply needed to satisfy agricultural, industrial, municipal, and E&R use needs. The Southwest Basin Roundtable E&R Subcommittee requested development of an assessment approach that would allow for characterization of E&R water needs gaps under existing hydrological conditions, rather than by way of comparison to natural or projected future conditions. Threshold setting methods were, generally, identified as the most efficient assessment approach for characterizing E&R needs, given the geographic scale of the effort and limited time and budget resources for the project. In simple math terms, numerical E&R gaps are calculated as:

E&R Gap = Available Water Supply – Computed E&R Need

Where a negative value indicates a gap and a positive value indicates a surplus. It is important to note that water supply gaps identified by this report are *not an implicit recommendation for water management actions to fill each gap*. The

[32] Espegren, "Development of Instream Flow Recommendations in Colorado Using R2Cross."

sole purpose of this report is to identify E&R needs and gaps so that local communities can prioritize water management issues for closer evaluation in subsequent planning phases. Identifying E&R needs and gaps also provides important information for stakeholders interested in understanding how gaps may shrink or widen under alternate future hydrological regimes (e.g. those laid out in the 2019 Technical Update to the Colorado Water Plan), following development of one or more Identified Projects and Processes (IPPs) from the SWBIP [33], or under some water management regime proposed by local individuals or organizations.

The methods and results presented here that assign numerical values to E&R needs should not be construed as minimum standards for meeting those needs during planning for future water supply projects etc. Future evaluations that contemplate the specific impact of a proposed project or altered hydrological condition will be better served through application of an incremental assessment approach [34] and more intensive site-specific investigations. Long-term monitoring and diagnostics may be required to further validate relationships identified between flow conditions and the various ecosystem and recreational attributes evaluated here.

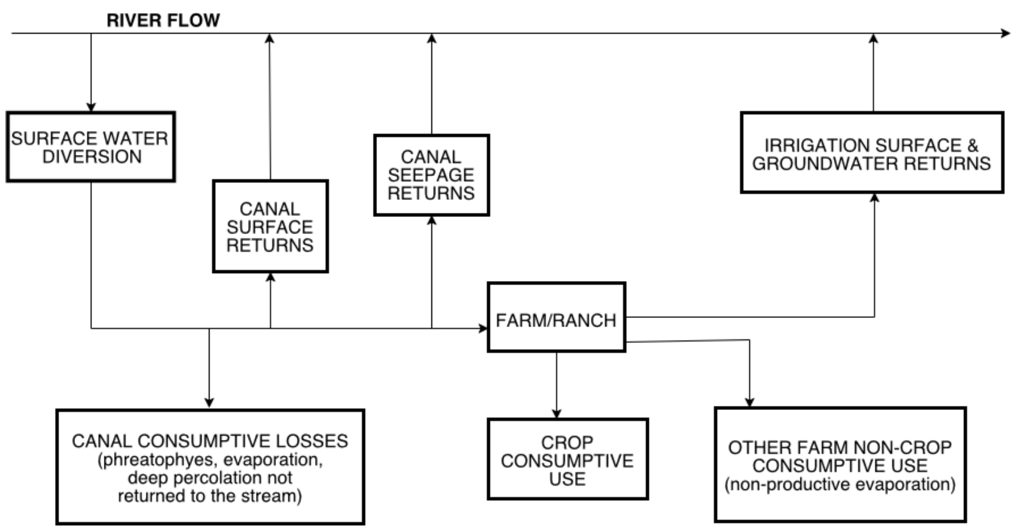

Figure 11. The conceptual representation of irrigation water demands/deliveries incorporated into the simulation model for the San Miguel watershed.

3.2 Hydrology

River science experts often treat the flow regime (i.e. the annual and longer-term fluctuation in streamflow levels) as the "master variable" exerting the largest influence on river ecosystem form and function [35]. Activities that deplete or augment streamflow have the potential to impact important regime characteristics, including:

[33] Oliver and Lile, "Southwest Basin Implementation Plan."

[34] Cavendish, Mary G., and Margaret I. Duncan, "Use of the Instream Flow Incremental Methodology: A Tool for Negotiation."

[35] Poff et al., "The Natural Flow Regime."

total annual volume, magnitude and duration of peak and low flows, and variability in timing and rate of change. Changes to total annual volume and peak flows may impact channel stability, riparian vegetation, and floodplain functions. Impacts to base flows frequently alter water quality and the quality and availability of aquatic habitat. Alterations to natural patterns of flow variability (e.g. the frequency and timing of floods) impact fish, aquatic insects and other biota with life history strategies tied to predictable rates of occurrence or change [36].

Streamflow gauges on the San Miguel River at Placerville and Uravan provide relatively long data records suitable for evaluating historical changes in hydrological regime behavior. The Placerville gauge is particularly useful for assessing watershed scale changes in hydrology driven by long-term drought and/or a changing climate due to the limited impact of human water management activities on flows at this location (Figure 12, Figure 13, Figure 14).

Analysis results indicate weak declines in some metrics of annual flow behavior since the 1970s. Similar patterns are observed downstream at the San Miguel River at Uravan. Declines in maximum daily flows may be reducing the channels ability to mobilize and transport sediment downstream. Changes in low-flow metrics like average annual 30-day and 7-day minimum flows likely restrict the availability of aquatic habitat for fish and other species. If the drought conditions observed over the previous 20 years persist into the coming decades, these weak downward trends may become stronger and/or statistically significant.

Unfortunately, long-term streamflow records are not available for every tributary in the San Miguel watershed. This assessment, therefore, relied extensively on hydrological simulation modeling to estimate flow behaviors in areas without streamflow gauges. This approach was particularly important for assessing hydrological impacts associated with a range of potential future climate and population growth futures.

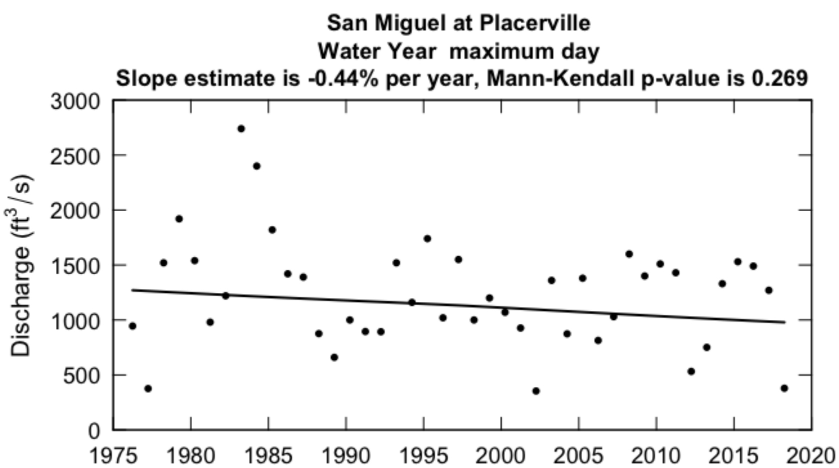

Figure 12. Historical patterns in maximum daily flows recorded on the San Miguel River at Placerville. A Mann-Kendall test indicates a non-statistically significant negative Sen's slope in this metric over recent decades.

[36] Johnson, Beardsley, and Doran, "FACStream Manual 1.0: Functional Assessment of Colorado Streams."

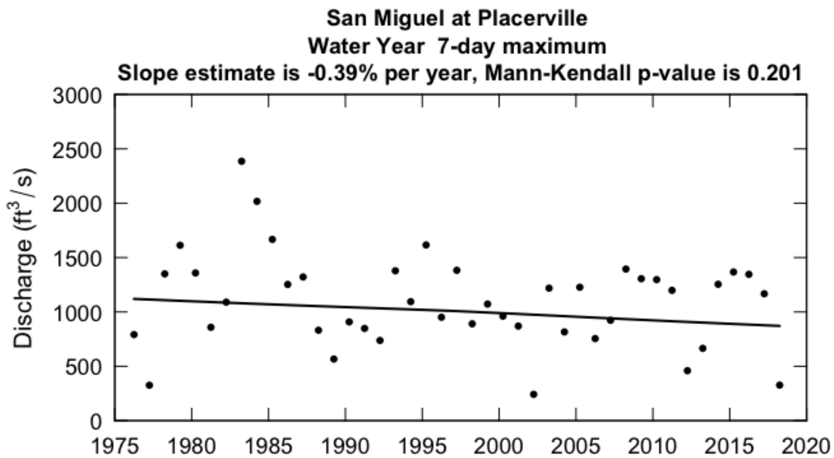

Figure 13. Historical patterns in 7-day maximum daily flows recorded on the San Miguel River at Placerville. A Mann-Kendall test indicates a non-statistically significant negative Sen's slope in this metric over recent decades.

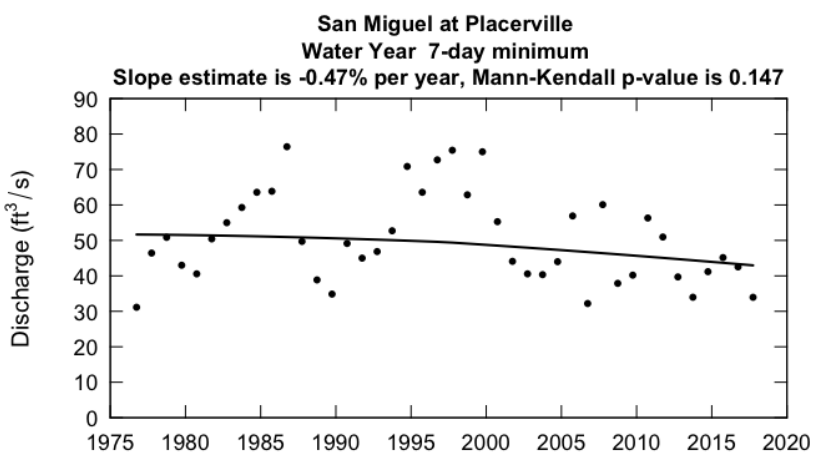

Figure 14. Historical patterns in 7-day minimum daily flows recorded on the San Miguel River at Placerville. A Mann-Kendall test indicates a non-statistically significant negative Sen's slope in this metric over recent decades.

3.2.1 Predicting Hydrological Change

Future water management activities or shifts in climate that deplete or augment streamflow have the potential to impact important regime characteristics, including: total annual volume, magnitude and duration of peak and low flows, and variability in timing and rate of change. Changes to total annual volume and peak flows may impact channel stability, riparian vegetation, and floodplain functions. Impacts to base flows frequently alter water quality and the quality and availability of aquatic habitat. Alterations to natural patterns of flow variability (e.g. the frequency and timing of floods) impact fish, aquatic insects and other biota with life history strategies tied to predictable rates of occurrence or change.[37]

Different perspectives on future hydrological behavior and its relationship to consumptive and non-consumptive water uses are gleaned from trends analysis on historical streamflow records and scenario modeling. While trends analysis may be the best tool for understanding near-term hydrological conditions, extrapolation of historical trends out to 30 or 50-year time horizons may be an insufficient or inappropriate approach for understanding future conditions. This is especially true where historical behavior in the joint hydrological/socio-political/administrative system is not necessarily predictive of potential future behavior. Simulation models of future hydrology, water use, and water management provide a tool for evaluating the effects of various future scenarios. Scenario modeling is used extensively across Colorado for risk assessment and decision support. That approach is adopted here as well to provide local stakeholders with insights into the ways in which changes in water availability and water use may alter local waterways' ability to deliver goods and services to local communities.

The CWCB recently provided a Technical Update to the Colorado Water Plan.[38] That update includes a set of revised StateMod scenario planning models for the Southwest Basin. The models simulate the effects of several climate change and development futures (Table 1). Results generated by the models provide a lens through which potential future conditions in the San Miguel Watershed can be evaluated. Modeled scenarios encompass a wide range of future conditions according to the best available science and stakeholder inputs. This scenario planning approach, unlike the more simplistic low to high stress conditions, recognizes that the future holds a degree of uncertainty where the various drivers will impact each other. The nine impact drivers considered by the Technical Update include:

- Population/Economic Growth
- Social/Environmental Values
- Climate Change/Water Supply Availability
- Urban Land Use/Urban Growth Patterns
- Energy Economics/Water Demand
- Level of Regulatory Oversight/Constraint
- Agricultural Economics/Water Demand
- Municipal and Industrial Water Demands
- Availability of Water-Efficient Technologies

Each of the planning scenarios presented in the Technical Update reflects a possible future state, which depends on a variety of environmental and social drivers. The differentiating components of the planning scenarios are listed below:

Baseline – Current Conditions

- Current irrigated acreages and irrigation practices
- Historical Irrigation Water Requirement (IWR)
- Historical hydrology

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[37] B. Johnson, M. Beardsley, and J. Doran, "FACStream Manual 1.0: Functional Assessment of Colorado Streams.," 2016.

[38] "Technical Update to the Colorado Water Plan," Colorado Water Conservation Board, Volume 1., 2019.

Scenario A – Business as Usual

- Some reduction of irrigated acreage near towns
- Increased modest improvements to irrigation efficiency
- Climate is similar to conditions in the 20th century

Scenario B – Weak Economy

- Reduction of irrigated acreage near towns
- Economy struggles, slow population growth
- Climate is similar to conditions in the 20th century
- Little change in social values, levels of water conservation, urban land use patterns, and environmental regulations

Scenario C – Cooperative Growth

- Reduction of irrigated acreage
- 20% increase to IWR due to climate factor (i.e. warmer)
- Population growth consistent with current forecasts
- Increased water and energy conservation
- Emergence of water saving technology
- Water development more restrictive requiring high efficiency as well as environmental/recreational benefits
- Moderate warming of the climate increasing water demands in all sectors (Ag + M&I)

Scenario D – Adaptive Innovation

- Much warmer climate with technological innovation to address associated socio-environmental problems
- Population growth higher than current projections
- Reduction of irrigated acreage, but less than other scenarios due to demand for locally produced food
- 31% IWR increase from climate factor (i.e. warmer)
- 10% IWR reduction from improved technology or efficiency (i.e. lower water use by crops)
- 10% system efficiency increase to offsets water use in warmer climate

Scenario E – Hot Growth

- Much warmer climate with increased population
- Rapid transition of agricultural lands to urban and suburban land uses near existing towns
- Reduction of irrigated acreage[39]
- Earlier snowmelt runoff
- 31% IWR climate factor

[39] Note that reductions in irrigated acreage included in scenarios C, D, and E may not necessarily correlate to decreased consumptive water use demand and warmer air temperatures and a longer growing season increase annual water demands on a per acre basis.

Table 1. Climate change and development scenarios included in Technical Update to the Colorado Water Plan.

Drivers	A Business as Usual	B Weak Economy	C Cooperative Growth	D Adaptive Innovation	E Hot Growth
A. Economy/ Population					
B. Urban Land use	No change	No change	Higher density	Higher density	Lower density
C. Climate Status/ Water Supply	Same as 20th century observed	Same as 20th century observed	Between hot and dry and 20th century observed	Hot and dry	Hot and dry
D. Energy Water Needs	Low (no oil shale)	Moderate (no oil shale)	Low (no oil shale)	Low (no oil shale)	High (oil shale)
E. Agricultural Conditions	Total ag water demands slightly higher • Decrease in irrigated acres due to urbanization • Ag exports and demands lower • Ag is less able to compete with urban areas for water	Total ag water demands decrease • Decrease in irrigated acres due to urbanization • Ag exports and demands constant • Ag is less able to compete with urban areas for water	Total ag water demands slightly higher • Slight decrease in irrigated acres due to urbanization • Ag exports down and local demands up • Ag is better able to compete with urban areas for water • Increased ET due to climate change	Total ag water demands slightly higher • Slight decrease in irrigated acres due to urbanization • Ag exports down and local demands up • Ag is better able to compete with urban areas for water • Increased ET due to climate change	Total ag water demands higher • Significant decrease in irrigated acres due to urbanization • Ag exports and demands high • Ag is better able to compete with urban areas for water • Increased ET due to climate change
F. Availability of New Water Efficiency Technology	• M&I Moderate • Ag: Efficiencies are increased	• M&I Moderate • Ag: Efficiencies are increased	• M&I High • Ag: Efficiencies are increased	• M&I High • Ag: Much higher efficiencies are implimented	• M&I Moderate • Ag: Efficiencies are increased
G. Social/ Environmental Values	No change	No change	• Increased awareness • Increased willingness to protect environment and stream recreation	• Increased awareness • Increased willingness to protect environment and stream recreation	• Full use of resources • Low willingness to protect environment and stream recreation
H. Regulatory Constraints	Regulation / Deregulation No change	Regulation / Deregulation No change	Regulation / Deregulation Increased	Regulation / Deregulation Increased but expedited	Regulation / Deregulation Reduced
I. M&I Water Demands	Lowest of the five scenarios	Middle of the five scenarios	Second lowest of the five scenarios	Second highest of the five scenairos	Highest of the five scnarios

The predictions for changes in hydrological regime behavior, water use, and water management made in the Technical Update to the Colorado Water Plan were used to explore risks for alteration of ecosystem conditions and the delivery of important ecosystem goods and services to local communities. Those risk assessments, along with a characterization of existing conditions, are discussed in subsequent sections.

The scenario models included in the Technical Update run on a monthly timestep. For the purposes of evaluating impacts of climate change, population growth, etc. on ecological characteristics of the San Miguel watershed, a daily timestep was required. Monthly simulation results were disaggregated to daily results using a method of fragments approach.[40] The validity of the disaggregation approach was initially assessed by comparing 100 computed metrics of annual streamflow behavior (e.g. 7-day minimum flow, average September flow, 3-day maximum flow, etc.) for Baseline simulation results representing the San Miguel River at Placerville, Naturita, and Uravan to the same metrics computed on observed streamflow data from those locations using a Wilcox Rank Sum test. Results indicate no statistically significant difference in the computed metrics between the simulation results and observation data for most metrics at all three locations. The comparison yielded some significant differences between several daily minimum and maximum flow metrics (e.g. 7-day minimum flow) at Uravan. We expect this is may be due to the particular gauge(s) selected for calibration of the monthly CWCB models, the influence of regional groundwater inflows not captured by the model, or an artifact of the daily disaggregation approach. Nonetheless, we found these results encouraging and, generally, supportive of our intention to use scenario modeling results to characterize changes in annual flow characteristics *between* scenarios. Modeling results should not be interpreted as precise predictions of baseline or future conditions, particularly at locations where no existing or historical streamflow gauges exist to support model validation.

Comparison of the various climate change and population growth scenario simulation results to the baseline simulation result indicate a shift toward earlier peak runoff and lower total annual runoff volumes associated with increasingly warm climate futures (Figure 16, Figure 17, Figure 17, Figure 18). These patterns are typical of predictions elsewhere on Colorado's western slope. Simulation results for the mainstem San Miguel River indicate relative insensitivity to the changes from the baseline condition included in scenarios A and B. As a result, many of the analyses presented in subsequent sections of this report consider differences between scenarios A, C, and E. These three scenarios effectively bracket the range of potential future conditions predicted in the entire suite of model scenarios.

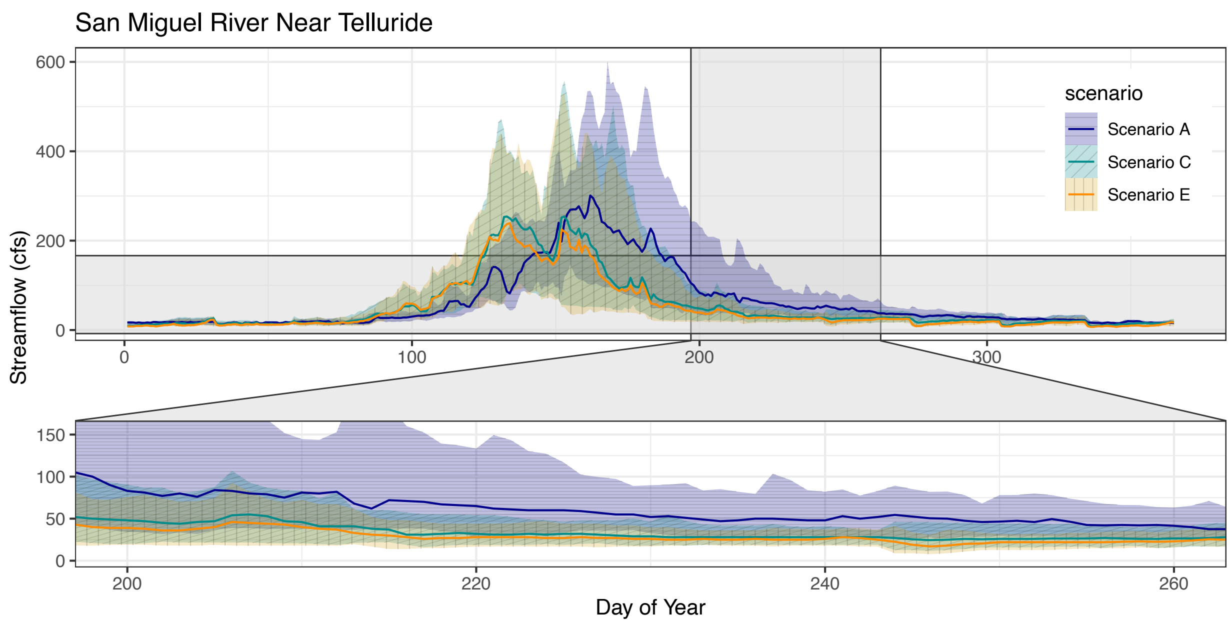

Figure 15. Hydrological regime behaviors for the San Miguel River at near Telluride modeled under three scenarios from the Technical Update to the Colorado Water Plan. Solid lines indicate mean daily flow values across the full simulation period, shaded areas indicate full range of daily flow values observed across the simulation period for a given scenario.

[40] Acharya, A., & Ryu, J. H. (2014). Simple method for streamflow disaggregation. Journal of Hydrologic Engineering, 19(3), 509-519.

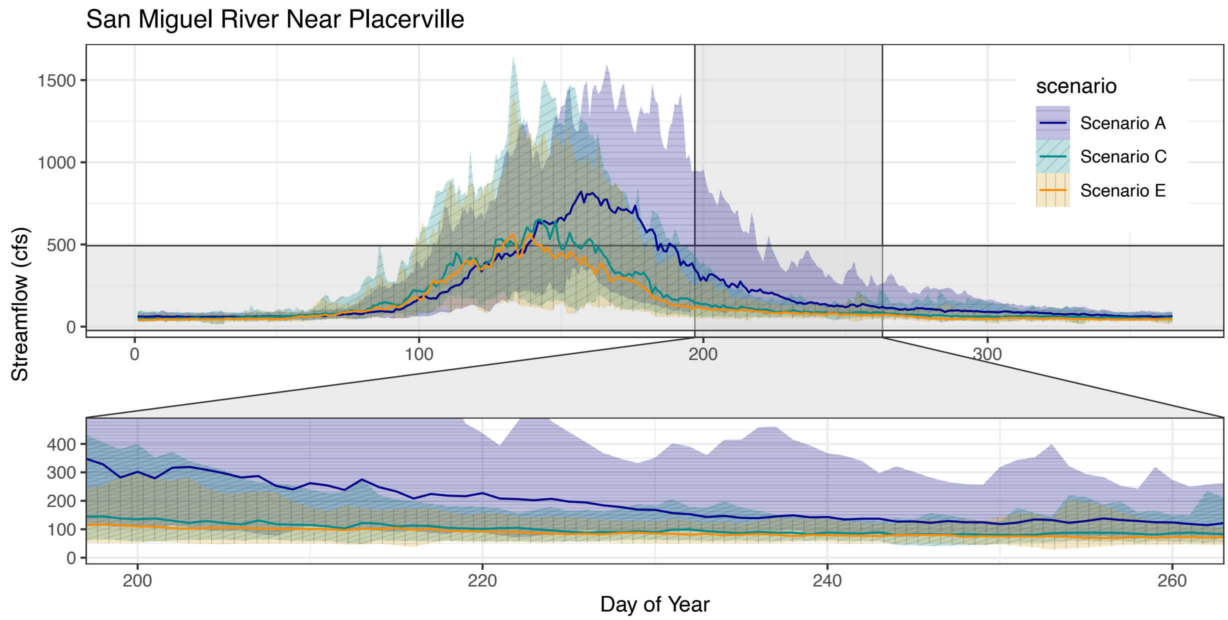

Figure 16. Hydrological regime behaviors for the San Miguel River at Placerville modeled under three scenarios from the Technical Update to the Colorado Water Plan. Solid lines indicate mean daily flow values across the 40-year simulation period, shaded areas indicate full range of daily flow values observed across the simulation period for a given scenario.

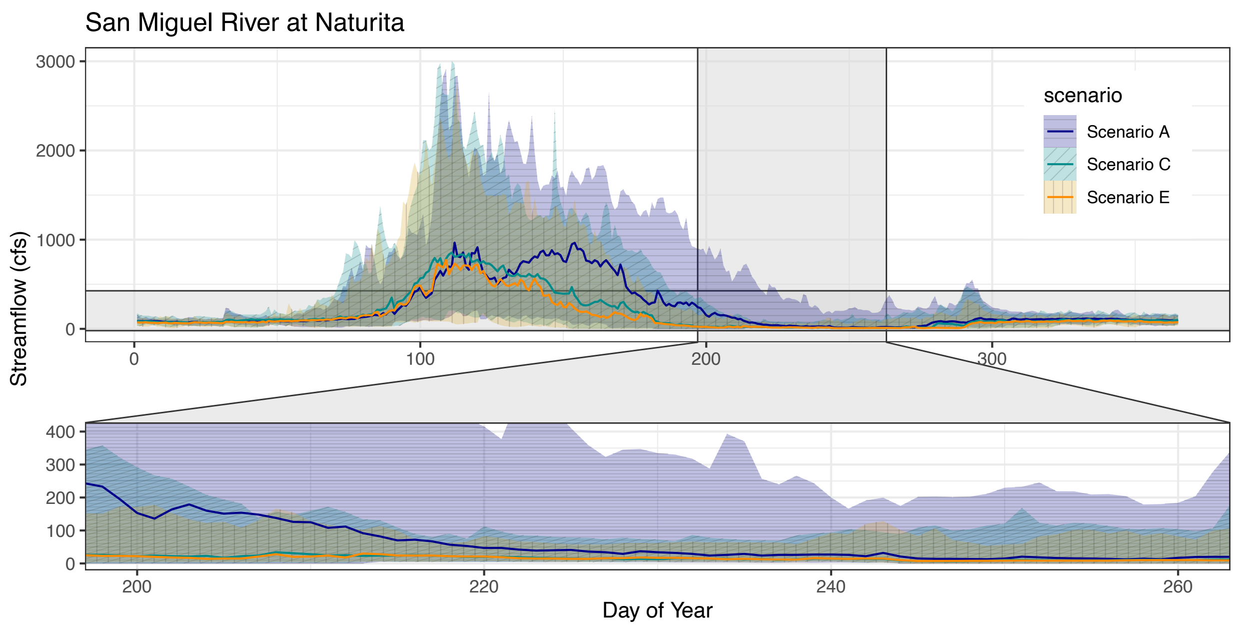

Figure 17. Hydrological regime behaviors for the San Miguel River at Naturita modeled under three scenarios from the Technical Update to the Colorado Water Plan. Solid lines indicate mean daily flow values across the 40-year simulation period, shaded areas indicate full range of daily flow values observed across the simulation period for a given scenario.

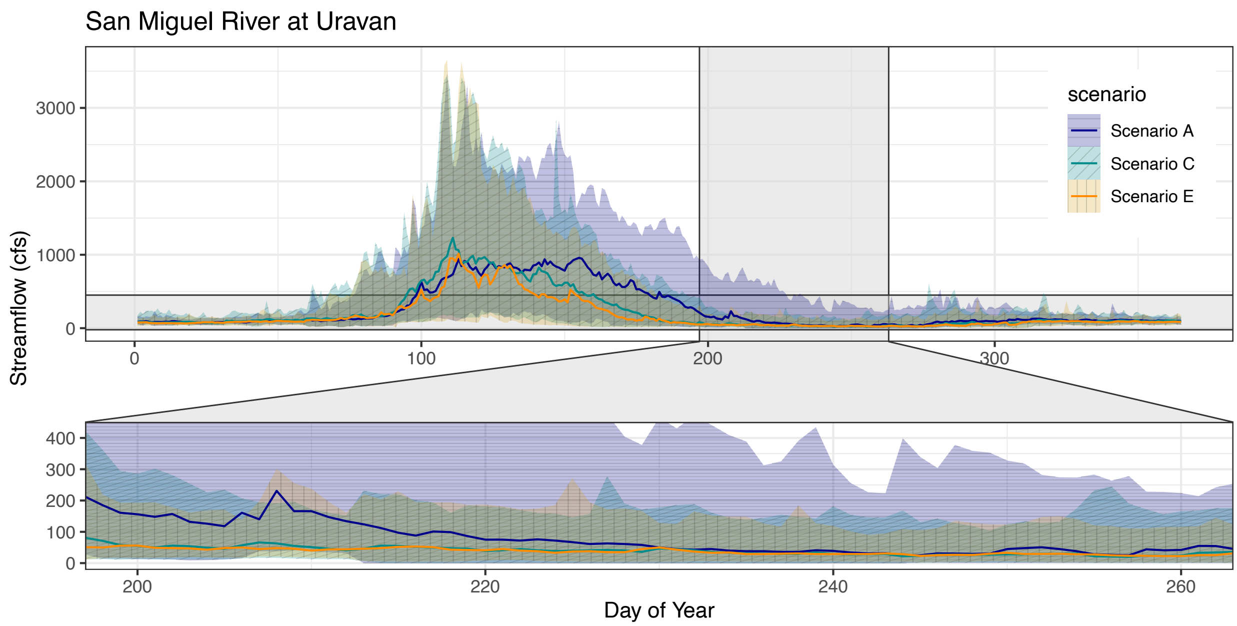

Figure 18. Hydrological regime behaviors for the San Miguel River at Naturita modeled under three scenarios from the Technical Update to the Colorado Water Plan. Solid lines indicate mean daily flow values across the 40-year simulation period, shaded areas indicate full range of daily flow values observed across the simulation period for a given scenario.

The visual comparison of streamflow behavior predicted by the scenario models is supported by computation of various metrics of hydrological behavior (e.g. median July flow, annual 3-day minimum flow). Metrics were computed for each year in the 40-year simulation time series provided for each scenario. Then, the annual metric values were summarized for each scenario by computing the 25th, 50th, and 75th percentiles in the range. A subset of those results deemed most relevant for subsequent discussions of values-at-risk are included here in tabular form (Table 2, Table 3, Table 4).

Table 2. Predicted changes in streamflow behavior for the San Miguel River near Telluride as a function of several climate and development futures included in the Technical Update to the Colorado Water Plan [41].

Metric	Units	Percentile	Baseline Value	Scenario A % Change	Scenario B % Change	Scenario C % Change	Scenario D % Change	Scenario E % Change
Annual Max	cfs	25th	322.5	0	0	-15	-26	-26
		50th	412	0	0	-7	-24	-24
		75th	537.5	0	0	-9	-18	-18
Time to 75% of Total Annual Yield	doy	25th	198	0	0	-10	-12	-12
		50th	206	0	0	-11	-13	-13
		75th	213	0	0	-8	-11	-11
April Max	cfs	25th	63.5	0	0	70	64	64
		50th	78	0	0	88	88	88
		75th	93	0	0	75	83	83
May Max	cfs	25th	207	0	0	13	3	3
		50th	247	0	0	31	15	15
		75th	332.5	0	0	16	12	12
June Max	cfs	25th	286	0	0	-32	-47	-47
		50th	368	0	0	-26	-35	-35
		75th	537	0	0	-9	-20	-20
July Max	cfs	25th	147	0	0	-60	-66	-66
		50th	231	0	0	-55	-63	-63
		75th	348.5	0	0	-58	-65	-65
July Min	cfs	25th	49.5	0	0	-46	-53	-53
		50th	69	0	0	-46	-54	-54
		75th	87.5	0	0	-46	-54	-54
August Min	cfs	25th	31.5	0	0	-40	-46	-46
		50th	39	0	0	-33	-44	-44
		75th	48.5	0	0	-40	-48	-48
September Min	cfs	25th	29	0	0	-41	-58	-58
		50th	31.5	0	0	-33	-52	-52
		75th	38	0	0	-32	-47	-47
Octobr Min	cfs	25th	21	0	0	-55	-67	-67
		50th	25	0	0	-40	-68	-68
3-day Min	cfs	75th	12	0	0	-21	-36	-36
		25th	10	0	0	-30	-40	-40
		50th	11	0	0	-30	-39	-39
7-day Min	cfs	25th	11.29	0	0	-30	-39	-39
		50th	12	0	0	-27	-38	-38
		75th	13.29	0	0	-17	-37	-37
30-day Min	cfs	25th	13.88	0	0	-29	-41	-41
		50th	14.87	0	0	-23	-39	-39
		75th	15.6	0	0	-15	-35	-35

[41] "Technical Update to the Colorado Water Plan."

Table 3. Predicted changes in streamflow behavior for the San Miguel River at Placerville as a function of several climate and development futures included in the Technical Update to the Colorado Water Plan [42].

Metric	Units	Percentile	Baseline Value	Scenario A % Change	Scenario B % Change	Scenario C % Change	Scenario D % Change	Scenario E % Change
Annual Max	cfs	25th	863	0	0	-18	-24	-26
		50th	1113	0	0	-19	-20	-21
		75th	1461	0	0	-8	-20	-21
Time to 75% of Total Annual Yield	doy	25th	198	0	0	-11	-11	-11
		50th	203	0	0	-9	-9	-9
		75th	211	0	0	-6	-7	-6
April Max	cfs	25th	346	0	0	11	5	-2
		50th	481	0	0	22	13	8
		75th	619.5	0	0	29	23	11
May Max	cfs	25th	655.5	0	0	-3	-10	-11
		50th	834	0	0	4	2	0
		75th	1038	0	0	7	1	5
June Max	cfs	25th	812	0	0	-37	-49	-50
		50th	1092	0	0	-37	-41	-42
		75th	1447.5	0	0	-21	-33	-34
July Max	cfs	25th	364	-8	-8	-53	-63	-63
		50th	606	0	0	-56	-62	-62
		75th	955	0	0	-58	-65	-66
July Min	cfs	25th	131	5	5	-43	-48	-48
		50th	201	0	0	-51	-57	-56
		75th	327	0	0	-63	-66	-65
August Min	cfs	25th	93.5	2	2	-34	-44	-43
		50th	114	1	1	-37	-39	-40
		75th	140	0	0	-37	-44	-44
September Min	cfs	25th	69.25	0	0	-28	-36	-38
		50th	84	1	1	-26	-32	-33
		75th	95.5	8	8	-19	-29	-28
Octobr Min	cfs	25th	60	-4	-4	-36	-54	-53
		50th	77	0	0	-33	-48	-49
3-day Min	cfs	75th	57.83	0	0	-24	-35	-34
		25th	39.33	0	0	-22	-58	-58
		50th	46.67	0	0	-21	-40	-37
7-day Min	cfs	25th	41.71	0	0	-22	-56	-55
		50th	48.43	-1	-1	-18	-35	-35
		75th	60.21	0	0	-23	-35	-34
30-day Min	cfs	25th	45.63	0	0	-20	-39	-39
		50th	52.77	0	0	-17	-32	-31
		75th	64.53	0	0	-22	-35	-34

42 "Technical Update to the Colorado Water Plan."

Table 4. Predicted changes in streamflow behavior for the San Miguel River at Uravan as a function of several climate and development futures included in the Technical Update to the Colorado Water Plan.

Metric	Units	Percentile	Baseline Value	Scenario A % Change	Scenario B % Change	Scenario C % Change	Scenario D % Change	Scenario E % Change
Annual Max	cfs	25th	1112	-1	-1	7	-6	-5
		50th	1922	-2	-2	-1	-10	-11
		75th	2454.5	1	1	4	-8	-16
Time to 75% of Total Annual Yield	doy	25th	168	0	0	-10	-9	-9
		50th	172	0	0	-7	-8	-6
		75th	193	0	0	-9	-5	-7
April Max	cfs	25th	866.5	-4	-3	-1	-1	-3
		50th	1601	0	0	1	4	6
		75th	2219.5	0	0	15	1	-7
May Max	cfs	25th	863	0	0	4	-12	-18
		50th	1501	0	0	-17	-32	-27
		75th	2326.5	0	0	-24	-29	-32
June Max	cfs	25th	665	-2	-2	-66	-83	-81
		50th	1040	2	2	-42	-45	-40
		75th	1718	-1	-1	-24	-42	-45
July Max	cfs	25th	246	-6	-6	-51	-72	-64
		50th	589	6	6	-66	-72	-71
		75th	866	4	4	-65	-72	-71
July Min	cfs	25th	40	20	20	-62	-68	-57
		50th	72	21	21	-62	-69	-67
		75th	218	3	3	-77	-81	-81
August Min	cfs	25th	10	10	10	43	-20	30
		50th	24	0	0	-8	-33	-12
		75th	62	6	6	-41	-50	-48
September Min	cfs	25th	6	21	21	-17	0	29
		50th	14.5	3	3	-10	-10	14
		75th	42	1	1	-15	-26	-35
Octobr Min	cfs	25th	14.25	5	5	-35	-30	-35
		50th	28	0	0	-29	-36	-36
3-day Min	cfs	75th	23.33	3	3	-18	-36	-21
		25th	2.67	0	0	12	-13	43
		50th	6.33	26	32	58	11	58
7-day Min	cfs	25th	3.07	14	14	30	2	63
		50th	8.29	34	34	41	-2	34
		75th	26.43	2	2	-15	-28	-22
30-day Min	cfs	25th	5.58	22	25	29	8	83
		50th	19.33	18	18	11	-26	6
		75th	47.73	4	5	-31	-49	-46

Simulation results representing the potential effects of climate change were produced by applying adjustment factors to historical hydrology and, thus, do not effectively demonstrate potential or expected changes in late summer extreme rainfall events produced by a warming climate. Characterizing the effects of increasingly severe rainfall events on flows in the San Miguel and its tributaries requires some consideration of all the potential locations of such events across the entire watershed, the relative intensity and duration of any given event, and the effects of flow routing on flood waves propagating along the stream network—not a trivial task. The reader should take note that such changes were not captured by simulation modeling results that form the basis for scenario comparisons in this effort. This caution is particularly relevant to the presentation of peak flow return periods that indicate declining snowmelt runoff peak flows associated with an increasingly warm future at, for example, a 10-year return period (Figure 19).

Increasing atmospheric moisture content and an associated increase in extreme rainfall event frequency and/or severity might produce the opposite pattern during the summer monsoon period. A simplistic approach to accounting for increasing summer monsoon activity was included here. The potential impact of increased late summer precipitation can be approximated by applying a 107% increase (as per Colorado Dam Safety Office proposed Rule 7.2.4) to observed July-September peak flows on the San Miguel River at Placerville and Uravan.

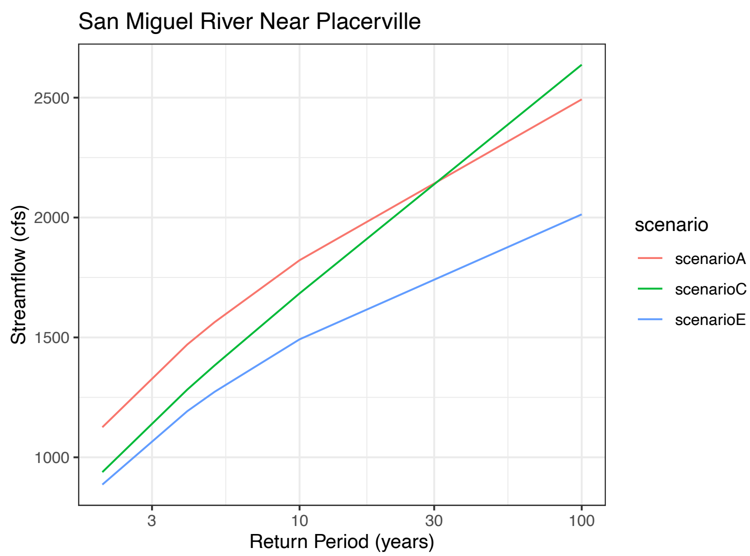

Figure 19. Changing flood return intervals predicted by hydrological scenario modeling for the San Miguel River at Placerville.

3.2.2 Notable Findings

Streamflows in much of the San Miguel watershed reflect natural conditions, particularly during winter and early summer months. However, flows on some reaches of the mainstem and several tributaries are significantly altered by reservoir operations and/or surface water diversions. Climate change scenario modeling suggests that future hydrology may be characterized by earlier snowmelt runoff and reduced annual water yields throughout the planning area. The hydrological analysis presented here is discussed in greater depth in Appendix C. Notable findings of the hydrological assessment effort conducted here include:

- Reservoir operations in the upper watershed alter streamflows on the South Fork San Miguel River in winter months.
- Several tributary streams in the Beaver Creek drainage are completely captured by surface water collection systems during most of the year.
- The segment of the San Miguel River below the Highline Canal is significantly affected by surface water diversions in the late summer months in most years.
- Changing climate may significantly reduce streamflows available to support consumptive and non-consumptive uses by 2050. Impacts of climate change characterized by scenarios C, D, and E suggest

earlier snowmelt runoff, lower average peak flows, lower late summer and fall flows. Climate change scenarios also indicate a wider range of variability in peak flows and low flows (e.g. higher, infrequent runoff events and stronger, infrequent dry summer conditions).

- Potential hydrological changes brought about by climate change include a shift toward earlier peak runoff, a longer low flow summer season, and lower median and minimum flows on the mainstem San Miguel River and its various tributaries. These changes will likely lead to longer periods in any given year when some sections of stream are completely dewatered or experience elevated stream temperatures due to partial dewatering—conditions that might impact the fishery, macroinvertebrates, and other aquatic biota.
- The magnitude of floods with 2-year, 5-year, and 10-year, return intervals is predicted to decline under climate change in the San Miguel watershed, particularly on tributaries and on the mainstem above Naturita. These changes in flood behavior may drive changes in riparian community structure.
- Any changes in peak flow timing and the median flows in summer months on the mainstem San Miguel River will likely impact the ways that recreational boaters and anglers user the river.

The intersection between hydrology and other environmental and recreational attributes of the San Miguel River and its tributaries is explored in greater detail in the sections below.

3.3 Channel Structure

Consideration of the concepts of connectivity, capacity, and complexity are useful for process-level understanding of patterns and distribution of different morphological river states across the San Miguel watershed. Interplay between these critical components of the physical system govern a stream or river's resilience to perturbation. There are no ideal targets for the degree to which a stream reach is connected to adjacent hillslopes or floodplains, for its capacity to move water, sediment, and woody debris, or for the complexity of longitudinal and planform channel structures. Rather, the manifestation of connectivity, capacity, and complexity play out on stream reaches differently depending on landscape position, climate, hydrology, etc. Where these considerations are useful is in understanding existing conditions and natural or management-induced changes to one of the three concepts that may trigger rapid or dramatic changes in system and different—and, potentially, undesirable—channel form and behavior.

A coarse-scale examination of stream and river conditions across the San Miguel watershed indicates the greatest sensitivities to changes in hydrology and sediment transport dynamics along the alluvial reaches of the South Fork of the San Miguel River and along the mainstem of the San Miguel River between Naturita and the Dolores River (Figure 20). Along these reaches, the relationship between peak flow magnitude and frequency and the particle size distribution of sediment in the streambed exerts significant control on channel geometry and rates of change. Most other streams in the watershed exhibit steep gradients and strong process-based connections with adjacent hillslopes. These reaches are likely much more sensitive to land use development and natural disturbances in upland areas (e.g. forest fire) that alter the frequency and magnitude of woody debris inputs, hillslope sediment yields and/or landslide activity.

As a drying climate increases the risk for high-intensity wildfire in the lower watershed, the risk for increased erosion and transport of hillslope soils to the river channel also increases. Drainages that experience high-intensity fires generally produce large yields of sediment in the years following the fire. This may be particularly relevant in areas like the lower San Miguel watershed where the risk of high-severity fire is high (Figure 21) and high-intensity monsoonal rainstorms are a common occurrence. Sediment mobilized by precipitation events can quickly move downslope to streams and rivers where it can cause rapid aggradation of the stream channel, changes in the alignment of the river, and significant damage to transportation infrastructure, water diversion infrastructure, homes, and businesses.

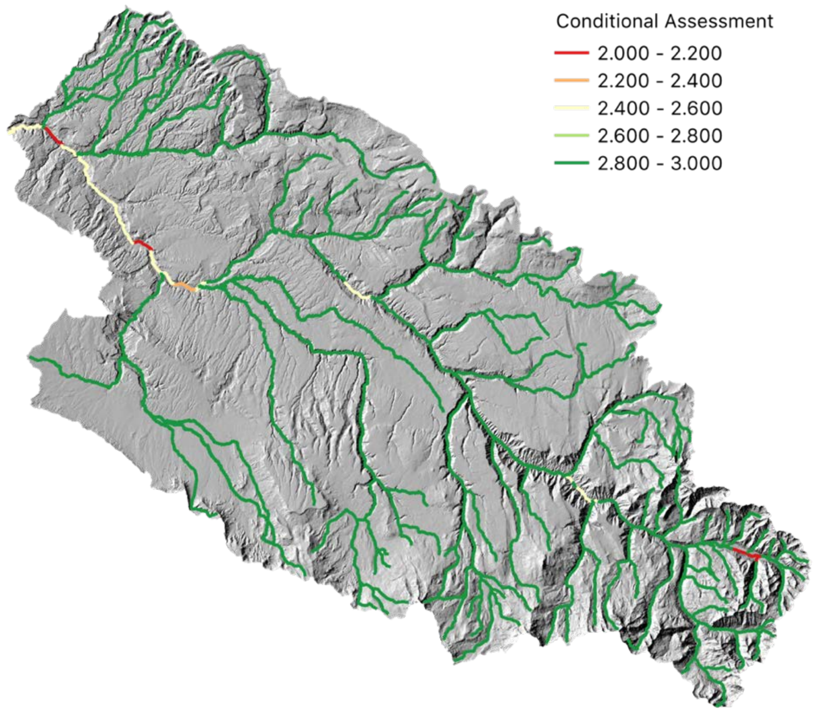

Figure 20. Channel form and behavior conditional assessment results from across the San Miguel watershed. High scores indicate greater resilience to change following perturbation.

The coarse scale analysis applied here did not indicate alterations to expected channel conditions due to land use activities in tributary basins. The relatively low channel form and behavior conditional assessment scores assigned to segments of the San Miguel River between Naturita and the Dolores River reflect important changes in sediment transport dynamics that occur within the river in this part of the watershed. Development activities in several reaches of the San Miguel significantly resulted in channel straightening that significantly reduced channel complexity and limited connections between the river and its floodplain. This condition is most pronounced on the San Miguel River mainstem in Uravan and in Telluride between Bear Creek and Prospect Creek. Short segments of the mainstem near Sawpit, Placerville, and the confluence with Horsefly Creek exhibit similar, albeit less severe, conditions.

The most pronounced impacts to channel morphology and dynamics exist in and around Telluride where historical straightening and diking of the San Miguel River alters sediment and water transport capacity and continues to limit connectivity to the floodplain. The section of straightened channel between these locations appears to be transporting sediment at a much faster rate than it receives loads from upstream. This likely results in some down-cutting, streambed and bank armoring, and reduced likelihood for lateral channel movement through the straightened reach. These changes produce a channel that is out of alignment with its biophysical setting and likely limit habitat quality and riparian function on the San Miguel River near Telluride. Ongoing work in the Telluride Valley to realign this portion of the stream and reconnect it with the floodplain is expected to yield improvements in numerous physical and biological river processes. Among the potential beneficial impacts is an elevated water table and enhanced late season baseflows on this section of river.

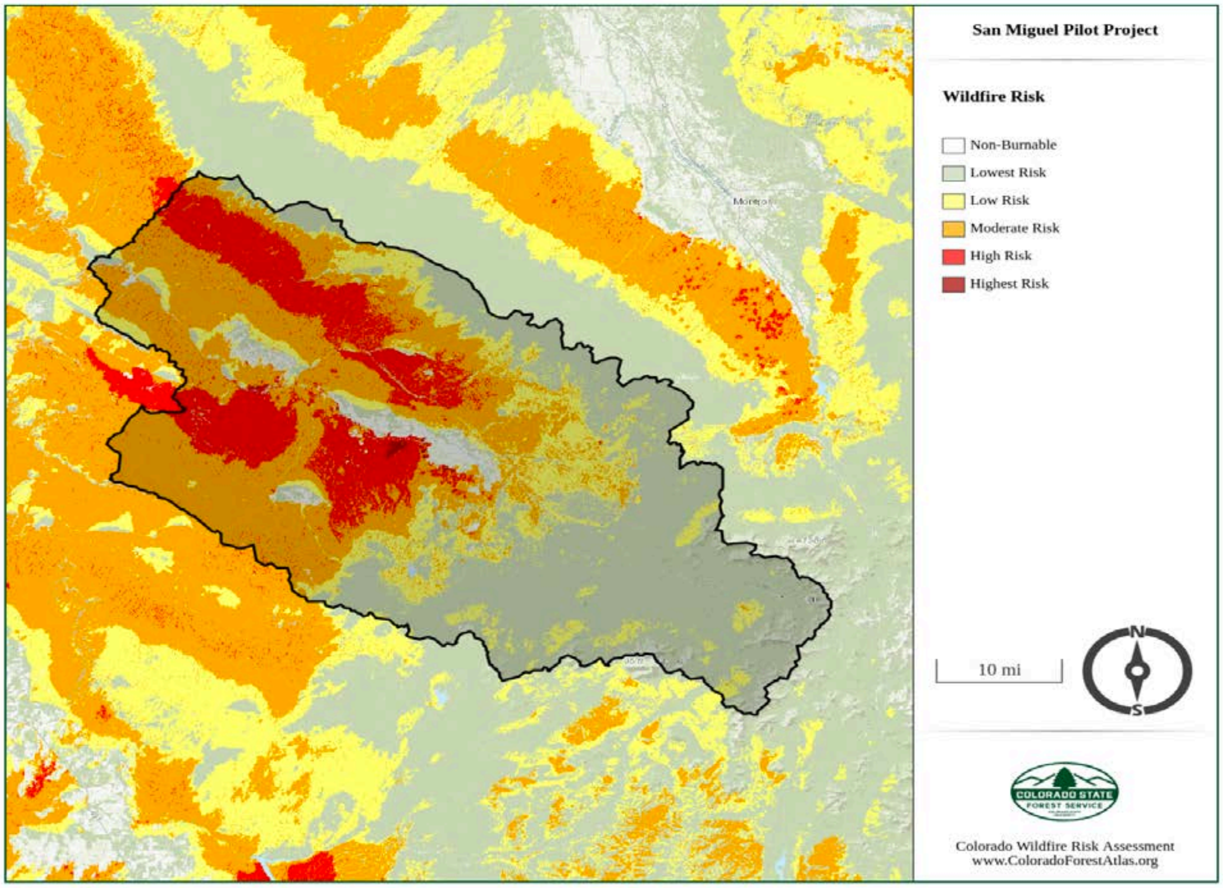

Figure 21. Wildfire risk in the San Miguel watershed.

Some concern existed historically in the watershed for the impact of ice floes on rates of erosion and cannel form on the mainstem San Miguel River. Floes typically begin in the South Fork San Miguel River, 2.5 miles from confluence with mainstem. Floes can transit all the way to the Dolores River. Ice jamming and flooding in the lower watershed usually occur in the spring. Ice growth usually occurs immediately following hydropower surges, and ice floe surges are triggered by sustained cold temperatures. Ice jamming and flooding in the lower watershed usually occur in the spring. Ice growth is anecdotally linked to hydropower surges, and ice floe surges typically occur during periods of sustained cold temperatures. Observations indicate that the size of a given ice flow is roughly proportional to number of preceding degree days below freezing[43].

Previous investigations were unsuccessful in associating ice floes with rates of increased channel erosion or instabilities[44]; however, local residents remain concerned about the potential impact of scour produced by ice movement to impair the fishery, macroinvertebrate communities and near-shore vegetation. Recent data

[43] Ferrick, Michael and Dennis Murphy. 2000. Investigation of River Ice Processes on the San Miguel River, Colorado (unpublished). 1U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, NH and 2U.S. Bureau of Land Management, Montrose, CO.

[44] D. P. Groeneveld, "An Overview of Recent Bank Instability on San Miguel River.," Hydro-Biological Consulting, San Miguel County, 2000.

collection efforts by CPW indicate potential impacts of ice floes on overwintering fish on the mainstem San Miguel River. A study conducted by BLM suggests that certain flow management activities at Trout Lake and the Ames Power Plant may promote ice floe formation on the South Fork San Miguel[45]. However, impacts on ice formation in the middle San Miguel watershed are more difficult to assess[46]. Ice floes have been documented to occur on the San Miguel River since at least 1909 (Figure 22).

Figure 22. An ice floe on the San Miguel River near Placerville in 1909. Photo courtesy of the Denver Public Library.

In September of that year, a large flood breached the Trout Lake dam and it wasn't rebuilt until the summer of 1910[47]. Thus, the ice floe event documented in the winter of 1909 was likely a natural event. A lack of ice floe records before this period and the fact that reservoir construction and hydropower plant operation in the upper watershed began in the late 1800s significantly complicates the task of understanding the degree to which ice floes are exacerbated (or not) by water management activities in the upper watershed. An evaluation of reservoir/hydropower facility operation on frazil ice formation in the South Fork San Miguel River in the FERC permit renewal for the AMES Power Plant recommended reservoir release ramping rates, minimum bypass flows, and installation of water column mixers to cool hypolimnetic water in Trout Lake—all strategies intended to promote stable ice cover on the South Fork San Miguel River and, thereby, limit downstream ice accumulation.[48]

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[45] Ice Accumulation Downstream of the Ames Powerhouse; Quality of the Sport Fishery Potentially Affected by the Project; Quality and Health of the Native Fish Communities, Ames Water/Terrestrial RWG Issue Nos. 1-2-4 Initial Study Plan Draft 09/08/2005

[46] Beltaos, S. (2008). Progress in the study and management of river ice jams. Cold regions science and technology, 51(1), 2-19.

[47] https://en.wikipedia.org/wiki/Trout_Lake_(Colorado)

[48] State of The San Miguel Annual Report, 2008, San Miguel Watershed Coalition.

3.3.1 Sediment Transport

Hydrological time series data and one-dimensional sediment transport models constructed using cross-sectional channel geometry and particle size distributions evaluated the magnitude and recurrence interval of flow events important for sediment transport on the South Fork of the San Miguel River and at various locations along the mainstem San Miguel River below Telluride. Conclusions provided by previous investigations into sediment transport[49,50] were verified and augmented through collection of new data in 2016. Sediment transport investigation results and previous studies conducted by USGS and others indicate a pattern of increasing divergence between the recurrence intervals associated with bankfull and sediment mobilization ("effective") discharges moving from upstream near the confluence with the South Fork San Miguel River downstream near Uravan.

This pattern seems to suggest that sediment moving from the upper watershed is accumulating in the lower watershed. However, associated evidence of sediment aggradation or lateral channel movement is somewhat lacking in this area. Another possibility is that colluvial inputs to the river in the lower watershed or sediment loads carried by ephemeral tributaries during large monsoonal events consist of somewhat larger particle-size fractions than the normal load carried downstream from the upper watershed. If this is the case, then it may be possible that the recurrence interval of colluvial or flood events that contribute these larger particle sizes to the river are lower than the recurrence interval of the flows required to mobilize them on the mainstem San Miguel. This would result in relatively short and infrequent periods of sediment deposition and accumulation in the lower river, followed by large transport events that would move the accumulated sediment out of the system. This may help explain why evidence of sediment aggradation is lacking. Regardless of the explanation, the increasing dissimilarity between bankfull discharge and the dominant sediment transporting flows as one moves from the upper watershed to the lower watershed indicates a reduced capacity for sediment transport and a greater sensitivity to changes in peak flow magnitude and frequencies or changes in the timing and magnitude of sediment inputs as one moves in the downstream direction.

3.3.2 Scenario Modeling

The characteristics of hydrology most directly related to the structure and behavior of the stream channel are those that relate to the scour, movement, and deposition of sediment along the river corridor. The scenario modeling conducted as part of this planning process yielded predictions for flood recurrence intervals at locations across the watershed under a variety of planning scenarios. Scenarios A and B do not diverge significantly from baseline (i.e. current conditions). Scenarios C, D, and E indicate varying degrees of departure form current conditions at locations on the mainstem San Miguel River (Figure 23) and the mouths of tributaries to the San Miguel. The flows responsible for mobilizing and transporting the greatest amount sediment on the San Miguel mainstem historically occurred at a 2.5 to 4-year frequency. A review of the flood recurrence interval curves associated with hydrological scenario modeling indicates that floods of those magnitudes occur less frequently under climate change. The impact is particularly pronounced at Telluride and Placerville. As sediment transporting flows become less frequent, the channel may become more sensitive to episodic or transient inputs of sediment (e.g. sediment loading produced by wildfire).

It is also important to note that climate futures that change the composition and extent of riparian communities may alter the way that riparian vegetation interacts with channel hydraulics to mediate channel form and

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[49] Allred, Tyler M. and E. D. Andrews, "Hydrology, Geomorphology, and Sediment Transport of the San Miguel River, Southwest Colorado." U.S. Geological Survey.

[50] D. P. Groeneveld, "An Overview of Recent Bank Instability on San Miguel River.," Hydro-Biological Consulting, San Miguel County, 2000.

movement. The potential impact of a changing climate and hydrological regime on riparian communities is discussed in the next section.

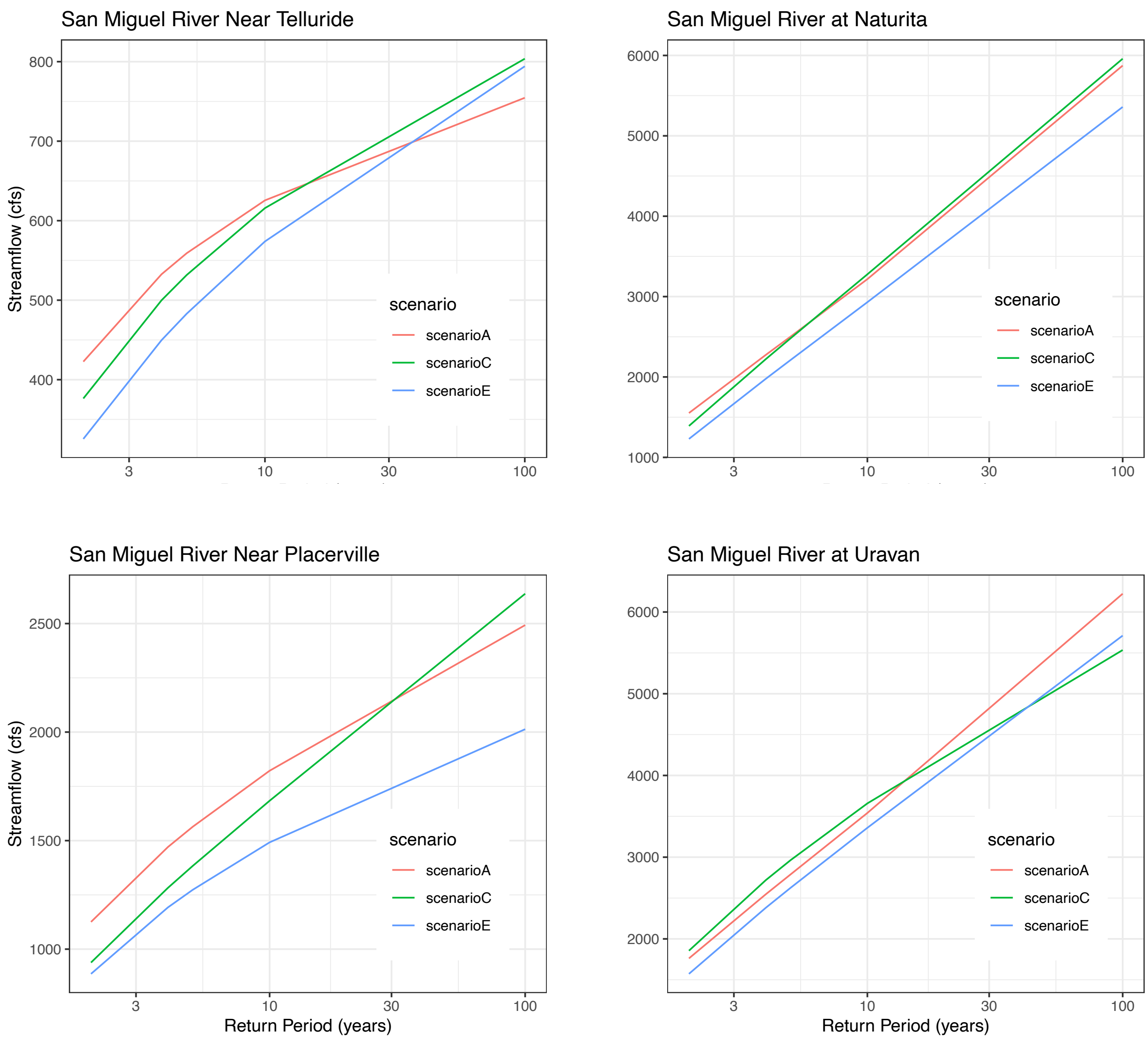

Figure 23. Flood magnitude return intervals predicted under Scenarios A, B, and C at locations in the upper, middle, and lower watershed.

3.3.3 Notable Findings

Modification of the hydrological regime, altered patterns of erosion, adjustments to the structure of the channel bed, or changes in riparian community composition and extent may yield fundamental shifts in the geometry and behavior of the stream channel. Changes in sediment supply, peak flow magnitude and duration, or the extent of streambank vegetation may lead to changes in local channel forms, reductions in aquatic habitat quality, altered connectivity between the stream and the floodplain, and the stability and reliability of local infrastructure (e.g. surface water diversion structures, bridges, roadways). A full discussion of the channel structure and sediment transport assessment methodology and results is included in Appendix D. Primary findings produced by this assessment include:

- Structural modification of the channel on the San Miguel River near Telluride increases sediment transport capacity and limits floodplain development and maintenance in what would otherwise be a depositional zone hosting a well-connected alluvial channel. Ongoing restoration work in this area should address this condition.
- Peak flows required to perform channel maintenance activities on the mainstem San Miguel River (e.g. between 3300-4600 cfs at Uravan) historically occurred at least once every 2-4 years.
- Shifts in either the peak flow characteristics of the San Miguel River or in the delivery of sediment to the river channel from hillslopes and tributary streams can lead to shifts in channel form and behavior and corresponding impacts on aquatic/riparian habitat and water delivery and transportation infrastructure located in the river corridor.
- Scenario modeling indicates that under a "Business as Usual" future, flows require to perform channel maintenance activities will continue to occur at least once every 2-4 years. Scenarios that consider the potential impacts of change scenarios (i.e. scenarios C, D and E) indicate a decline in magnitude of floods with 2-4 year recurrence intervals. If these flood magnitudes are decreased and sediment inputs to the system remain unchanged, altered channel form and behavior on some sections of the San Miguel River is likely. The largest change in mainstem peak flow behavior under climate change is expected on reaches above Naturita. Pocket floodplains in Norwood Canyon and alluvial valley bottoms near Telluride and at the confluence with the South Fork San Miguel may be the first places changes to channel form and behavior will manifest following diminished peak flow magnitudes.
- San Miguel mainstem segments below Cottonwood Creek appear more vulnerable to changes in sediment delivery produced by wildfire. This portion of the watershed is at higher risk for wildfire than the rest of the watershed and the historical record indicates that monsoonal rainfall is capable of producing major runoff responses in lower-watershed tributaries and, subsequently, in the lower reaches of the mainstem San Miguel River. High-intensity rainfall events on burn areas are known to mobilize massive amounts of sediment in similar geographic settings. Increased sediment delivery to the river channel may lead to rapid channel migration across valley bottoms, degradation of aquatic habitat, and impacts to water diversion infrastructure.
- The risk for synergistic impacts of decreased peak flow magnitudes due to climate change and increased sediment delivery following wildfire appear greatest in reaches of the San Miguel River between Placerville and Naturita. This section of the river corridor is home to unique riparian forests, both warm-water and cold-water fish, and is regularly used by anglers and whitewater boaters. Numerous important irrigation water diversions also exist along this section. Thus, changes in channel form and behavior in this reach of river may impact both consumptive and non-consumptive water uses.

3.4 Riparian Health

Riparian zones are ecosystems that exist adjacent to rivers and streams. Often, they act as transitional zones from the riverbed to drier uplands and provide important habitat for wildlife. They can provide water quality benefits by absorbing runoff originating in hillslopes and overbank areas. Riparian area extent and function is largely a function of landscape position, local hydrology, and development activities in the floodplain. Despite their relatively small total land coverage in the San Miguel watershed, riparian zones produce outsized contributions to biological diversity and abundance, as well as strong controls on water quality, aquatic habitat, and physical channel dynamics.

The Bureau of Land Management (BLM) designates several segments of the San Miguel River and its tributaries as Areas of Critical Environmental Concern (ACEC) due to high biodiversity significance (Figure 24). BLM applies special management actions towards preserving the extensive and exemplary riparian community present in these areas. Existing and proposed ACEC lands within the watershed extend from Deep Creek to the Dolores River and include sections of Saltado Creek, Beaver Creek and a portion of Leopard Creek[51]. Stakeholders indicated that all special management areas and reaches containing rare and significant plant communities should be included in evaluations of water management impacts on riparian health.

Flood-dependent and woody species dominate riparian areas along the lower San Miguel River. Below the confluence with Horsefly Creek, Fremont cottonwood dominate the overstory. Rio Grande cottonwood and hybrid cottonwood species dominate the overstory in the San Miguel mainstem above Uravan Canyon. The understory in the lower watershed is mostly comprised of native shrubs: skunkbush, New Mexico Privet, and buffaloberry, with sandbar willow present immediately adjacent the channel. Above the confluence with Horsefly Creek, riparian community composition is less strongly governed by floods. The riparian overstory in Norwood Canyon is conifer-dominated: mostly blue spruce, Douglas fir, and ponderosa pine. The understory consists of alder and redosier dogwood in areas adjacent the stream. Native shrubs, including skunkbush and buffaloberry, occur in less-frequently inundated areas on the floodplain. The reaches of the San Miguel River between Norwood and Telluride exhibit an overstory of mixed conifer and narrowleaf cottonwood, which occur primarily on high terraces. Alder, sandbar willow and planeleaf willow dominate the understory immediately adjacent to the channel. Above Telluride the overstory consists mostly of barren ground and planeleaf willows. Sedges and tufted hairgrass dominate the understory in this area [52].

[51] "Draft Evaluation of Proposed and Existing Areas of Critical Environmental Concern for the Uncompahgre Planning Area." Bureau of Land Management, Jun-2010.

[52] Kittel and Lederer, "A Preliminary Classification of the Riparian Vegetation of the Yampa and San Miguel/Dolores River Basins."

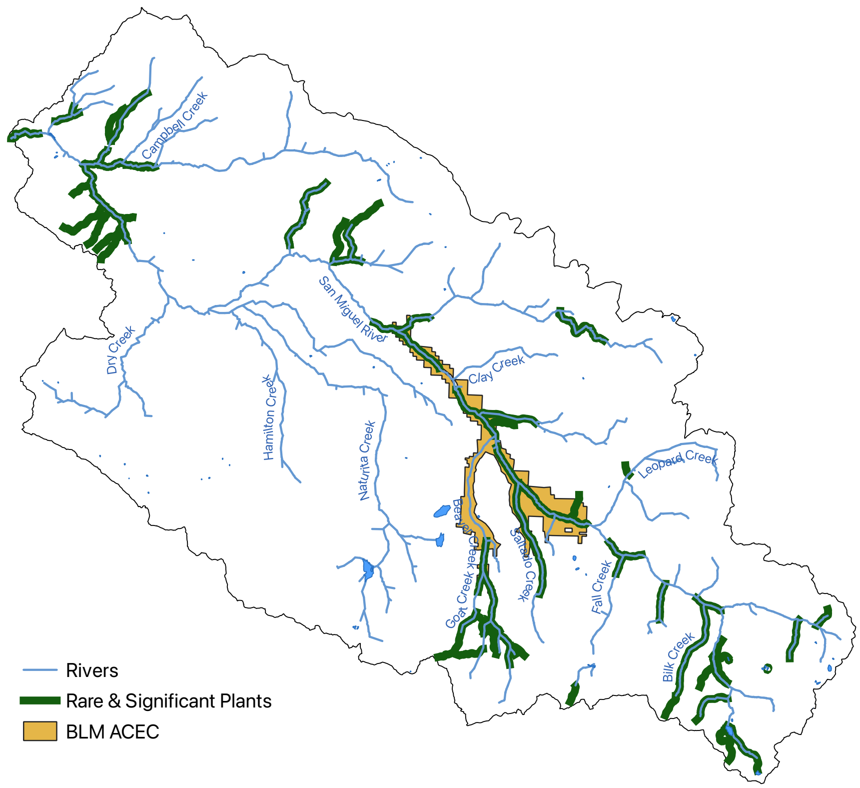

Figure 24. Locations of rare and significant plant communities inhabiting riparian zones and river segments managed as Areas of Critical Environmental Concern (ACEC) by the BLM within the San Miguel watershed.

The disturbance regime and moisture gradients controlling riparian zone position and extent significantly differ between the upper and lower watershed. Alluvial processes control disturbance and riparian recruitment in the lower basin, while riparian extent is more strongly controlled by colluvial processes (e.g. landslides) and beaver activity in the upper basin and in headwaters tributaries. Shallow water tables exist only in close proximity to streams, rivers, and irrigation canals in the lower basin, constraining areas with soil moisture sufficient to support most riparian species. In the upper basin, hillslope groundwater inputs and a wetter precipitation regime create patches of favorable soil moisture and water table elevations much further from the stream. The effect of these disturbance and moisture patterns plays out in the decreasing fraction of riparian vegetation occupying the historic river channel as one moves from upstream to downstream along the San Miguel River. Near Uravan 100% of the riparian zone occurs within the historically inundated floodplain, while only 50% of riparian vegetation occurs within that zone along the South Fork of the San Miguel River (Figure 25) [53]. As a result, riparian areas in the lower watershed are expected to exhibit less resilience to water management activities than those in the upper watershed. Conversely, riparian areas in the upper watershed will respond to changes in land use activities on hillslopes much more strongly than those occurring lower in the system.

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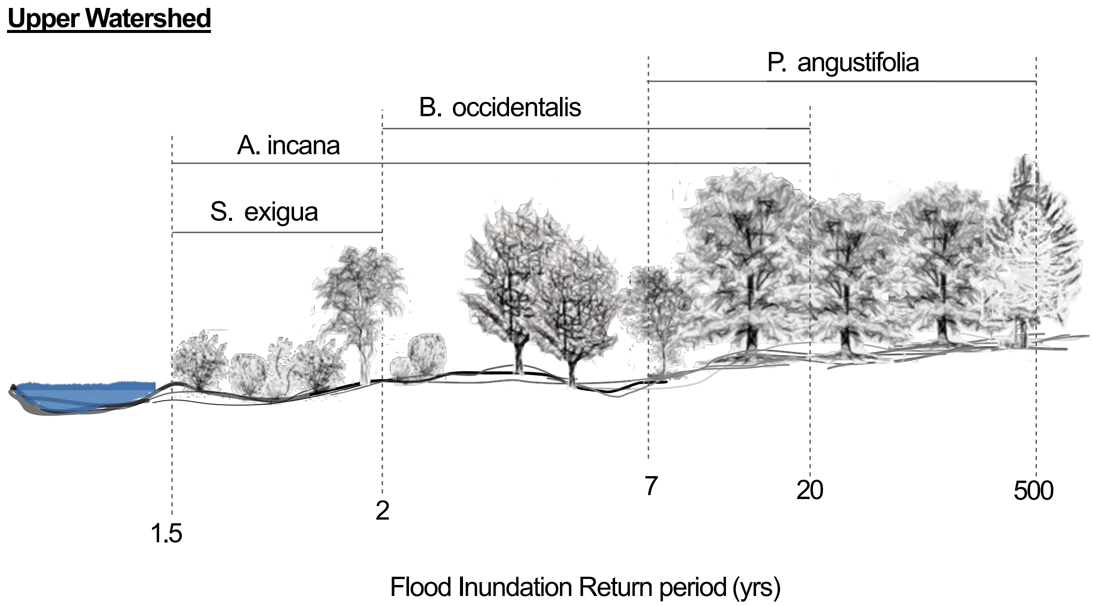
[53] Friedman et al., "Transverse and Longitudinal Variation in Woody Riparian Vegetation along a Montane River."



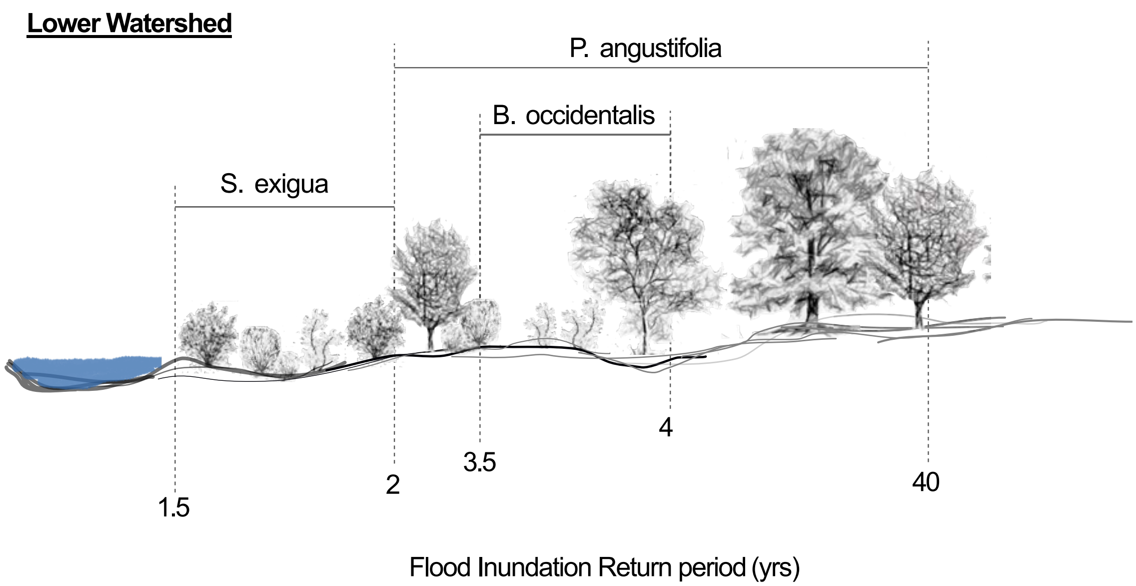


Figure 25. Distributions of riparian plant species, including Populus fremontii (Freemont cottonwood), Populus deltoids (Rio Grande cottonwood), and Populus angustifolia (narrowleaf cottonwood) relative to the frequency of flood inundation in the upper (top) and lower (bottom) reaches of the San Miguel River. The distribution of riparian vegetation in the lower watershed is much more strongly controlled by flood hydrology. Hillslope hydrology plays a much more important role in the upper watershed.

Riparian vegetation communities exist in a dynamic state both physically (between the river and its floodplain) and in time (between periods of runoff and baseflows). Occasional scouring of overbank areas provides the necessary habitat for germination of many riparian plant species. Following germination, seedlings require a relatively slow reduction in water table height over the progression of the growing season. Rapid water table elevation reductions or late season water table heights that drop below the rooting depth of cottonwoods and other riparian plants stress vegetation and can lead to seedling mortality. Changes in channel and floodplain structure or adjustments in the magnitude, timing or frequency of peak flows and baseflows may, therefore, limit the establishment of younger plants and produce stands of mostly mature plants. Riparian health was assessed in the field by evaluating relationships between the hydrological regime, local channel structure, and riparian recruitment potential [54]. Recent investigations conducted by the BLM on segments of the mainstem San Miguel considered relationships between river flows, floodplain groundwater elevations, and vegetation stress [55].

Flow recommendations for support of existing riparian communities reflect the assessment of low-flow thresholds discussed above and the natural peak flow hydrology present on the alluvial sections of the San Miguel River and the expectation that existing riparian extents will be maintained through hydrological regime behavior reflecting historical conditions. Existing flood hydrology regimes in this part of the watershed are critical to maintaining riparian zone width and providing suitable conditions for recruitment of new plants. While existing hydrological regime characteristics do not appear to limit riparian recruitment potential, biophysical conditions on the San Miguel River and its tributaries in the lower watershed tend to support invasive species and allow them to outcompete native vegetation in many areas (Figure 26). As a result, ongoing mechanical and/or biological invasive species control programs are likely necessary.

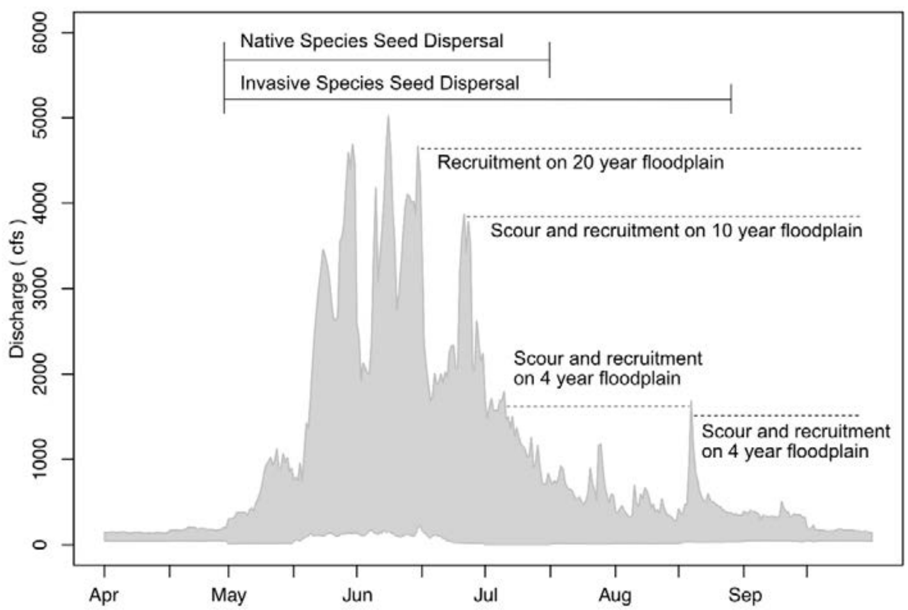


Figure 26. In the lower reaches of the San Miguel River, late season peak flow events scour floodplain surfaces, providing recruitment opportunity for invasive species with longer seed dispersal windows than native riparian vegetation.

Recent efforts by local organizations to control and eradicate Tamarisk from the western portion of the watershed yielded significant successes and the presence of the species was much diminished by 2013 (Figure 27). Concerns about the impact to riparian areas from Russian olive and Russian knapweed remain. These species are of particular concern in the western portion of the watershed. Russian olive exists in and around

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[54] Mahoney and Rood, "A Device for Studying the Influence of Declining Water Table on Poplar Growth and Survival."

[55] Cooper and Conovitz, "Surface and Groundwater Interactions along the Middle and Lower San Miguel River, CO: Implications for Plant Water Sources, Plant Water Status, and the Susceptibility of Riparian Vegetation to Impacts from Changing River Base Flows."

the towns of Norwood, Nucla and Naturita. The seeds from these trees can be viable for up to 20 years and are often transported significant distances by birds, making control of the species difficult once it's established. Russian knapweed, an invasive herbaceous plant is common in the western watershed[56]. A full discussion of invasive plant species, the riparian assessment methodology and results is included in Appendix E.

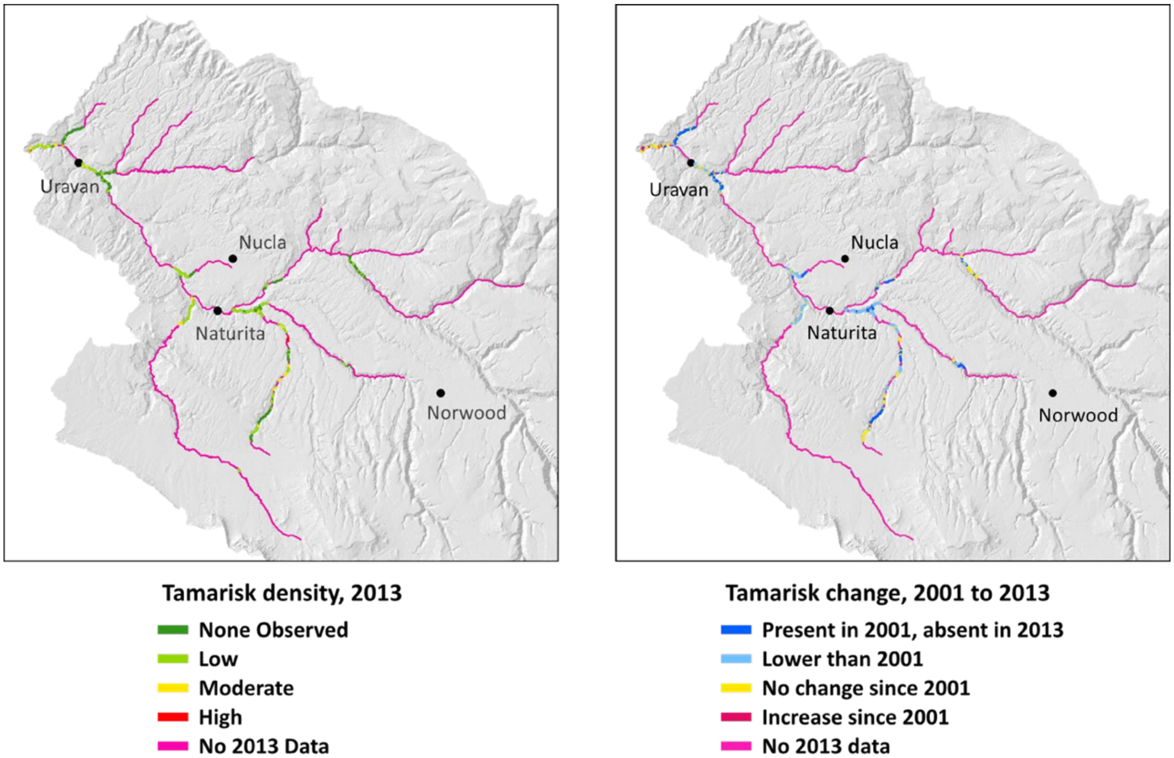

Figure 27. Tamarisk densities observed in 2013 and observed changes in density between 2001 and 2013 following active treatment and removal efforts (Data source: The Nature Conservancy).

3.4.1 Scenario Modeling

Evaluation of the distribution of riparian plant communities across floodplains in the lower San Miguel watershed, combined with characterization of flood regimes and mapping of flood inundation frequency bounds within those riparian communities (Figure 25) provides a means for understanding how future changes in flood regimes may impact riparian forests. Riparian communities along the lower San Miguel River are, generally, expected to become less diverse as peak flow magnitudes diminish (Figure 28). Cottonwood-alder forests, sandbar willow communities, and birch communities decrease in areal extent as floods with a given return frequency decrease. Cottonwood forests mixed with spruce and other upland shrubs, woody and herbaceous species are expected to become more dominant. A reduction in the diversity of riparian plant communities present along the river corridor is expected to diminish habitat quality for terrestrial and avian species.

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[56] https://sanmiguelwatershed.org/uploads/docs/water/reportCardUpdate_2006.pdf

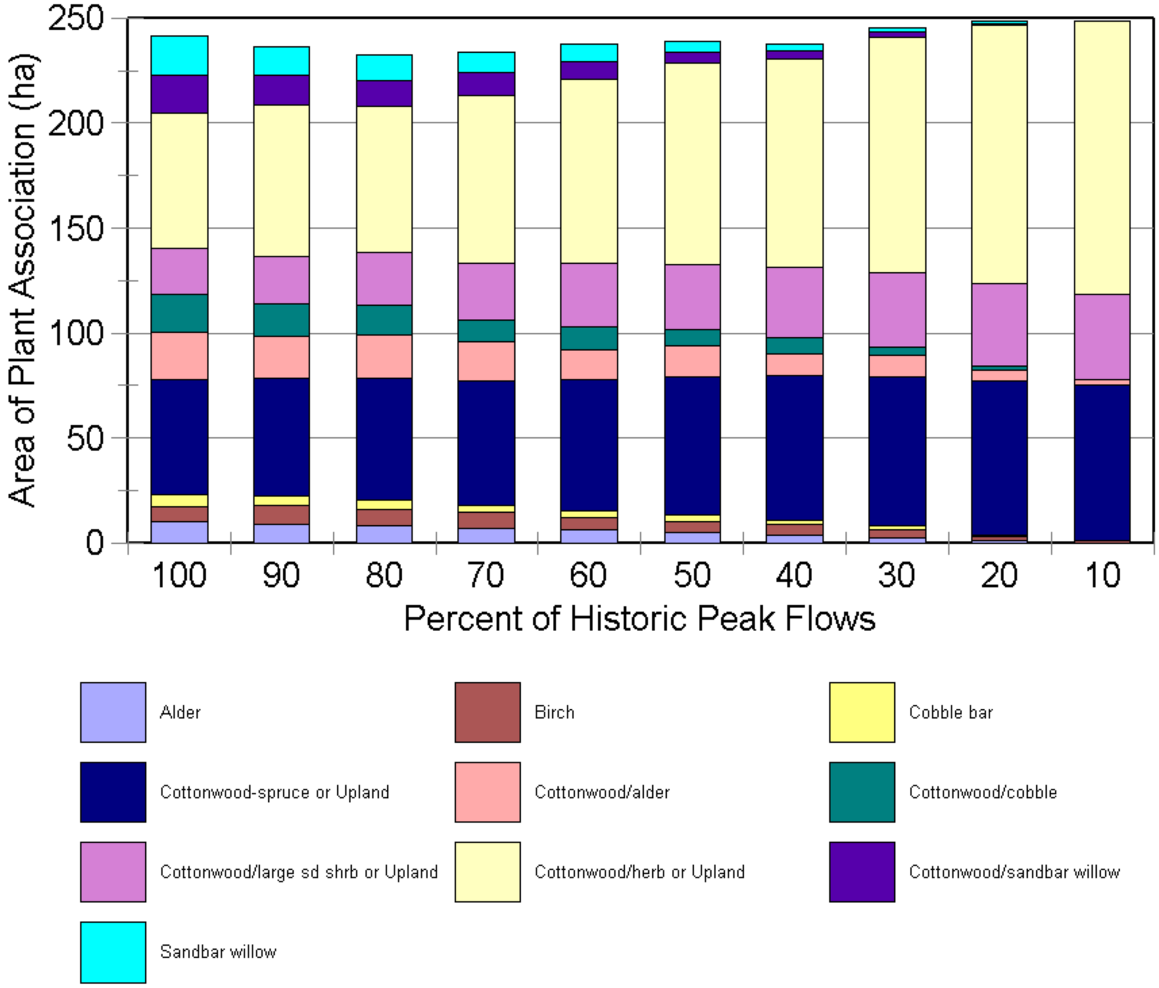

Figure 28. Changes in riparian community composition under reduced peak streamflows predicted by a model of observed relationships between flood magnitude and recurrence interval and the relative position of various plant communities[57].

Scenario modeling indicates varying degrees of change in annual peak flow change in the upper, middle and lower San Miguel River corridor. The climate change scenarios (i.e. C, D, and E) indicate a ~10% to 25% decline in the 50th-75th percentile peak flow magnitude between Telluride and Naturita (Table 5). Declines predicted at Uravan are less severe and range between ~0% and 15%. Scenario modeling, thus, indicates that the potential impacts of climate change in the San Miguel basin include simplification of riparian forest community structure.

[57] J. M. Friedman and G. T. Auble, "High flow and riparian vegetation along the San Miguel River, Colorado," U.S. Geological Survey, Fort Collins, Colorado, Intra-Agency Agreement USGS #3302-20C21.

Table 5. Annual flood magnitudes predicted at several locations along the San Miguel River corridor under various scenarios. The 50th percentile annual flood magnitude is equivalent to the 1-in-2-year flood. The 75th percentile magnitude is approximately equivalent to the 1-in-4-year flood.

Location	Percentile	Baseline Value	Scenario A % Change	Scenario B % Change	Scenario C % Change	Scenario D % Change	Scenario E % Change
San Miguel River at Telluride	50th	412	0	0	-7	-24	-24
	75th	537.5	0	0	-9	-18	-18
San Miguel River at Placerville	50th	1113	0	0	-19	-20	-21
	75th	1461	0	0	-8	-20	-21
San Miguel River at Naturita	50th	1472	5	6	9	-27	-25
	75th	2184	2	2	-2	-9	-7
San Miguel River at Uravan	50th	1922	-2	-2	-1	-10	-11
	75th	2454.5	1	1	4	-8	-16

3.4.2 Notable Findings

The San Miguel watershed is home to unique and diverse riparian forests. Assessment of these forests indicates and increasing sensitivity to peak flow change and low flows among those forests in the lower portion of the watershed. Those findings are discussed in detail in Appendix E. Notable findings regarding riparian areas include:

- Peak flow magnitudes with a recurrence interval of 5-years correspond to the area of greatest vegetation diversity on floodplains in the lower watershed. All riparian vegetation in the lower reaches of the San Miguel River corridor exists within areas that are inundated at a frequency less than or equal to the lifespan of the oldest lived individual plants. This suggests that the extent of riparian communities is strongly mediated by flood behavior in the lower watershed. Riparian vegetation extent in the upper watershed appears weakly controlled by flood behavior. Thus, riparian forests in the lower watershed are at greater risk for impact due to some change in peak flow behavior.

- Mortality inducing conditions for newly recruited cottonwood species tend to increase in dry years and are more extensive in the lower watershed. Drying conditions predicted under climate change scenarios C, D, and E may increase the frequency of mortality inducing conditions and, thus, limit the rate of recruitment of new woody vegetation in riparian forests.

- Significant water supply related to late season vegetation stress may exist between Cottonwood Creek and the Dolores River in average and dry years. Growing season baseflows at or above 85 cfs on the San Miguel River below Placerville may be required to avoid critical vegetation stress and xylem cavitation in cottonwoods[58]. **Note:** The BLM identified critical water stress in riparian vegetation during late-summer at a study plot in Uravan but did not estimate the elevated flow condition necessary to avoid this condition. The study did provide a flow management target at a study plot near Placerville, however. Floodplain conditions generally get drier and hotter between Placerville and Uravan. Therefore, the flow target identified for Placerville was assumed relevant for lower sections of the San Miguel River. Stakeholders may elect to support additional study to verify this assumption.

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[58] Cooper and Conovitz.

- Colonization of riparian areas by invasive vegetation, tamarisk and Russian olive in particular, is an ongoing management concern in the lower watershed[59]. Short-duration flood events produced by late-summer monsoon rainfall scour floodplain surfaces and provide preferential conditions for spread of invasive species with long seed dispersal windows.
- Reductions in peak flow magnitude predicted by climate change scenarios C, D, and E may lead riparian forests in the lower watershed to become less diverse and more dominated by mixes of cottonwood and upland woody, shrub, and herbaceous species.

3.5 Biota

The San Miguel watershed is also home to many aquatic, avian, amphibian, and mammalian species that inhabit stream channels the riparian areas. Notable indicator species of overall river health include trout, macroinvertebrates, bald eagles, river otters, and great blue heron. Just as characterizing the extent and condition of fisheries throughout the watershed can promote understanding of physical and biological processes that promote or degrade ecosystem resilience, so too can examination of the presence and condition of terrestrial and avian species.

3.5.1 Terrestrial and Avian Species

The San Miguel ACEC is home to more than 300 bird species, including five species of large waterbirds, 25 species of waterfowl, 16 raptor species, 5 fallinaceous, 5 rails and cranes, 25 plovers and sandpipers, 2 doves, 8 owls, 6 hummingbirds, 7 woodpeckers, 15 flycatchers, 7 swallows, 9 corvids, 11 thrushes and thrashers, 4 vereos, 17 warblers, 2 tanagers, 24 grosbeaks and sparrows, 8 blackbirds, 12 finches, and 17 species of chickadees, nuthatches, wrens, kinglets, and gnat catchers [60]. Ash-throated flycatchers are known to inhabit the San Miguel River corridor in the vicinity of Tabaguache Creek.

The mid-watershed serves as an important wintering area for the bald eagle. Bald eagles roost and nest in tall cottonwood and ponderosa pines along the river, moving around areas seasonally based on regional weather patterns and current weather conditions. They are sensitive to human activity near nesting areas. Populations, historically, have been severely impacted by DDT poisoning and habitat destruction nationwide, earning Federal Threatened and Endangered Species listing. Populations have since recovered, and the bird was delisted from Federal listing but is still on the State species list of Special Concern. Populations in the San Miguel are threatened by riparian habitat destruction from oil/gas, residential, and agricultural development in floodplains and human intrusion on nearby roosting and nesting sites. Important bald eagle habitat exists in riparian zones along Horsefly Creek, the San Miguel River through Norwood Canyon, Wright's Mesa, and the Dry Creek Basin[61,62].

After disappearing from Colorado completely following initial settlement, CPW began reintroducing river otters to waterways throughout the state in the 1970's. The river otter was reintroduced to the Dolores River in the

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[59] The Nature Conservancy, "Save the Native: San Miguel Tamarisk Monitoring Update 2014."

[60] https://www.audubon.org/important-bird-areas/san-miguel-area-critical-concern

[61] Lyon, P., & Sovell, J. (2000). A natural heritage assessment: San Miguel and western Montrose counties, Colorado. Fort Collins, CO: Colorado Natural Heritage Program. Retrieved from https://dspace.library.colostate.edu/handle/10217/47150

[62] The Nature Conservancy, & San Miguel Watershed Coalition. (2005). 2005 Report Card: Ecological Health of the San Miguel Watershed.

late 1980's and has since established an expanded population along the mainstem San Miguel River between the Dolores River and the Town of Telluride. They typically occur in riparian areas, frequently near abandoned beaver dens, and subsist on a variety of aquatic animals. The river otter is listed as a State Threatened Species[63,64,65] and remains sensitive to development or resource management activities that alter the quality and availability of riparian habitat.

While there are no specific methodologies available for characterizing changes to the quality and/or availability of habitat for the species noted above as brought about by changing flow conditions, most of these species utilize or rely on riparian zones for some part of the year. Land and water management actions that degrade riparian area extent or health are, therefore, expected to degrade conditions for avian and terrestrial species that inhabit those areas.

Beavers occupy a unique role as a species that is both dependent on flow from rivers and stream to provide critical habitat and a species that is quite effective at modifying the physical and vegetative characteristics of the stream corridor and the behaviors of the hydrological regime. Beavers in the San Miguel watershed tend to occupy low-order, high-elevation streams. The history of interactions between beavers and humans across the western United States is full of conflict. Beavers may build dams on culverts, irrigation ditches, or other human-made water conveyances. For these reasons, beavers may be targeted for removal or extermination from some streams. Notably, the activity of beaver dam construction may help maintain groundwater elevations in alluvial aquifers and, thereby, support late season streamflows in downstream segments[66]. The specific impacts of beaver activity on hydrological behavior on streams throughout the planning area is not known. However, some aggregate impact is expected and late summer flows in some areas may be higher than they would be in the absence of the species.

3.5.2 Aquatic Biota

Fish and macroinvertebrates are the two most frequently referenced groups of organisms in efforts to assess biological conditions in Colorado rivers and streams. Both groups are readily observed and sampled. A wide array of methodologies is available to assess characteristics of populations or individuals to evaluate the quality and availability of aquatic habitat. Both macroinvertebrates and the fishery were considered on the San Miguel and its tributaries.

Aquatic macroinvertebrates help scientists gauge trends in stream health.[67] Macroinvertebrates are sensitive to pollutants (including temperature) and streamflow, and their relative immobility, short lifespans, and easy observation make them a great yardstick for overall stream health. Both the BLM and CDPHE monitor macroinvertebrates in the San Miguel watershed. The BLM's analysis found that macroinvertebrate populations were 'good' between Beaver Creek and Tabeguache Creek, 'fair' below the Uravan Mill site, and 'poor' below the CC Ditch[68]. CDPHE's macroinvertebrate monitored segments all satisfied the agency's minimum

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[63] Colorado Parks and Wildlife. (n.d.). River Otter. Retrieved from http://cpw.state.co.us/learn/Pages/SpeciesProfiles.aspx

[64] San Miguel Watershed Coalition. (2014). State of the San Miguel Watershed: 2014. Telluride, CO: San Miguel Watershed Coalition.

[65] The Nature Conservancy, & San Miguel Watershed Coalition. (2005). 2005 Report Card: Ecological Health of the San Miguel Watershed.

[66] Munir, T. M., & Westbrook, C. J. (2020). Beaver dam analogue configurations influence stream and riparian water table dynamics of a degraded spring-fed creek in the Canadian Rockies. River Research and Applications.

[67] San Miguel Watershed Coalition, State of the San Miguel Watershed at 20 (2014).

[68] Id.

threshold[69]. An earlier 2005 study by TNC and the San Miguel Watershed Coalition graded four different segments for macroinvertebrates, showing a trend of decreasing quality moving downstream: South Fork to Specie Creek, A-; Specie Creek to Horsefly Creek, B+; Horsefly to Tuttle Draw, D; Tuttle Draw to the Mouth, C[70]. Degraded macroinvertebrate communities co-occur with sections of stream that are regularly dewatered during summer months. Degradation of these communities can have cascading impacts on aquatic food webs as macroinvertebrates represent and important food source for other aquatic species like fish.

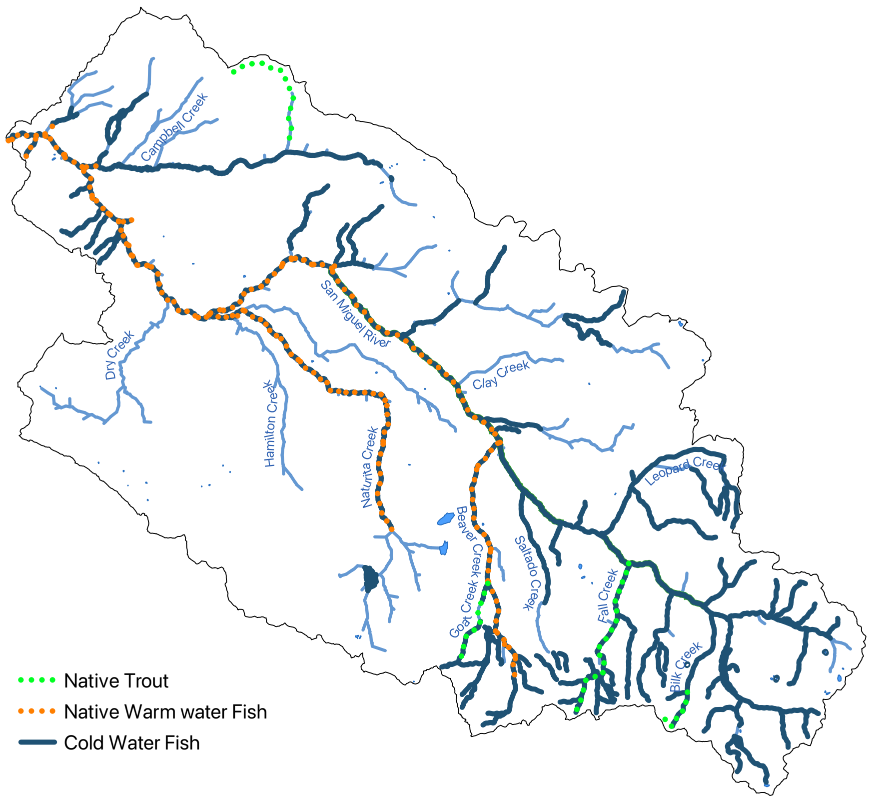

Figure 29. Stream segments in the San Miguel watershed with known populations or potential to support native warm-water, native trout, or sport fisheries.

The fisheries supported by streams and rivers throughout the San Miguel watershed are typically broken into two basic classifications: warm-water and cold-water. Both fishery classifications include native and non-native fish and several state or federally-listed species of concern (Figure 29). The lower San Miguel basin provides important habitat to support several native warm-water fish species, including roundtail chub, flannelmouth sucker, and bluehead sucker. Non-native species include several species of dace, bass, suckers, some species of minnow, and catfish. Native cold-water fish in the San Miguel watershed include Colorado cutthroat trout mottled sculpin and speckled dace. Non-native cold-water species in the San Miguel watershed comprise the main sport fishery and include rainbow trout, brown trout, and brook trout. Stocking of non-indigenous

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[69] San Miguel Watershed Coalition, State of the San Miguel Watershed (2014).

[70] The Nature Conservancy and the San Miguel Watershed Coalition, 2005 Report Card: The Ecological Health of the San Miguel River Watershed, at 19.

cutthroat trout has also historically occurred in some tributary reaches in the San Miguel watershed. Both native cold-water and warm-water fisheries exhibit significant alteration due to historic human management activities but demonstrate some recent movement back toward historical conditions. Fishery health in both the San Miguel River and the Dolores River below the confluence is supported by a relatively natural hydrological regime in the basin. Primary challenges to fishery health in the San Miguel include habitat loss and competition/hybridization between native and non-native species.

Warm-water fish species typically reside in the San Miguel River mainstem and its tributaries below Horsefly Creek. These species also use the mainstem and tributaries between Horsefly Creek and Beaver Creek for spring spawning migration (*personal communication with Colorado Parks and Wildlife*). The lower watershed is home to several species of note, including roundtail chub, bluehead sucker and flannelmouth sucker. All three are BLM-listed Sensitive Species due to significant reductions in historic range and largely unprotected habitat [71]. Historic population reductions resulting from mining-related water quality impacts and habitat loss due to surface water depletions have recently stabilized and each species now occurs throughout their historic ranges in the San Miguel watershed. However, persistent population decline in surrounding basins and unprotected habitat throughout the region keep these species on the Sensitive Species list.

Of the three native warm-water species, the bluehead sucker ranges highest in the basin, as they prefer steeper, faster streams. Species success is dependent on adequate base flows and the availability of high-quality of riffle habitat [72]. Bluehead suckers prefer rocky-bottomed streams with moderately cool temperatures (~68° F). Spawning is triggered by a critical water temperature (~60° F) and, therefore, starts earlier for fish residing at lower elevations in the watershed. Young bluehead suckers prefer slow-moving water close to streambanks. They move to deeper, covered areas away from streambanks as they progress into juvenile and adult life stages. Feeding preferences mirror habitat preferences: larval fish find vertebrates in the deep rocky pools and riffles near shore, and older fish feast on algae, plant detritus and invertebrates in their covered pools and riffles further away from streambanks [73].

Like the bluehead sucker, the flannelmouth sucker is also dependent on adequate base flows and the quality of riffle and run morphology [74]. Flannelmouth suckers generally inhabit unvegetated murky pools or riffle/run areas in gravel, rock, sand, or mud bottomed streams. Younger fish seek out shallow riffles and eddies near the shore, migrating towards the deeper riffles and runs in adulthood. Larval flannelmouth suckers prey on invertebrates, transitioning to a variety of algae, detritus, plant debris and invertebrates in later life stages. This species will migrate long distances in the spring to find suitable spawning habitat [75].

Roundtail chub are habitat generalists; however, the species remains sensitive to baseflow reductions [76]. Roundtail chub prefer slow-moving, deep pools for cover and feeding but will inhabit streams with a variety of substrate types -- silt, sand, gravel -- and occur in both murky and clear water. Preferred habitat varies by lifestage. Juveniles and young-of-year seek out pools and quiet backwaters, while adults gravitate towards eddies and pools adjacent to strong currents. Spawning is triggered by water temperatures, beginning in June or early

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[71] "State of the San Miguel Watershed 2014."

[72] Kowalski, "Native and Sport Fish of the San Miguel and Dolores Rivers."

[73] "Range-Wide Conservation Agreement and Strategy for Roundtail Chub, Bluehead Sucker, and Flannelmouth Sucker."

[74] Kowalski, "Native and Sport Fish of the San Miguel and Dolores Rivers."

[75] "Range-Wide Conservation Agreement and Strategy for Roundtail Chub, Bluehead Sucker, and Flannelmouth Sucker."

[76] Kowalski, "Native and Sport Fish of the San Miguel and Dolores Rivers."

July when temperatures have reached 65° F. Spawning is expected to occur on clean substrates in the mainstem San Miguel River and on the lower portion of tributaries of the San Miguel River. Roundtail chub are carnivorous, opportunistically feeding on available insects, fish, snails, crustaceans, algae and sometimes lizards. They are more likely to be limited by available food resources than by habitat [77].

Water quality impacts from numerous legacy mining operations and whirling disease contributed to population declines in the recent past. Warm-water fishery health experienced marked improvement following the completion of uranium mining cleanup efforts around Uravan. Despite these gains, cumulative water diversions on the mainstem and tributaries below the CC-Highline Ditch decrease water quantity, increase water temperatures, and reduce stream network connectivity, impacting the quantity and quality of available aquatic habitat for warm-water species.

Habitats suitable for cold-water and warm-water fish overlap in the middle portion of the San Miguel watershed. In this area, it is possible to find species belonging to both groups. The CC-Highline Ditch is generally considered the dividing line between the expected ranges for cold-water and warm-water fish species. This is reflected in Colorado Water Quality Control Division 305(b) segmentation under the Clean Water Act and the accompanying water quality standards for aquatic life health. However, local knowledge and observations indicate viable cold-water trout habitat could exist below the CC-Highline Ditch if and when water temperatures were suitable. Furthermore, CPW believes that certain warm-water fish species move up the tributaries near Norwood Hill to spawn in the spring, though there is no documentation of this due to typical monitoring timeframes by CPW in the San Miguel [78]. Overlapping habitat among native warm-water fish and piscivorous non-native, stocked sport fish like brown trout may suppress native fish populations in some reaches during some periods of the year.

Cold-water native fish species, including Colorado cutthroat trout, mottled sculpin, and speckled dace occur at higher elevations on the San Miguel River mainstem and its tributaries. The Colorado cutthroat trout is designated a Colorado Species of Concern. Cutthroat trout lost approximately 90% of their original habitat range in the San Miguel and experienced significant population reductions due to impacts from water diversion, stocking of non-native fish species, and mining. Populations stabilized in recent years, but vulnerability to population declines in the future persists due to a significant reduction in range [79]. Cutthroat trout tend to occupy lower order streams and alpine lakes. Occurrence in these streams is correlated to habitat characteristics unfavorable to non-native fish. Populations of cutthroat in the San Miguel watershed exist in Fall Creek, Muddy Creek, Leopard Creek, Elk Creek, East Beaver Creek, Middle, East and West Beaver Creeks, Deep Creek, upper Bilk Creek, Goat Creek, and Red Feather Canyon. Isolated populations also exist in Red Feather Canyon off Horsefly Creek and in the North Fork of Tabeguache Creek. CPW stocks Woods Lake, which feeds Muddy and Fall Creek, with genetically pure hatchery-raised cutthroat trout. The Colorado Natural Heritage Program has delineated Protected Conservation Areas along Elk Creek and Red Feather Canyon to protect cutthroat populations in those tributaries [80].

Seasonal migration to smaller perennial streams for spawning is triggered by increased flow from spring runoff. Once in spawning habitat, cutthroat wait until water temperatures reach 44-50° F and peak runoff subsides before depositing redds and returning to their stream of origin. The extent of movement between spawning

[77] "Range-Wide Conservation Agreement and Strategy for Roundtail Chub, Bluehead Sucker, and Flannelmouth Sucker."

[78] Personal communication with Colorado Parks and Wildlife staff.

[79] "State of the San Miguel Watershed 2014"; Lyon and Sovell, "A Natural Heritage Assessment: San Miguel and Western Montrose Counties, Colorado"; Kowalski, "Native and Sport Fish of the San Miguel and Dolores Rivers."

[80] Id.

grounds and streams of origin is largely dictated by stream network connectivity. After emergence, fry move to shallow, slow moving areas near spawning zones before migrating to larger streams. Juveniles and adults favor covered, slow-moving pools and protected areas for feeding in the summer and deep pools, beaver ponds and groundwater upwelling zones during the winter [81].

The dominant non-native cold-water species in the San Miguel watershed include brown trout, rainbow trout and brook trout. These species occupy similar ecological niches to Colorado cutthroat trout, and have become important keystone species and indicators of overall health of riverine ecosystems. Additionally, USFS considers them a Management Indicator Species. Non-native trout populations in the San Miguel are considered stable, but natural reproduction rates are low. These populations are stocked, managed and promoted by CPW as a sports fishery. Rainbow trout are stocked regularly, and brown trout and brook trout only occasionally. Brown trout require less stocking because they are generally successful in establishing self-sustaining populations. Ecological concerns regarding the impact of stocked brook trout on the viability of Colorado cutthroat trout populations significantly influence management decisions regarding sport fish.

Both brook and brown trout prefer clear streams that support robust and diverse riparian vegetative cover. Brook trout can exist in high population densities, thriving in beaver ponds and other confined areas. Brown trout prefer slightly deeper, slower and warmer water, undercut banks and covered bankside areas, and can tolerate lower quality habitat. Rainbow trout are habitat generalist, but often occupy mid-channel areas. Rainbow and brook trout feed mainly on insects, while brown trout are piscivorous, surviving mainly on other fish [82]. Non-native trout need warmer water temperatures than native cutthroat trout. Of the three non-native species, brook trout tolerates the coldest water temperatures (~57° F). Rainbow trout prefer warmer water temperatures (~70° F), and brown trout need the warmest water temperatures of the three, (~65-75° F) and are, therefore, generally found in the lowest elevations. Spawning and incubation periods for all non-native trout species are partially queued by and dependent on photoperiods and water temperatures. Brook and brown trout spawn in the late fall (September-November) when days get shorter and water temperatures fall. Rainbow trout spawn in the spring when water temperatures begin to rise (March-May). Both spring and fall spawning periods fall on the shoulders of the irrigation season when water is diverted from the San Miguel River and its tributaries to support agricultural, municipal, and industrial uses. Fall spawning species are probably most impacted by surface water divisions in the San Miguel as this is a period of acute water depletion on some stream segments.

Most sections of the mainstem San Miguel River exhibits insect abundance and high-quality spring and summer habitat capable of supporting robust cold-water fisheries. However, several natural and human phenomena do conspire to impact the fishery in some reaches and in some years. The mainstem San Miguel River below Horsefly Creek is regularly dewatered in summer months, limiting macroinvertebrate abundance, an important food supply for trout and native warm-water fish. The mainstem is also periodically impacted by large winter ice floes. These events frequently scour habitat and produce high mortality among over-wintering fish populations. Recognizing this, CPW manages the river as a stocking stream, stocking catchable-size rainbow trout that typically survive one winter at best. The San Miguel river does not boast any Gold Medal Fishery reaches. For waters to be considered a Gold Medal Fishery in Colorado, they must produce 60 pounds of trout

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[81] Young, "Colorado River Cutthroat Trout."

[82] Dare, Carrillo, and Speas, "Common Trout Species and Conservation Assessment for the Grand Mesa, Uncompahgre, and Gunnison National Forests."

per acre, and contain an average of at least twelve 14-inch or larger trout per acre.[83] The San Miguel does not typically meet the 60 pounds per acre portion of the standard.[84]

Water temperatures are also regularly noted by stakeholders as an issue of ongoing concern. The Colorado Water Quality Control Division classifies the Marshall Creek to South Fork reach, which flows through Telluride's bottom valley, as a cold water stream, and set an in-stream standard for dissolved oxygen (among others).[85] In 2018, the WQCD added this reach to Colorado's 303(d) Monitoring and Evaluation List for temperature.[86] The Telluride Regional Wastewater Treatment Plant's discharge permit requires the City to monitor stream temperatures within this reach, with a proposed Water Quality-Based Effluent Limit of 21.7°C.[87] Temperature loggers deployed at Society Turn from 2009 to 2011 showed daily mean temperatures are below the chronic high-temperature standard established for fish for the majority of the year; however, the report cautioned that the River appears to be warming.[88] Temperature loggers installed at Norwood Bridge from 2009 to 2011 told the same story as those at Society Turn: daily mean temperatures are below the chronic high-temperature standard established for fish.[89] Water temperatures warm considerably downstream of Horsefly Creek and the current water quality standard for the section below the Tri-State power generation facility has a much higher summer chronic threshold (26.3°C), reflecting the natural characteristics of this low-elevation reach and the combined impacts of dewatering and effluent from the power generation station. The water temperatures in this section of river are likely unsuitable for most cold-water species of fish.

The water supply needs of cold and warm-water fisheries (sport and native) throughout the San Miguel watershed were characterized by analyzing relationships between river structure, streamflows, and aquatic habitat quality and extent. This characterization occurred on the mainstem San Miguel River and on major tributaries where fisheries were documented and where sufficient data existed to complete an analysis. Most fish species exhibit preferences for certain habitat types, and those preferences change with life-stage. Habitat quality is generally evaluated based on an examination of the way that hydraulic conditions (e.g., water depth and velocity) change with varying streamflow at different times of year. Where and when optimal conditions exist, fish can utilize local habitat for feeding, sheltering, and reproducing. Changes in streamflow (in timing, magnitude, or frequency) may preclude use of some stream areas and create barriers to passage for fish or other types of aquatic wildlife.

This assessment also performed a desktop assessment of stream network connectivity for aquatic organisms. Private and public road crossings and surface water diversion structures are known to limit movement of fish in some settings. Those limitations can both stress fish (e.g. trapping a trout in warming stream reach) or protect them (e.g. by isolating native cutthroats from non-native populations of trout). Most of the barriers to aquatic organism passage appear to exist on tributary streams in the San Miguel watershed. Surface water diversions and culverts on USFS, BLM, and County Road stream crossings are the most likely infrastructure to create

[83] Colorado Parks and Wildlife Commission Policy: Wild and Gold Medal Trout Management (June 6, 2019).

[84] Email from Eric Gardunio, CPW Area Aquatic Biologist, to Zach Smith (Nov. 3, 2020).

[85] Appendix A, Water Quality Assessment San Miguel River, Telluride Regional WWTF, at 3 (2008).

[86] Regulation #93 Dashboard, found at: https://www.colorado.gov/pacific/cdphe/wq-regulation-93-dashboard; 5 C.C.R. 1002-93, at 25 (2020).

[87] Colorado Department of Public Health and the Environment, Colorado Discharge Permit System (CDPS) Fact Sheet for Permit Number CO0041840, City of Telluride, Telluride Regional WWTF.

[88] San Miguel Watershed Coalition, State of the San Miguel Watershed at 15 (2014).

[89] Id.

barriers. While a full cataloging of the types and severity of these barriers was beyond the scope of this project, areas of the network that where barriers are expected to be most limiting to local fish populations were noted. These include the lower 1.0 mile of every tributary to the San Miguel River. Tributary mouths are increasingly recognized by aquatic biologists as critical spawning and refuge habitat for native species. Any surface water diversions or road crossings on tributary streams that fall within this buffer should be considered potential candidates for fish passage enhancement projects. Providing passage at these locations will be most beneficial during spring and fall spawning seasons, which, conveniently, tend to fall on the shoulders of the primary irrigation season.

Any structure targeted for fish passage enhancements should also consider the associated benefits of fish screening. Screens help limit fish entrainment in water conveyance infrastructure—an outcome that generally lead to mortality of entrained individuals. The most important locations for identifying opportunities for fish screen projects are on reaches inhabited by native cutthroat trout. Fish passage and screening projects on reaches below those known to harbor native cutthroat may also help expand habitat for those species. Any project of this type should be conducted in close coordination with CPW biologist to limit the potential for inadvertent connection of adjacent habitats harboring cutthroat trout and non-native trout (i.e. brook and rainbow trout).

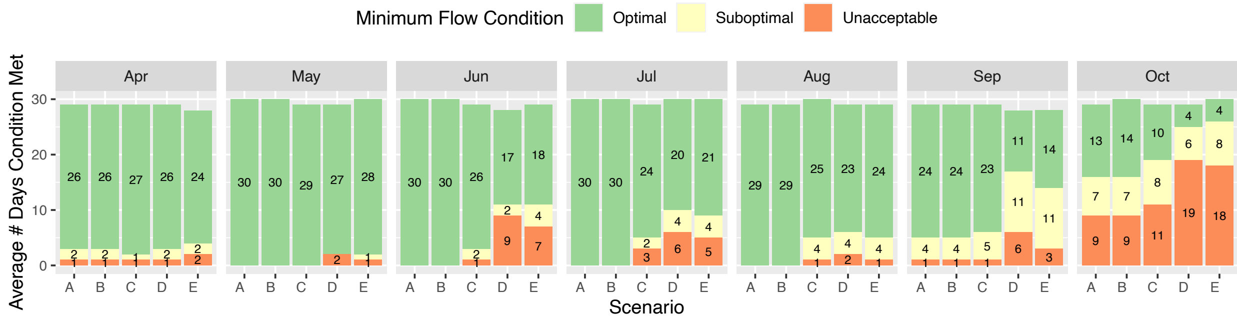
3.5.3 Scenario Modeling

The nexus between streamflow and habitat conditions for fish is regularly established by way of hydraulic habitat models. Several methodologies exist for assessing local habitat conditions against the preferred habitat conditions for various fish species. The State of Colorado relies on the R2Cross methodology [90] to describe minimum flow needs for assemblages of fish as support for development of Instream Flow (ISF) water rights. The methodology uses quickly obtainable hydraulic geometry data and assumes that streamflows sufficient to maintain aquatic habitat in critical riffle segments will also maintain habitat quality in other channel types such as runs and pools. The widespread use of R2Cross by the State of Colorado led the SWBRT E&R Subcommittee to recommend its use in the Pilot Project.

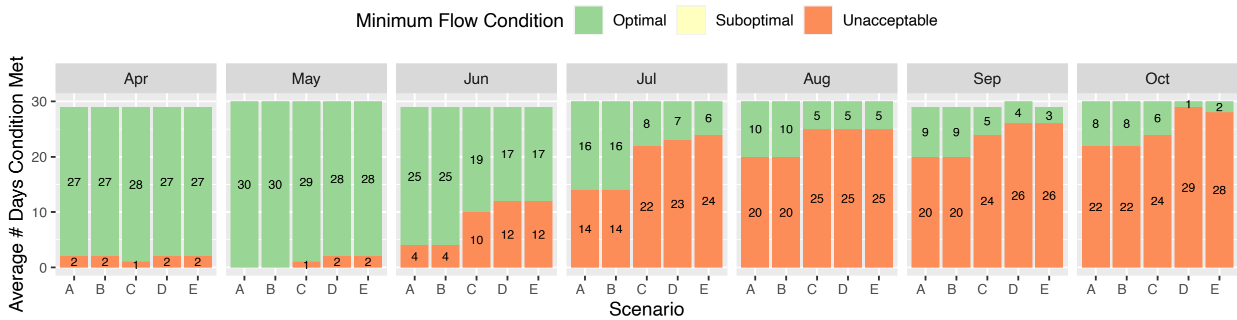
The R2Cross methodology evaluates streamflow against three hydraulic parameters: mean depth, percent bankfull wetted perimeter, and mean velocity. Importantly, existing ISF filings were not used as the benchmark for describing optimal minimum aquatic habitat flow needs in the San Miguel watershed, as many of these filings reflect adjustments to account for water availability and do not necessarily reflect the biological needs assessed for a particular stream reach. Rather, this project primarily utilized the biological basis for ISF filings to define optimal low-flow thresholds for aquatic habitat health. Where R2Cross modeling results were available, simulation models were used to assess the frequency and magnitude of flows falling below recommended flows under each of the modeling scenarios (Figure 30).

[90] Espegren, "Development of Instream Flow Recommendations in Colorado Using R2Cross."

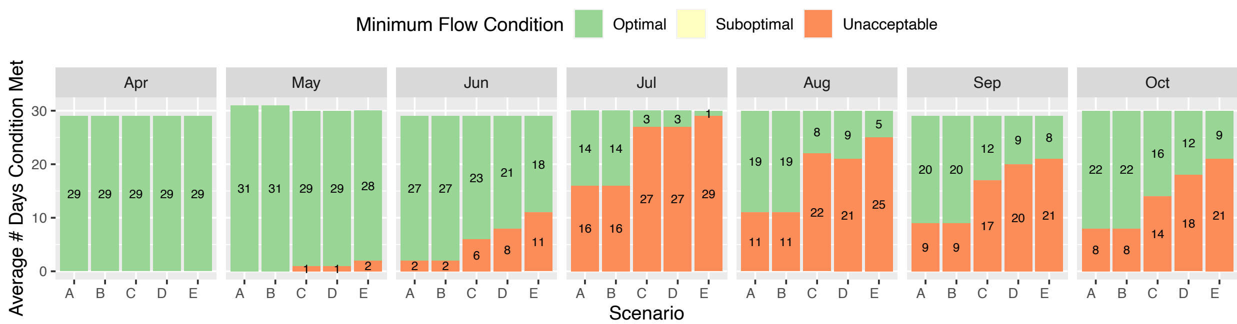
Fall Creek Near Fall Creek



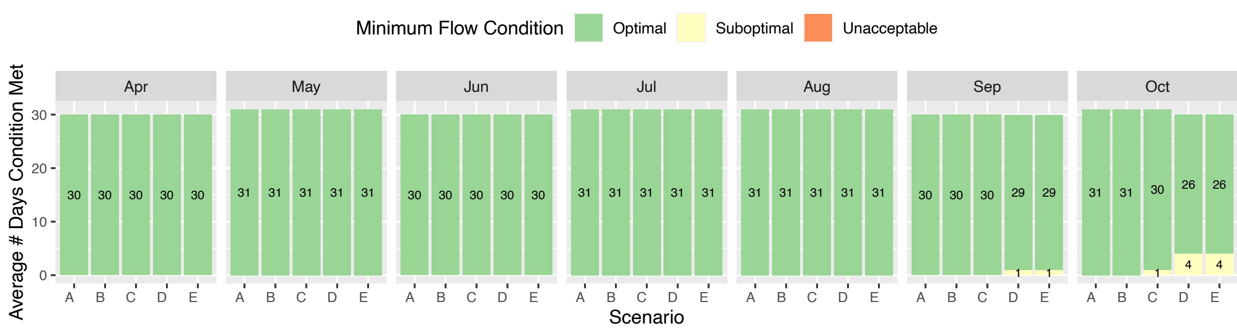
Lower Horsefly Creek

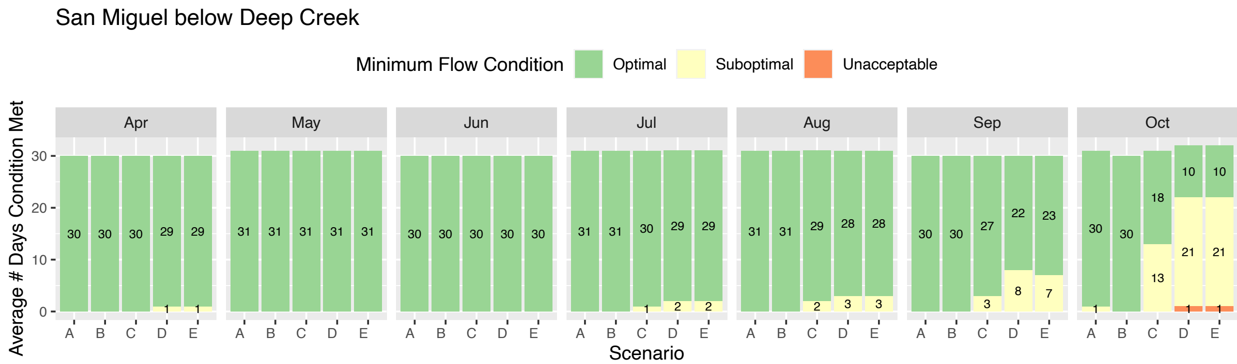


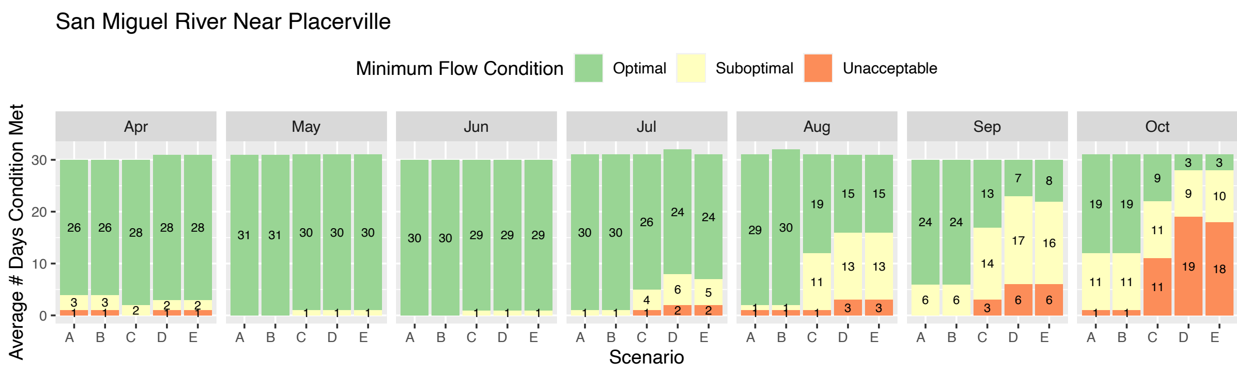
Lower Tabeguache Creek



San Miguel River Near Telluride




San Miguel below Deep Creek
Minimum Flow Condition
Optimal
Suboptimal
Unacceptable
Apr
May
Jun
Jul
Aug
Sep
Oct
Average # Days Condition Met
Scenario


San Miguel River Near Placerville
Minimum Flow Condition
Optimal
Suboptimal
Unacceptable
Apr
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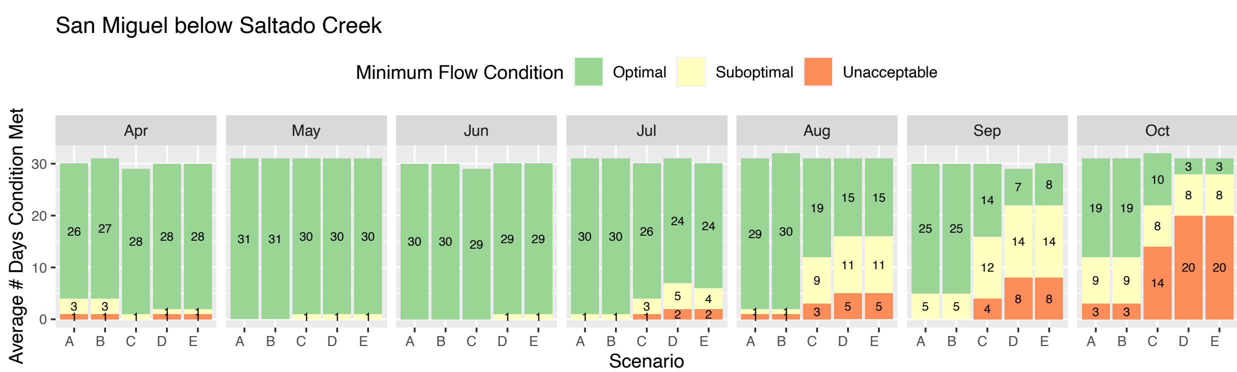
Oct
Average # Days Condition Met
Scenario


San Miguel below Saltado Creek
Minimum Flow Condition
Optimal
Suboptimal
Unacceptable
Apr
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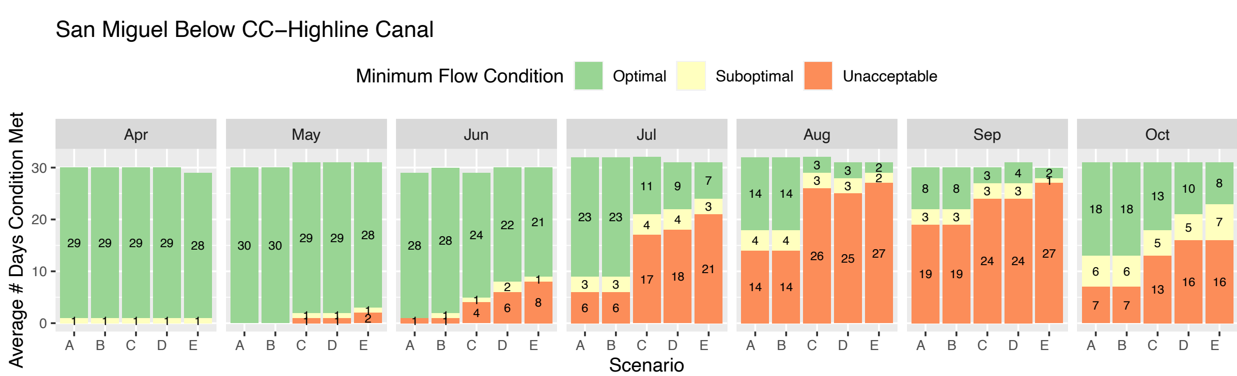
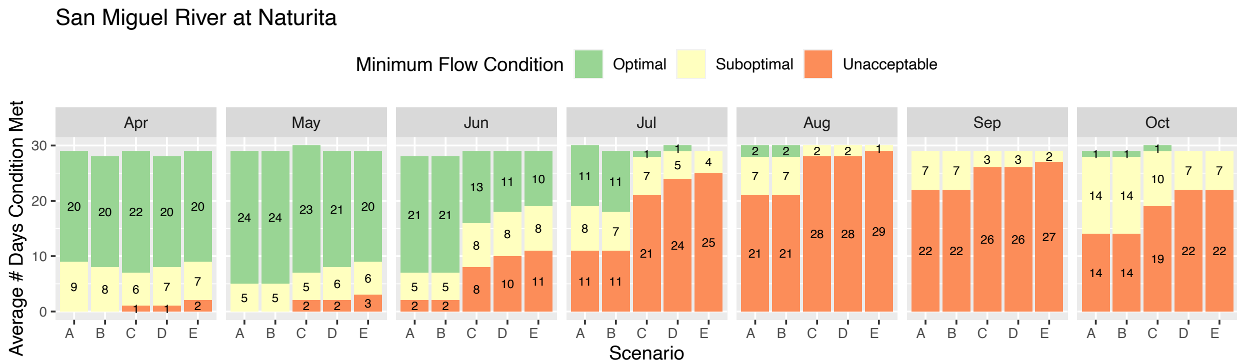
Average # Days Condition Met
Scenario


San Miguel Below CC–Highline Canal
Minimum Flow Condition
Optimal
Suboptimal
Unacceptable
Apr
May
Jun
Jul
Aug
Sep
Oct
Average # Days Condition Met
Scenario



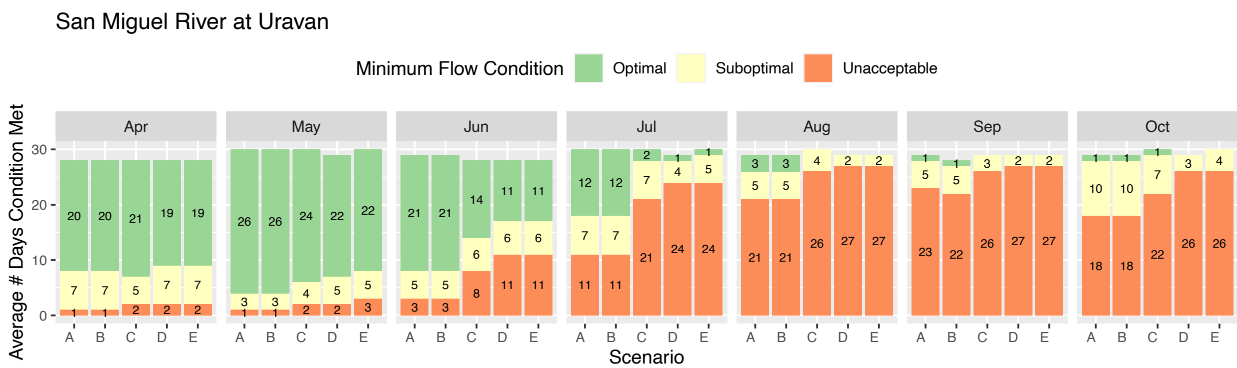


Figure 30. Changing aquatic habitat conditions predicted for stream reaches across the San Miguel watershed during summer months under several hydrological scenarios. Optimal flow conditions (green) correspond to periods when flows exceed 3-of-3 R2Cross criteria. Suboptimal flow conditions (yellow) correspond to periods when flows exceed 2-of-3 R2Cross criteria. Unacceptable flow conditions (orange) correspond to periods when flows are lower than 2-of-3 R2Cross criteria. Note that not all monthly totals sum to the correct number of days in each month. This is an unavoidable artifact of rounding errors incurred when summarizing the 40-year time series from each scenario.

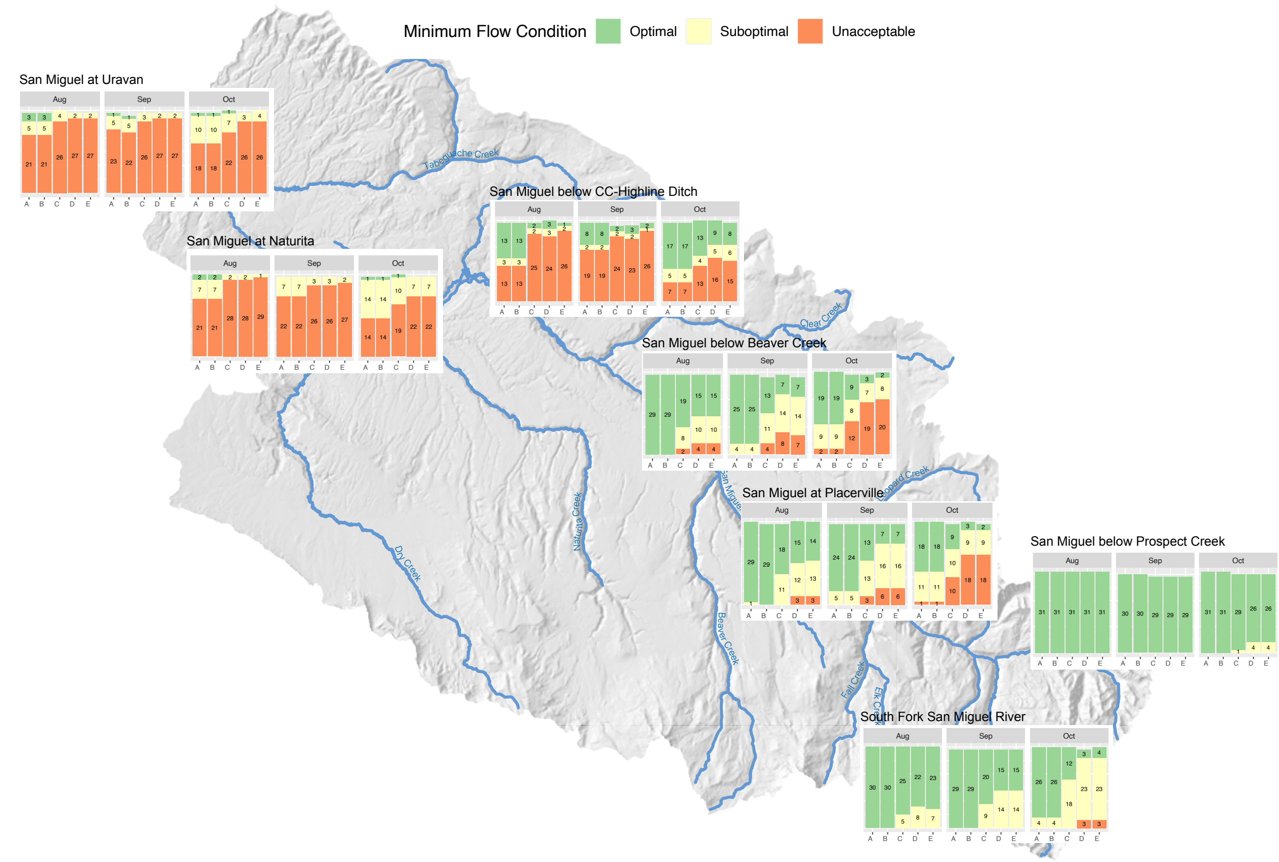


Figure 31. A watershed-wide view of the previous figures truncated to only include the Aug-Oct period and arranged spatially to support rapid visual assessment of the nature of changes to aquatic habitat one might expect to see moving upstream to downstream along the San Miguel River mainstem and across the five different planning scenarios: A-E.

3.5.4 Notable Findings

Most limitations to native fish survival and recovery are common among species, with some exceptions. Many are hydrological: reduced seasonal connectivity to spawning and rearing habitat, reduced spring flood flows, and reduced late summer baseflows. Others are physical: entrainment in diversion ditches and canals; modification of backwaters, side channels, and other off-channel habitat; and fragmentation of habitat by dams and other in-channel structures. Water quality impairment (including temperature), non-native fish competition and predation, and hybridization round out the top challenges these fishes face. The effects of climate change are predicted to exacerbate many of these limitations. Conservation opportunities for native fishes in the San Miguel arise from addressing limitations: increasing or protecting flood and summer streamflows; protecting and restoring off-channel habitat; installing fish screens in diversions and providing for fish passage around diversions and low-head dams; managing non-native species; improving water quality; controlling or eliminating invasive fish species, and supporting stocking efforts, to name a few. A full discussion of the aquatic biota assessment methodology and results is included in Appendix F. Specific findings regarding the fishery include:

- Fish habitat quality, as assessed by R2Cross analysis, exists in a suboptimal state in many locations across the watershed during certain portions of the year. The duration and magnitude of these suboptimal conditions tend to increase under increasingly dry climate change predictions (e.g. scenarios C, D, and E).
- Water supply gaps for fisheries are most persistent across year types on the San Miguel River mainstem below the Highline Canal, and on tributaries in the lower watershed. The most significant gaps on the San Miguel River occur in the area where the fishery is expected to transition from warm-water to cold-water species.
- The ability for local aquatic biota to respond and adapt to changing climate conditions may be constrained by limited stream network connectivity in some parts of the watershed. Two low-head dams on the San Miguel mainstem between Cottonwood Creek and Naturita and diversion structures or culverts on the lower reaches of tributary streams within 1.0 mile of the San Miguel River appear to be most limiting to aquatic organisms ability to access diverse habitats/refugia across different times of year.
- Entrainment of native trout, native warm-water fish and managed sport fish in surface water diversions may reduce the number individuals able to reproduce in any given year.
- The range of native cutthroat trout populations is limited to relatively short tributary reaches at high elevations. These populations may be particularly susceptible to reductions in streamflow brought about by a warming and drying climate.

3.6 Whitewater Boating

Participation in water-based outdoor recreation activities by residents and nonresidents leads to significant consumer spending and economic activity. The economic impact of whitewater boating recreation (i.e. canoeing/kayaking, rafting, standup paddle-boarding) by state of Colorado is estimated at ~$1.5 billion[91]. The state of Colorado estimates that each participant in whitewater boating activities contributes $245 of trip-related spending to the local economy per participation day and spends approximately $434 per year on equipment. These activities are an important contribution to the local economies in the San Miguel watershed.

Whitewater boating activity in the San Miguel watershed is concentrated on the mainstem San Miguel River. Excellent whitewater boating opportunities exist between Bilk Creek and the Ledges in Norwood Canyon. This section features a consistent gradient and Class II-III whitewater. Between the end of Norwood Canyon and Naturita, boating opportunities are challenged by access issues and potentially dangerous hydraulics created by diversion structures. Private property borders the river near Naturita, creating additional access challenges. Downstream, Class I-II floating can be enjoyed through the slick rock canyon between Uravan and the Dolores River confluence [92]. Whitewater boating use in the San Miguel typically starts in the spring as snowmelt begins and continues through peak runoff and late summer baseflows. The best boating conditions occur during peak runoff (May-June). Private boaters tend to concentrate usage in these time periods. Commercial usage coincides with the tourism season, June-August.

Recreational users enjoy whitewater boating in a variety of crafts: canoes, kayaks, duckies, rafts, and stand-up paddle boards. The enjoyment and challenges experienced by users at different flow levels can vary significantly by skill level and by craft. Boaters need enough streamflow to move their craft of choice downriver. However, at lower flows, rapids become more technical. Higher flows increase wave size making rapids more interesting and challenging to navigate. Very high flows can wash out rapids or make them too difficult for safe passage,

[91] https://www.americanwhitewater.org/content/Wiki/stewardship:recreation_economics

[92] EDAW, Inc., "San Miguel River Instream Flow Assessment Recreation Study."

decreasing boating enjoyment. Very low flows make it impossible to move the craft downstream. Variability in flow, watercraft type, and user experience level produce a wide range in user preferences for flows on various segments of the river. Notably, several diversion structures in the lower watershed can make navigation in whitewater craft difficult at some flow levels. The CWCB recently completed a high-level mapping of low-head dam hazards across the state of Colorado. Several structures on the lower San Miguel River were called out by this mapping effort (Figure 32). Opportunity may exist to upgrade these diversion structures to satisfy both the needs to water users and recreationalists. User flow preference thresholds for whitewater boating utilized by this study came from a recreational flow-needs assessment conducted by American Whitewater (AW) (Table 6). AW's user preference assessment involved collecting boater feedback through an online flow evaluation survey. Participants responded to a series of questions at specific measured flows in each reach, that, when compiled, describe how flows affect recreation quality and identify the range of flows that provide optimal and suboptimal whitewater recreation opportunities for each study reach. AW's survey targeted six reaches on the mainstem of the San Miguel: 1) Bilk Creek to Down Valley Park, 2) Down Valley Park to Specie Creek, 3) Specie Creek to Beaver Creek, 4) Beaver Creek to Pinon Bridge, 5) Pinon Bridge to Naturita, and 6) Naturita to the confluence with the Dolores River (Figure 33).

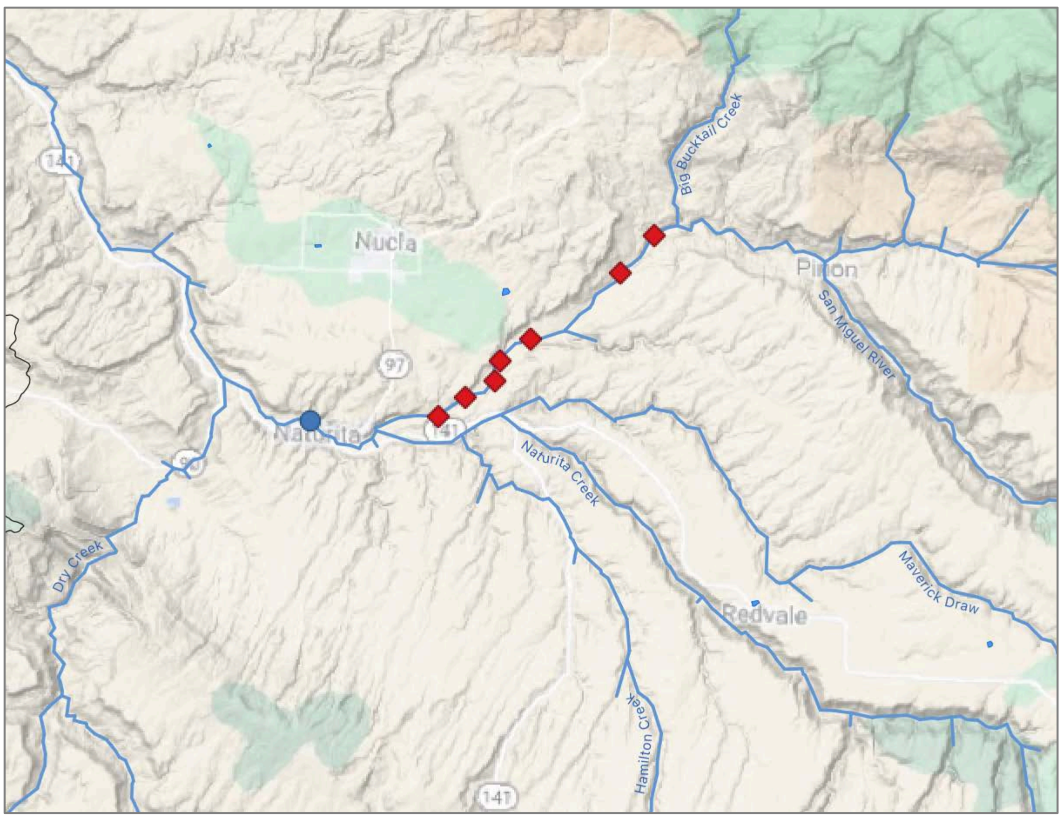


Figure 32. Low-head dam recreational hazards (red dots) mapped by CWCB. Two permanent diversion structures in this reach are often-noted river navigation hazards among the recreational boating community.

Table 6. User preferences for whitewater boating on reaches of the San Miguel River.

San Miguel River Segment	Minimum Flow (cfs)	Optimal Flows (cfs)	Acceptable Flows (cfs)
Bilk Creek to Down Valley	500	800 – 2,000	500 – 5,000
Down Valley to Specie Creek	500	800 – 2,000	500 – 5,000
Specie Creek to Beaver Creek	500	800 – 2,000	500 – 5,000
Beaver Creek to Pinon Bridge	600	900 – 2,000	600 – 5,000
Pinon Bridge to Naturita	600	1,000 – 2,000	600 – 5,000
Naturita to Dolores Confluence	600	900 – 2,000	600 – 5,000

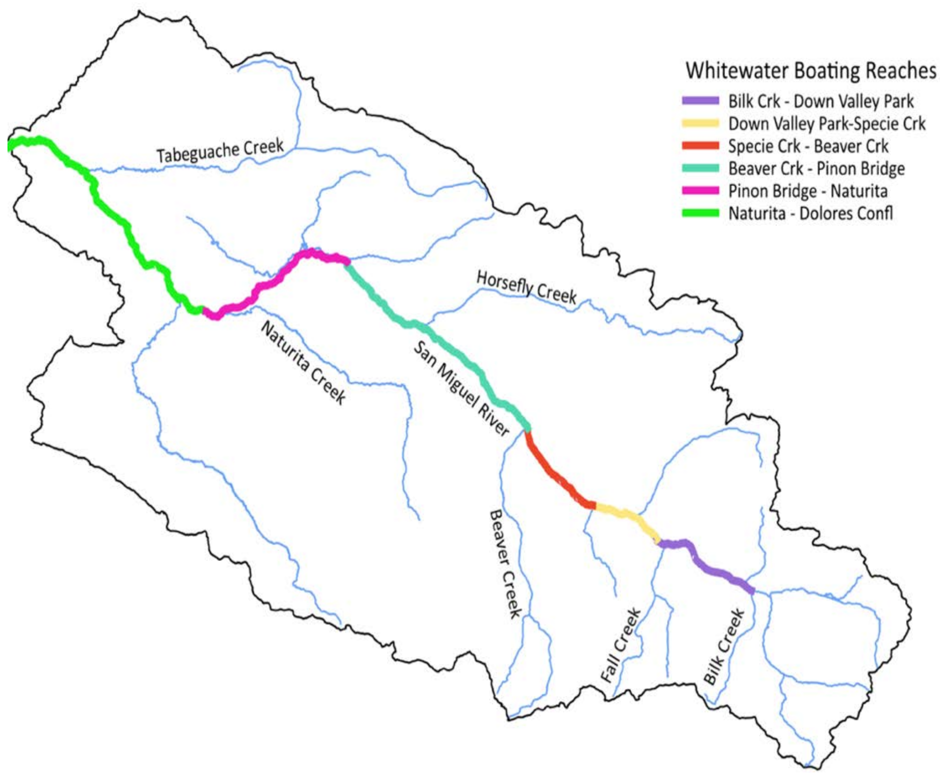


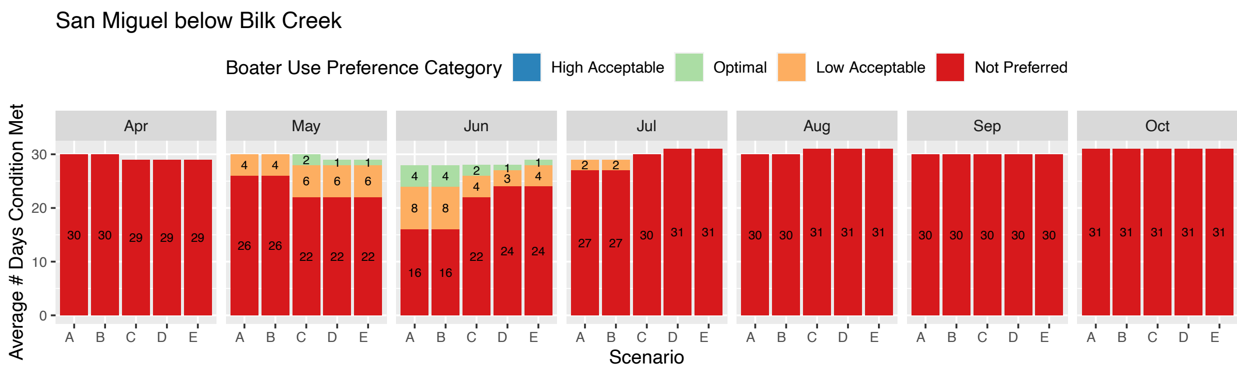
Figure 33. Reaches preferred for whitewater boating activities.

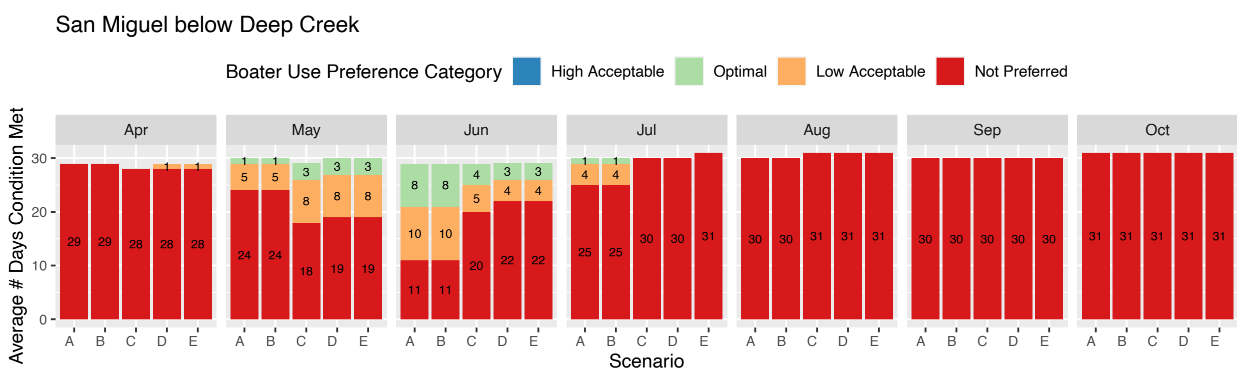
3.6.1 Scenario Modeling

The availability of recreational use potential on various segments of the San Miguel River was quantified by calculating a Boatable Days metric developed by AW. This metric reflects the number of days that optimal, acceptable, and unacceptable use conditions exist under different hydrological conditions. If the streamflow on a particular day fell within a given flow range described as optimal or acceptable, then that day counted as a

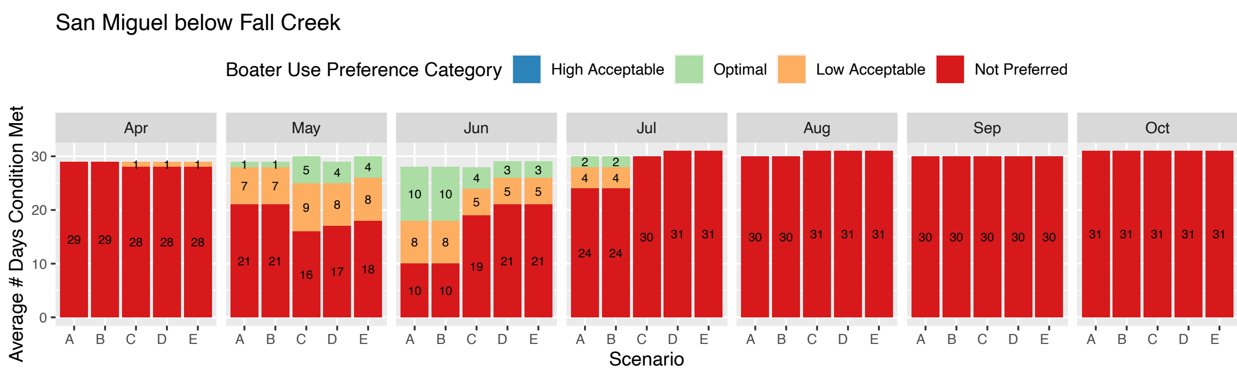
Boatable Day, regardless of whether or not users actually engaged in recreational activities on that day [93]. A Boatable Days analysis was completed for every day of the simulation period across three hydrological year types: moderate-wet, average, and moderate-dry on all reaches designated by stakeholders as important recreational use areas. A full discussion of the Boatable Days analysis methodology and results is included in Appendix G.

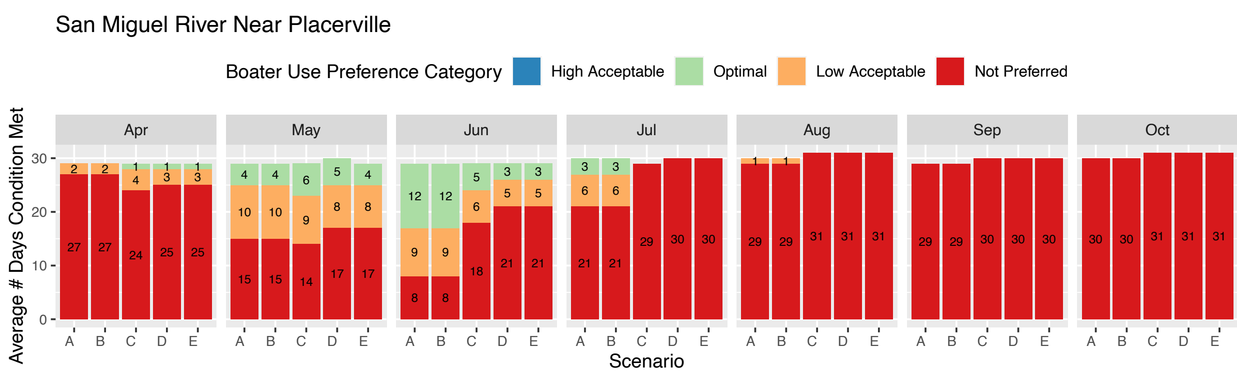
Characterization of the number of days falling within various user preference categories, as per the Boatable Days methodology, allows for evaluation of changes in streamflow mediated recreational opportunities between reaches on the San Miguel River and on a given reach across months and under different hydrological scenarios. This assessment indicated that most opportunities for recreational boating occur in May and June in the upper and middle watershed. In the lower watershed near Naturita and Uravan, boating opportunities exist in April as well. As flows decline in the late summer, conditions fall below user-preferred levels. Scenario modeling indicates significant reductions in the number of "Optimal" and "Low Acceptable" days for those scenarios that include the impacts of climate change (i.e. C, D, and E) (Figure 34). The impacts of climate change are most significant in the month of June and some shifting of Boatable Days to earlier in the year is apparent on several reaches.





[93] Fey, "Assessing Boatable Days to Describe Stream-Flow Influenced Recreational Attributes."


San Miguel below Fall Creek
Boater Use Preference Category
High Acceptable
Optimal
Low Acceptable
Not Preferred
Average # Days Condition Met
Apr
May
Jun
Jul
Aug
Sep
Oct
Scenario


San Miguel River Near Placerville
Boater Use Preference Category
High Acceptable
Optimal
Low Acceptable
Not Preferred
Average # Days Condition Met
Apr
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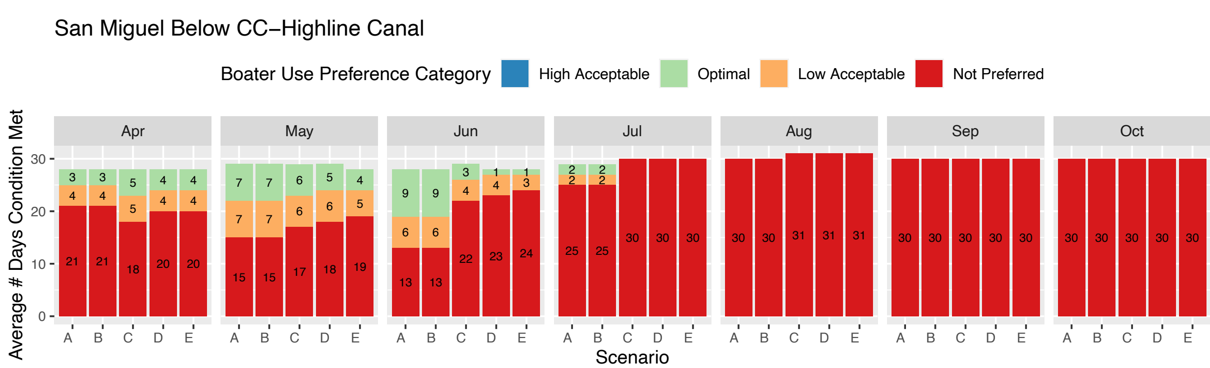
Scenario


San Miguel Below CC–Highline Canal
Boater Use Preference Category
High Acceptable
Optimal
Low Acceptable
Not Preferred
Average # Days Condition Met
Apr
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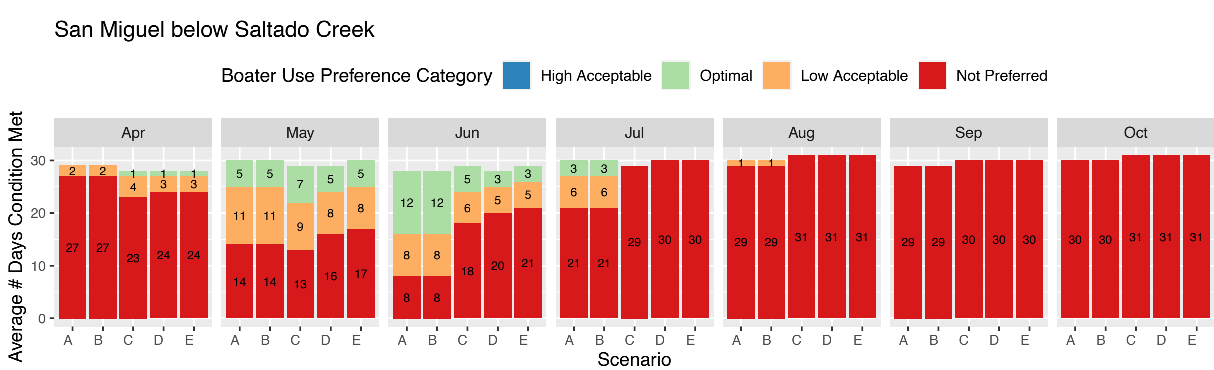
Scenario


San Miguel below Saltado Creek
Boater Use Preference Category
High Acceptable
Optimal
Low Acceptable
Not Preferred
Average # Days Condition Met
Apr
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Scenario

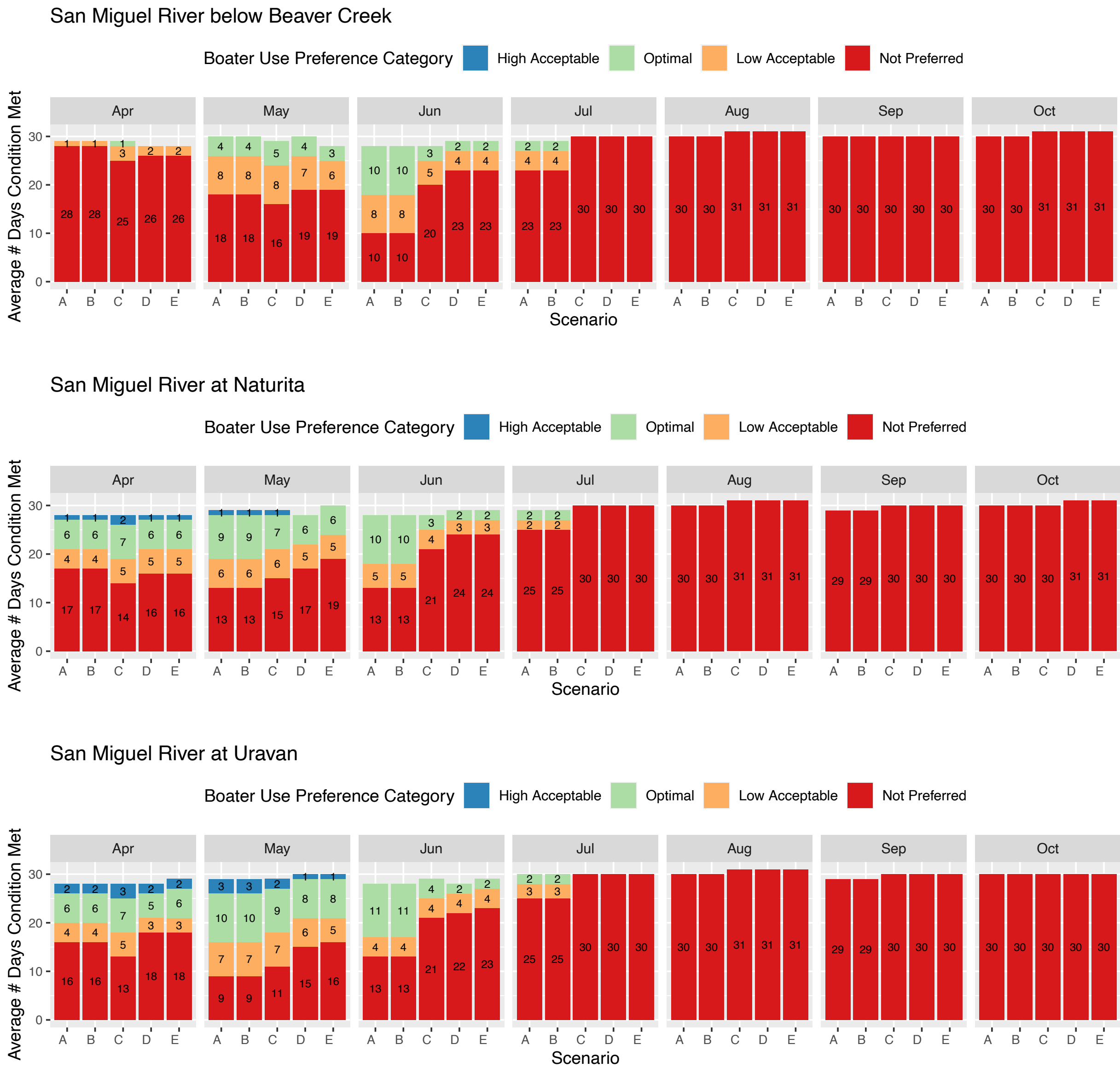

Figure 34. Distribution of boatable days across the summer recreation season under a variety of potential future hydrological scenarios on the San Miguel River between Bilk Creek and Uravan. Note that not all monthly totals sum to the correct number of days in each month. This is an unavoidable artifact of rounding errors incurred when summarizing the 40-year time series from each scenario.

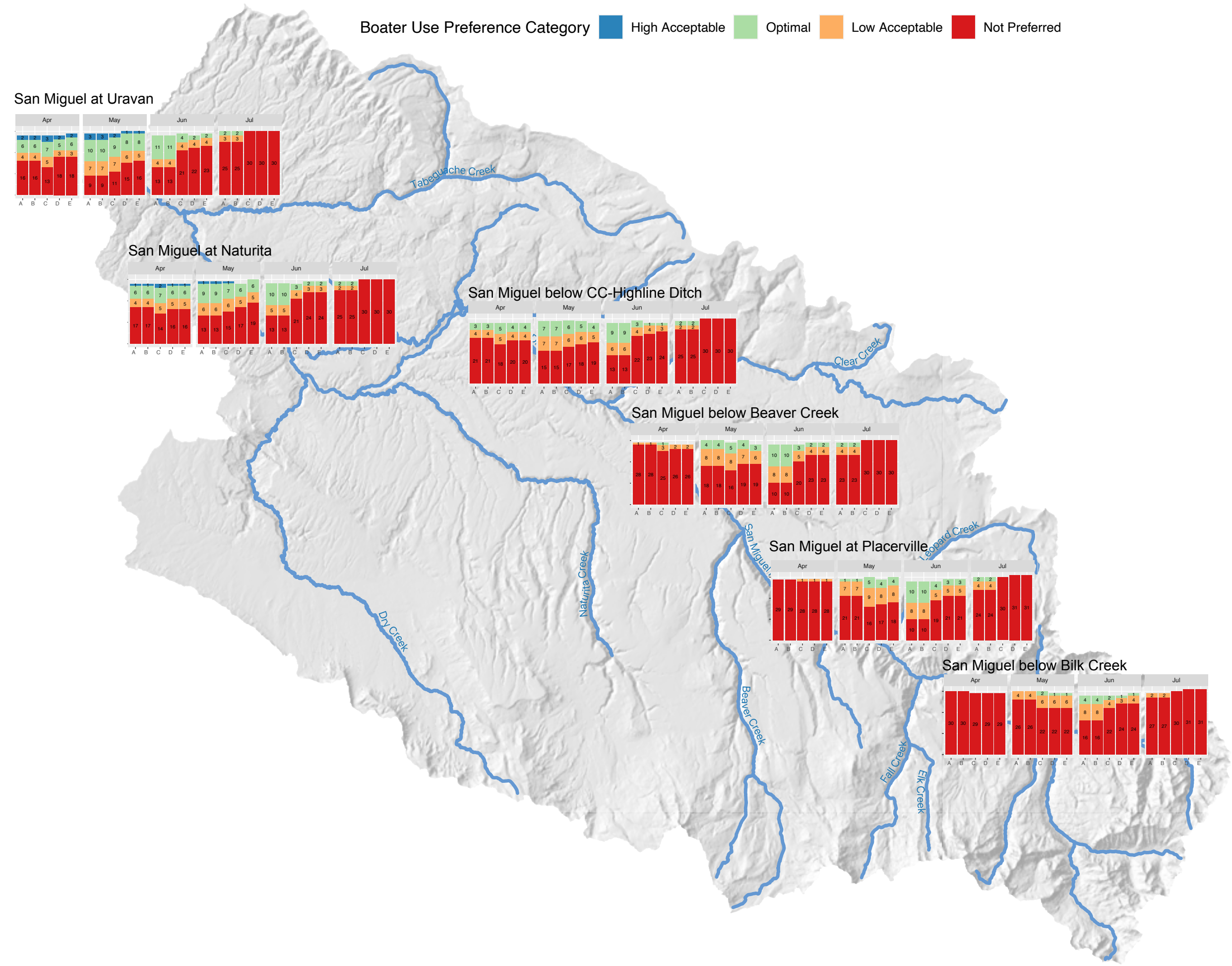

Figure 35. A watershed-wide view of the previous figures truncated to only include the Apr-Jul period and arranged spatially to support rapid visual assessment of the nature of changes to recreational boating opportunities one might expect to see moving upstream to downstream along the San Miguel River mainstem and across the five different planning scenarios: A-E.

3.6.2 Notable Findings

Whitewater boating activities are an important contribution to the local economy and an important quality-of-life contributor to some residents in the San Miguel watershed. Details of the whitewater boating analysis conducted here can be found in Appendix G. Notable findings of this assessment include:

- Two permanent irrigation diversion structures above the Town of Naturita present navigation hazards during moderate and low-flows.
- Recreational users identified minimum flow thresholds between 500-600 cfs for whitewater boating use on the San Miguel River between Bilk Creek and the Dolores River. Optimal flows tend to fall between 800-2000 cfs for all reaches.

- Boatable Days analysis indicates strong seasonal patterns dominate the distribution of days available for whitewater boating use on reaches along the San Miguel River. This reflects the natural, snowmelt runoff hydrology that is characteristic to these reaches.
- Scenario modeling that characterizes the impacts of climate change (i.e. scenarios C, D, and E) indicates the potential for a significant decrease in the number of days suitable for whitewater boating activities on many reaches, particularly in the month of June.
- This assessment did not consider the divergent preferences among different populations of recreational users. For example, individuals engaged in recreational gold-panning activities on the San Miguel River near the CC-Highline Canal likely prefer much lower flows during the summer months than recreation boaters. Future assessments may endeavor to explicitly consider flow preferences among these users and representatives from other user groups.
- This assessment did not explicitly consider the impact of hydrological variability on snowmaking. However, that recreational water use is particularly important to the economy of the Telluride area. The ability to continue snowmaking activities under a warming climate may be limited by both higher air temperatures in the October-December period and reduced availability of stored or free flowing water during this period. Future assessments may endeavor to explicitly consider these linkages.

3.7 Angling

The state of Colorado estimates that angling activities generate $120 million in annual economic output in the southwestern portion of the state[94]. River angling activity in the San Miguel watershed is concentrated in public access areas along the mainstem in the upper portion of the watershed (Figure 36). Smaller channels, smaller fish and difficult access limit angling activity on most tributary streams. Anglers typically seek out non-native trout (i.e., rainbow, brown and brook trout). Near the headwaters, popular fishing spots are found on the mainstem along the Telluride Town Trail, along the railroad grade on Lake Fork below the Trout Lake Dam, and along the South Fork of the San Miguel. Fishing opportunities on Howard's Fork are poor due to heavy metal contamination from mining waste. Quality angling opportunities with good access exist on the mainstem between Deep Creek and Fall Creek, Specie Creek and Beaver Creek, and on Leopard Creek above the mainstem. Fall Creek to Placerville offers average angling opportunities, and Placerville to Specie Creek has quality angling but only fair accessibility. Norwood Canyon, including Horsefly Creek, is fished by boat occasionally, but complicated access issues and shallow water limit boat use. Decreased streamflow and warmer water temperatures below Nucla limit trout fishing in the lower watershed. While angling opportunities for native warm-water fish species do exist below Nucla, research and outreach indicate most anglers do not pursue these fisheries.

Other conditions that limit angling opportunities in the San Miguel watershed include high turbidity that occurs during snowmelt runoff and following late-summer monsoonal rainstorms. Elevated water temperatures in the mid- and late-summer can stress fish and lead to voluntary or mandatory closures of some reaches of stream to angling. Elevated water temperature is particularly impactful to angling activities in the mid-watershed.

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94 https://cpw.state.co.us/Documents/Trails/SCORP/2017EconomicContributions_SCORP.pdf

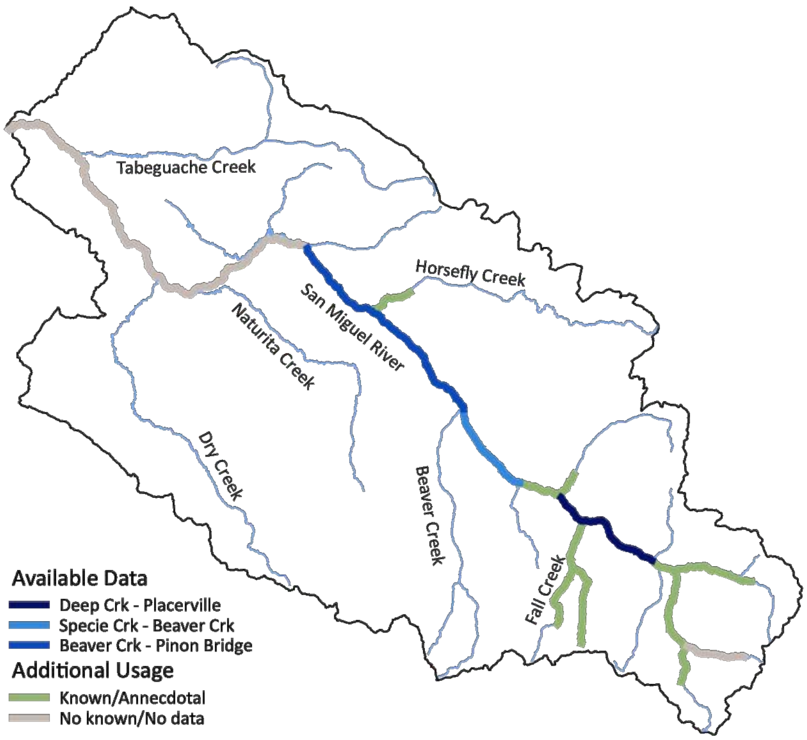

Figure 36. Reaches of the San Miguel River and its tributaries preferred by anglers.

Anglers in the San Miguel watershed engage in bank- and wade-fishing. The degree of enjoyment derived by each method at a given location reflects local flow levels, riparian vegetation density, and aquatic habitat quality. Acceptable angling conditions are available to bank anglers at higher flows than wade-walk anglers due to safety concerns. Extreme low flows diminish aquatic habitat availability and increase water temperature. These conditions reduce the number and size of fish present in a segment. The density of riparian vegetation along the riverbanks affects river access and an angler's ability to easily traverse the banks of the river. The most popular times for fishing in the San Miguel watershed include the summer months after peak runoff through the fall (approximately July-October). A small amount of private angling also occurs in the winter and spring months before peak runoff starts. Like whitewater boating, commercial usage coincides with the tourist season (June-August), often requiring commercial guides to work during non-optimal flow conditions.[6,18]

In the 1990's the BLM spearheaded an assessment of instream flow needs throughout the San Miguel watershed [95]. The assessment stayed in draft form and multiple ISF rights were decreed by the CWCB throughout the watershed before the assessment was finished. The assessment utilized interviews with local guides to identify a range of preferred flows for both wade- and bank-fishing [96]. The assessment utilized a flow preference study [97] that relied on interviews with local guides to identify a range of preferred flows for both wade- and bank-fishing. The initial study scope covered the entire watershed, but a lack of survey respondents in the lower watershed limited the identification of flow preferences in this area. Reaches that both produced sufficient data and represented the primary areas of private and commercial recreational angling included the following

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[95] Bureau of Reclamation, "San Miguel River Instream Flow Assessment."

[96] EDAW, Inc., "San Miguel River Instream Flow Assessment Recreation Study."

[97] Id.

segments of the San Miguel River: 1) Deep Creek to Fall Creek; 2) Specie Creek to Beaver Creek; and 3) Beaver Creek to Pinon Bridge.

Angler preferences reported by BLM reflected bank accessibility, riparian vegetation, safety accessing appropriate fish habitat, and ability to catch fish. Suitability responses utilized a four-point scale (1-unacceptable, 2-marginally acceptable, 3-acceptable, 4-optimal). The flow preference study utilized single flow (single time at random flow) and direct comparison (multiple times at various flows) techniques to derive flow preference curves for different reaches. BLM subsequently developed flow preference curves to define optimum and acceptable flow ranges for angling in each of these reaches [98]. An informal user survey was conducted in 2016 to verify the appropriateness of the flow ranges developed by BLM and gather information on additional reaches of importance. Where preferred fishing locations identified during the 2016 surveys did not align with original BLM study reaches, flow preferences were derived from a geomorphologically similar reach evaluated by BLM (i.e., Caddis Flats was identified as a preferred fishing reach by several anglers in 2016 and was assigned the flow preferences developed for Specie Creek to Beaver Creek due to geomorphological similarities) (Table 7).

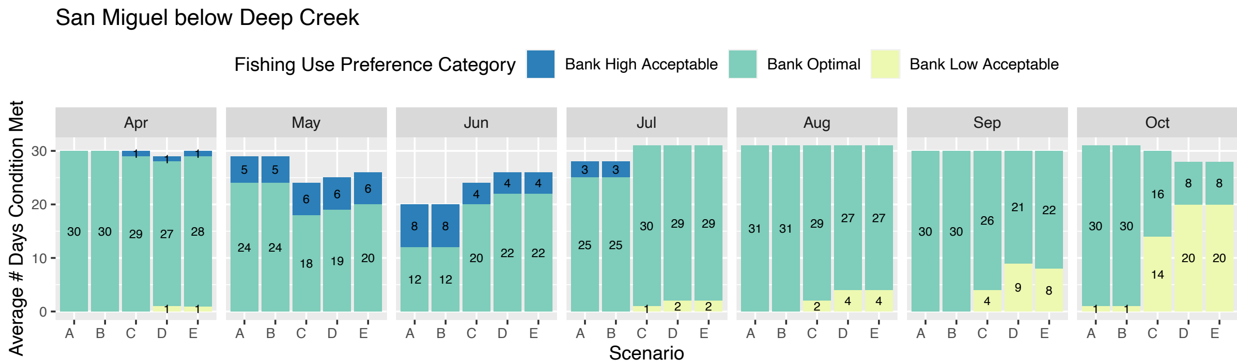
Table 7. User preferences for wade and bank fishing on segments of the San Miguel River.

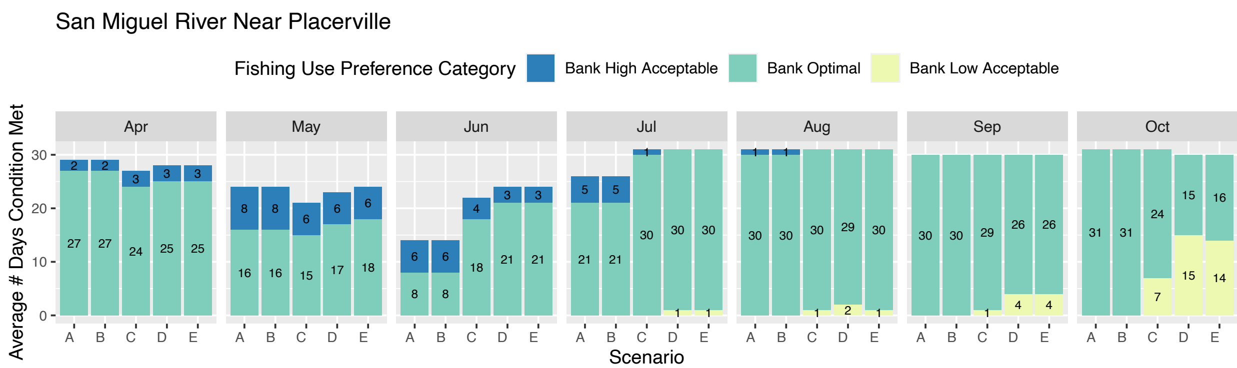
Reach	Type	Acceptable Min (cfs)	Optimum Min (cfs)	Optimum Max (cfs)	Acceptable Max (cfs)
Deep Creek-Placerville	Wade	25	50	275	275
	Bank	25	50	600	700
Caddis Flats	Wade	25	50	250	250
	Bank	25	50	550	650
Species Creek-Beaver Creek	Wade	25	50	250	250
	Bank	25	50	550	650
Beaver Creek-Pinon Bridge	Wade	25	50	275	275
	Bank	25	50	500	650

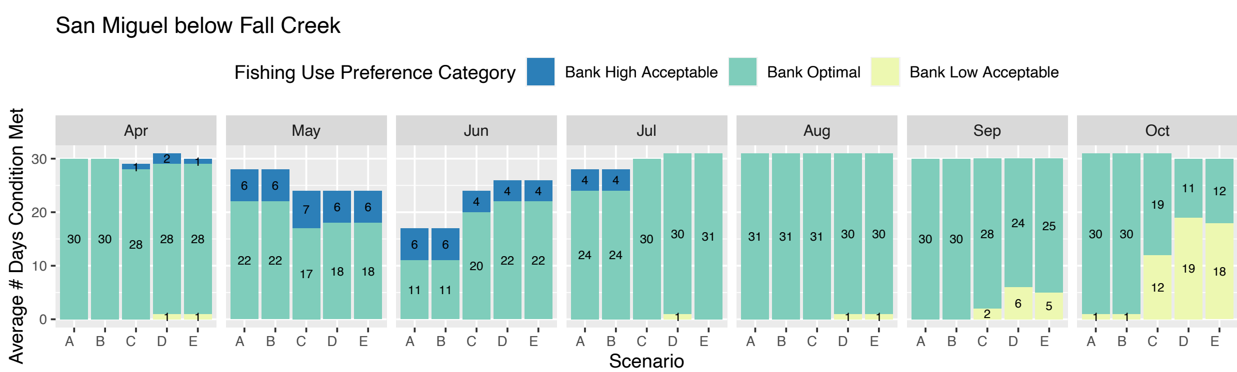
3.7.1 Scenario Modeling

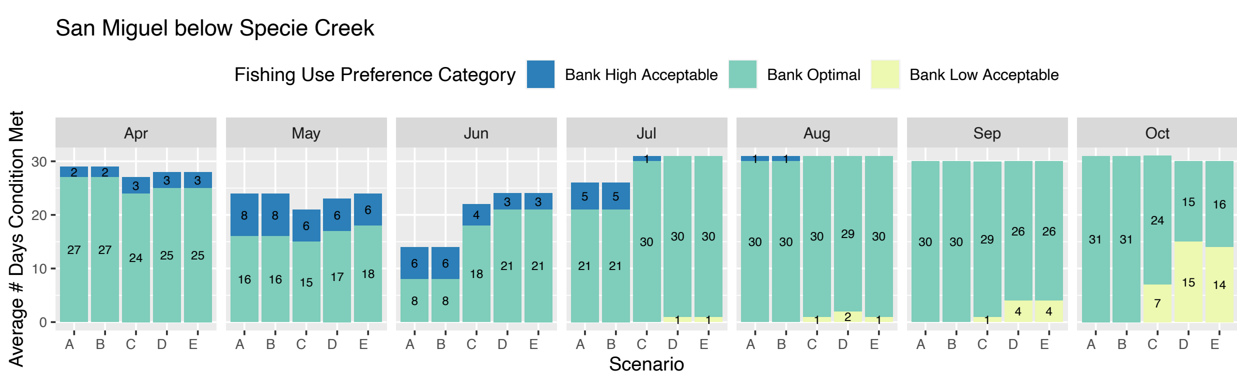
The availability of recreational use potential on various segments of the San Miguel River was quantified by calculating a Fishable Days metric. This metric reflects the number of days that optimal, acceptable, and unacceptable use conditions exist under different hydrological conditions. The hydrological scenario models were used to evaluate how angling opportunities change when moving between reaches of the San Miguel River. These models were also used to evaluate how those opportunities change under potential population growth and climate change futures (Figure 37, Figure 38).

[98] EDAW, Inc.


San Miguel below Deep Creek
Fishing Use Preference Category
Bank High Acceptable
Bank Optimal
Bank Low Acceptable
Average # Days Condition Met
Apr
May
Jun
Jul
Aug
Sep
Oct
A B C D E
Scenario


San Miguel River Near Placerville
Fishing Use Preference Category
Bank High Acceptable
Bank Optimal
Bank Low Acceptable
Average # Days Condition Met
Apr
May
Jun
Jul
Aug
Sep
Oct
A B C D E
Scenario


San Miguel below Fall Creek
Fishing Use Preference Category
Bank High Acceptable
Bank Optimal
Bank Low Acceptable
Average # Days Condition Met
Apr
May
Jun
Jul
Aug
Sep
Oct
A B C D E
Scenario


San Miguel below Specie Creek
Fishing Use Preference Category
Bank High Acceptable
Bank Optimal
Bank Low Acceptable
Average # Days Condition Met
Apr
May
Jun
Jul
Aug
Sep
Oct
A B C D E
Scenario

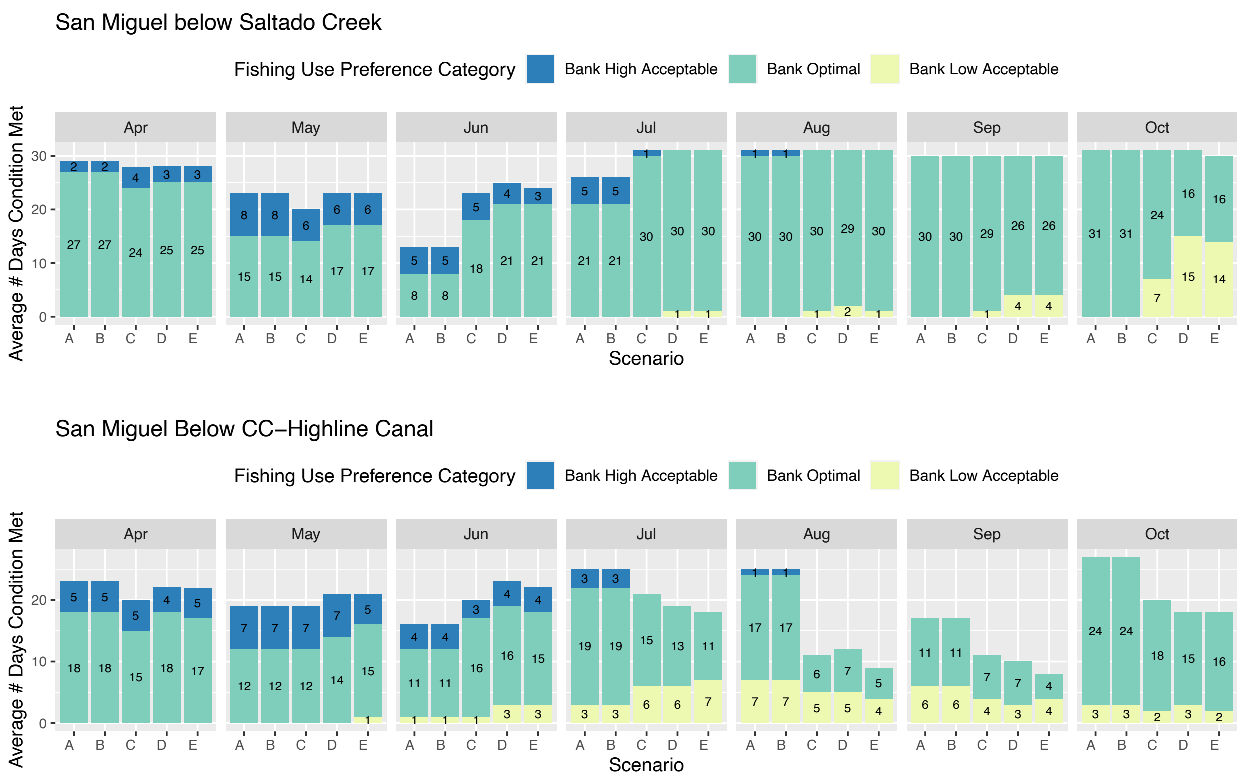
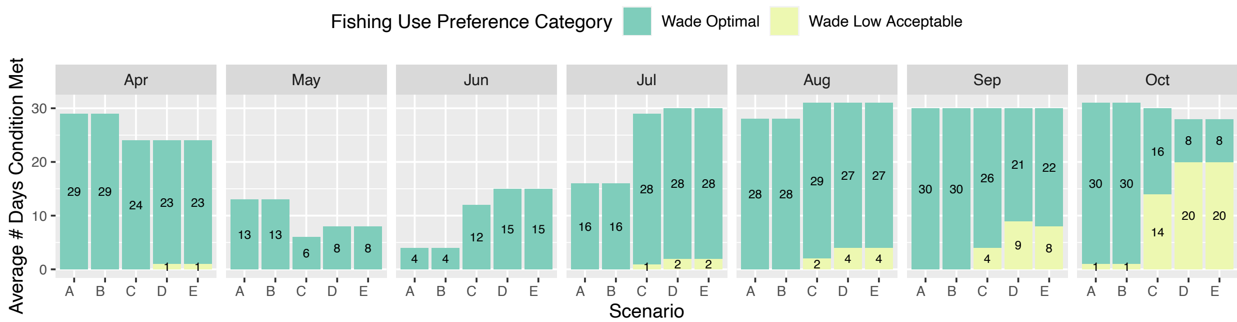
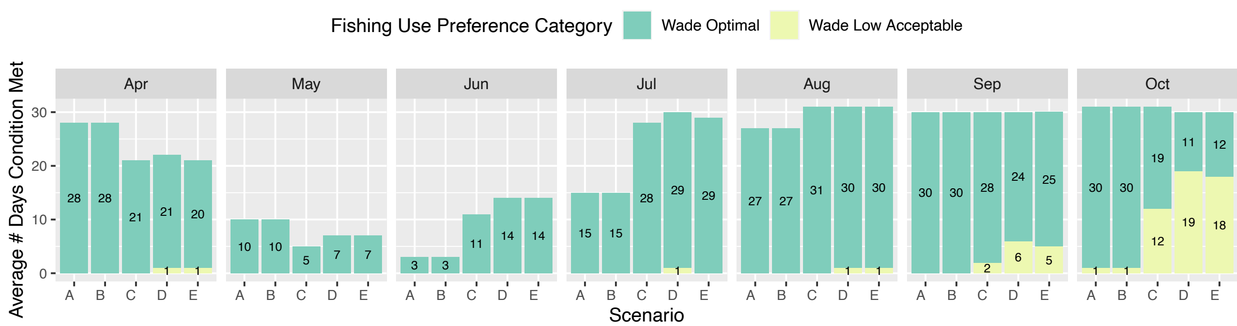


Figure 37. Distribution of the average number of days in each month falling in several bank fishing use preference categories on the San Miguel River under a variety of potential future hydrological scenarios.

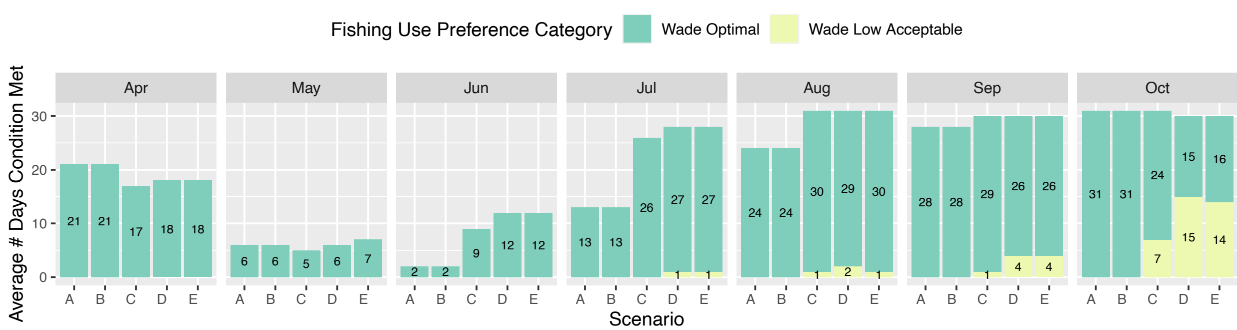
San Miguel below Deep Creek



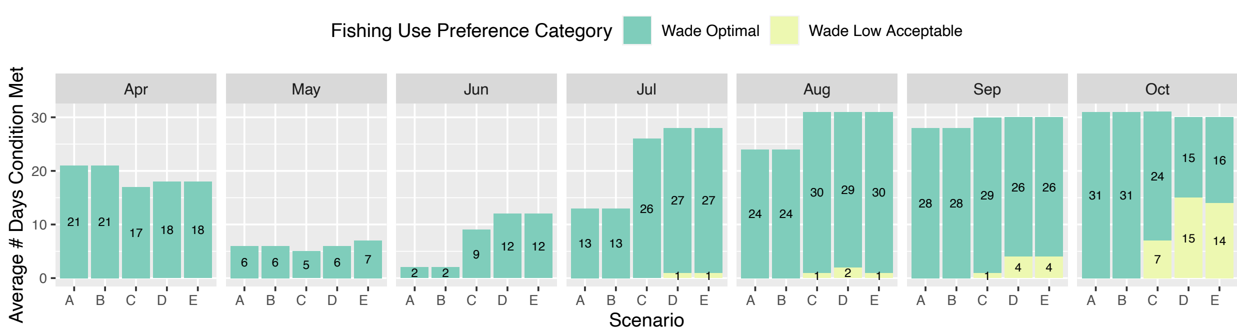
San Miguel below Fall Creek



San Miguel River Near Placerville



San Miguel below Specie Creek



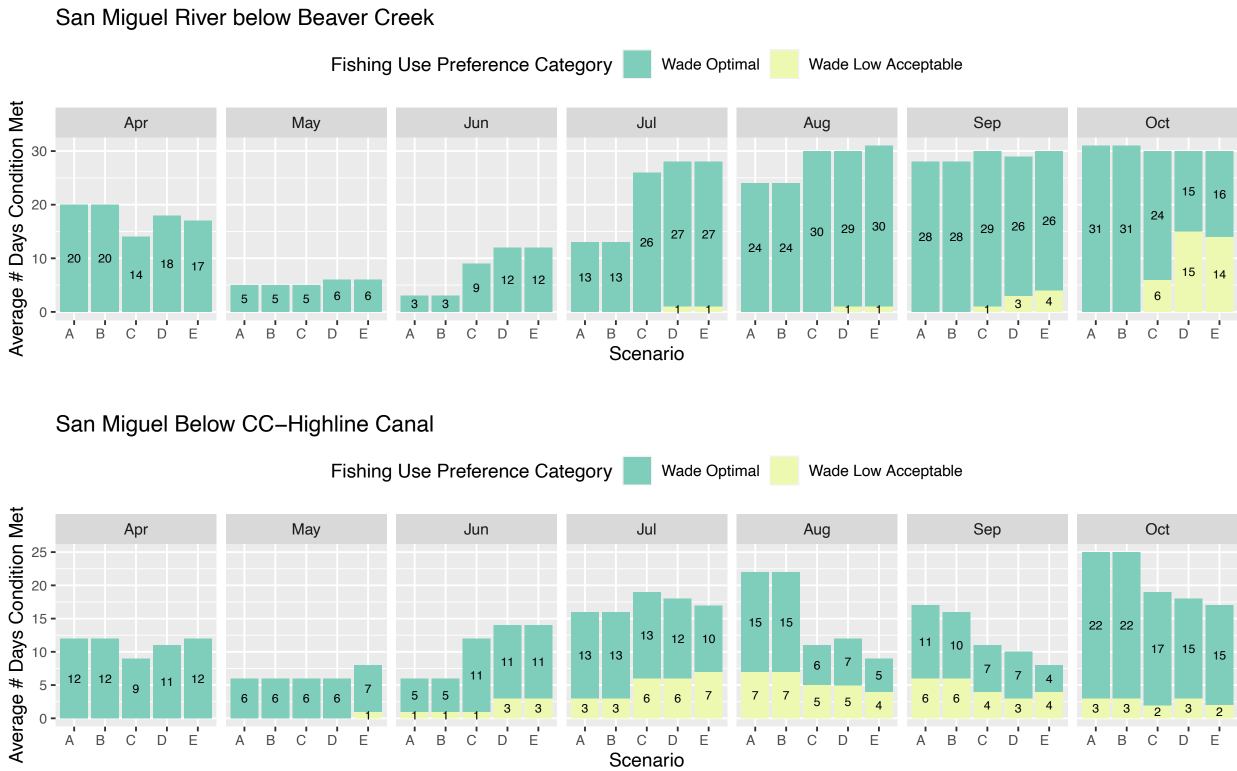


Figure 38. Distribution of the average number of days in each month falling in several wade fishing use preference categories on the San Miguel River under a variety of potential future hydrological scenarios. Note that some monthly totals may sum to a greater number of days than are present in a given month. This is an unavoidable artifact of rounding errors incurred when summarizing the 40-year time series from each scenario.

Scenario modeling results display distinct spatial and temporal patterns in Fishable Days that reflect the primary constraints on bank- vs. wade-fishing. Both use types are most constrained during May and June when flows are high. As flows drop in the early and mid-summer, conditions become more suitable for use. In many months there are more opportunities for bank fishing than wade-fishing due to the higher flow thresholds for the former. The greatest number of days for supporting both use types exist in reaches above the CC-Highline Canal. The reduced peak flows that characterize the climate change scenario models tend to increase the number of optimal days for angling. Decreased late season flows associated with the climate change scenarios tend to decrease the number of optimal days for both wade and bank fishing in the Sep-Oct. period. This effect is most pronounced in the upper watershed. Critically, the Fishable Days metric does not reflect social or biological constraints on angling activities. For example, climate change scenarios may produce elevated water temperatures that limit angling opportunities or quality before flow conditions do.

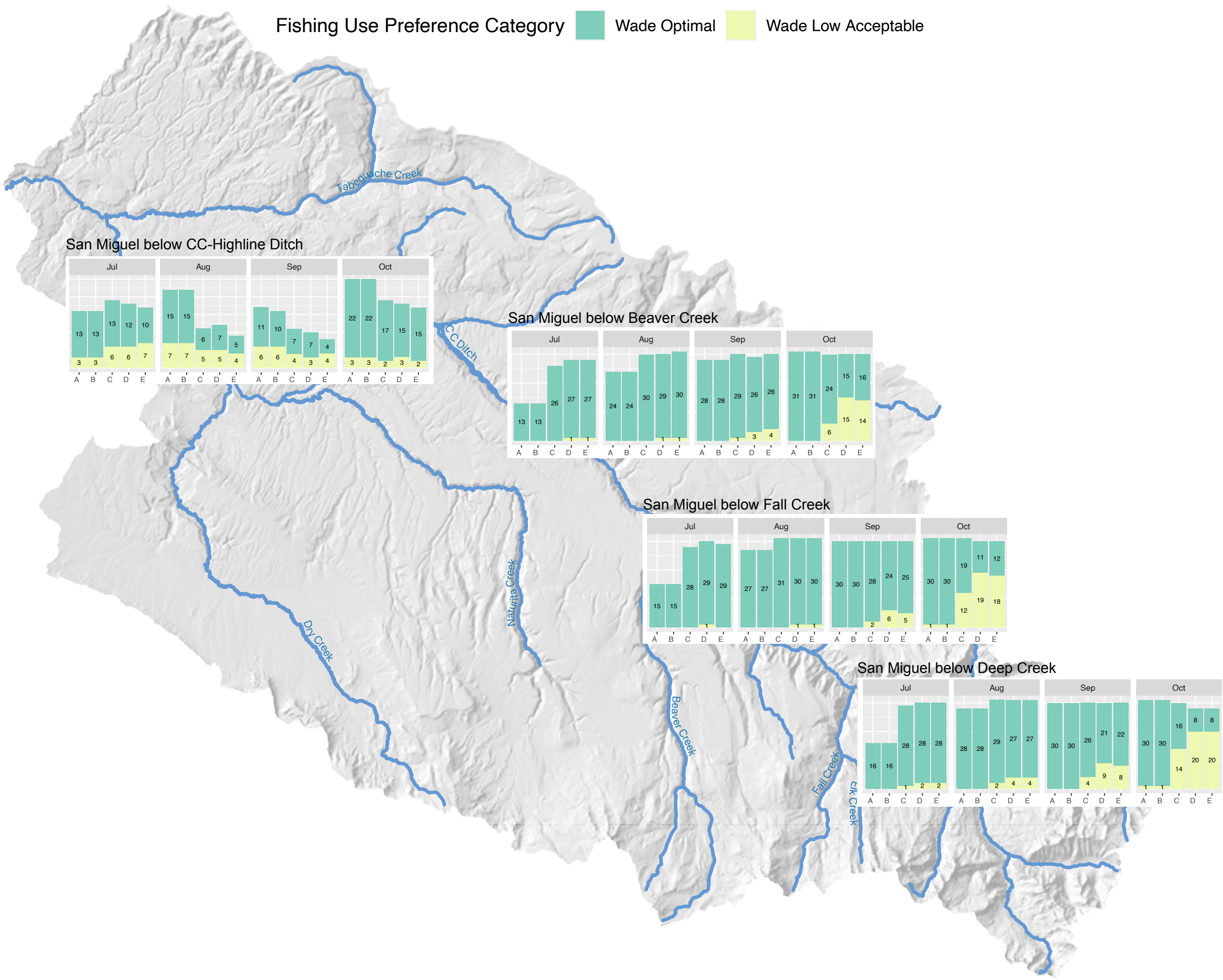


Figure 39. A watershed-wide view of the previous figures truncated to only include the Jul-Oct period and arranged spatially to support rapid visual assessment of the nature of changes to wade fishing opportunities one might expect to see moving upstream to downstream along the San Miguel River mainstem and across the five different planning scenarios: A-E.

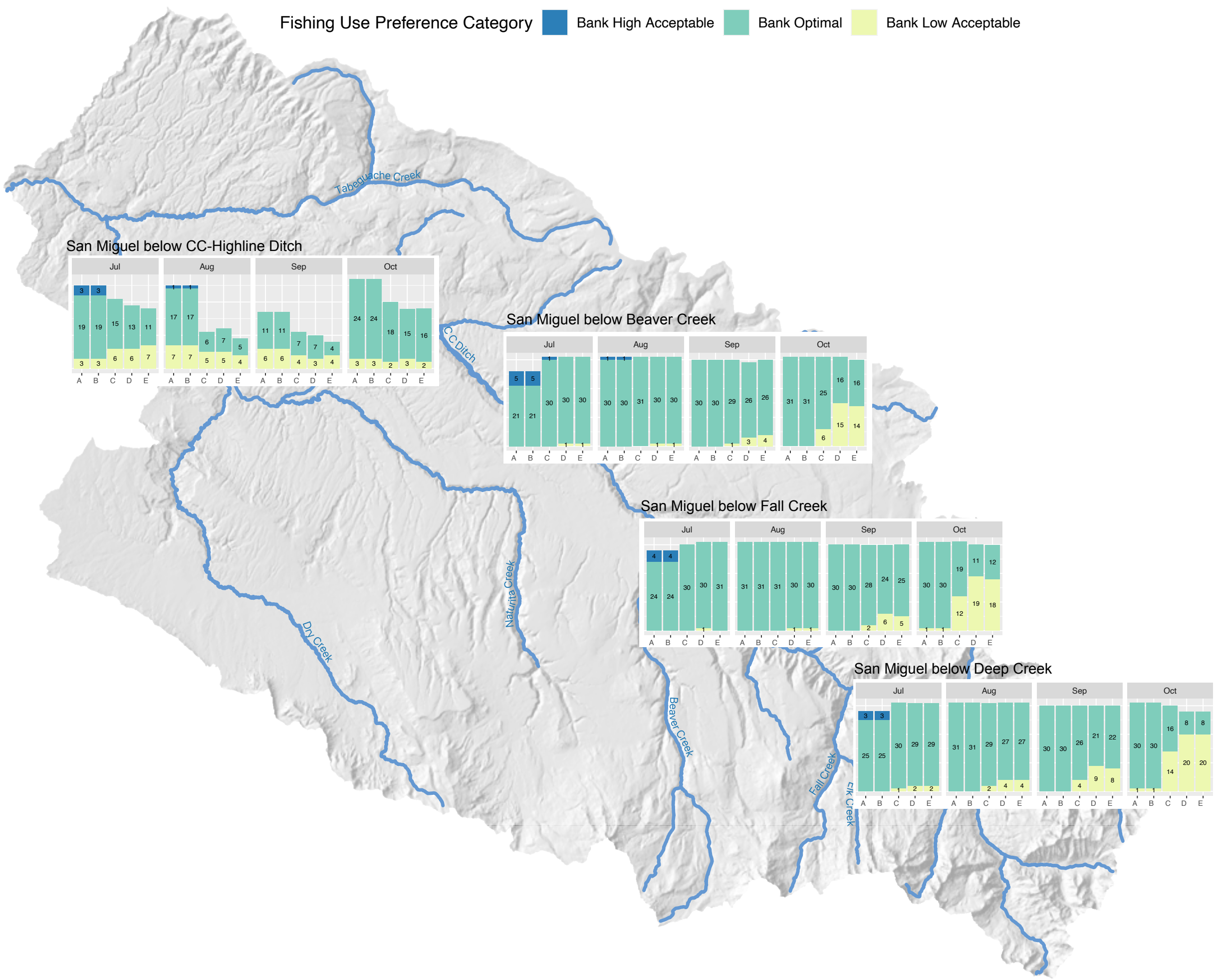


Figure 40. A watershed-wide view of the previous figures truncated to only include the Jul-Oct period and arranged spatially to support rapid visual assessment of the nature of changes to bank fishing opportunities one might expect to see moving upstream to downstream along the San Miguel River mainstem and across the five different planning scenarios: A-E.

3.7.2 Notable Findings

Angling is an important driver for local economies and an important quality-of-life attribute for local residents. Angling activities occur throughout the watershed. In many locations, these activities are mediated by streamflow conditions. Comparison of flow conditions across different reaches, times of year, and hydrological scenarios provides information about the role of variable hydrology in mediating patterns of angling use. A full discussion of the analysis methodology and results is included in Appendix G. Notable findings from this analysis include:

- Anglers generally agree that flows greater than 250-275 are acceptable but less preferred than lower flows. Optimal flows range from 100-275 cubic feet per second (cfs), depending on the reach. It becomes more challenging to access fishing banks, wade, or cast, and turbidity increases as flows increase above this optimal range

- High streamflows during May-June limit bank and wade-fishing opportunities throughout the watershed.
- Bank fishing opportunities are less sensitive to hydrological variability than wade fishing opportunities.
- Lower peak flows associated with climate change hydrological scenarios (i.e. scenarios C, D, and E) tend to increase the number of optimal and acceptable days for both wade and bank fishing during the May-June period. Lower late-summer flows associated with climate change hydrological scenarios tend to decrease the number of optimal days for both wade and bank fishing, especially in the upper watershed.
- Some types of angling that are of high-value to some local residents were not included in this assessment. These include angling in Miramonte Reservoir and catfish fishing at Biscuit Rock on the lower San Miguel River. Future assessments may be used to explicitly consider these uses and how they are mediated by variably hydrological conditions.
- Angling quality is tightly coupled with aquatic habitat availability and the health of the fishery. Therefore, consideration of results presented in the aquatic biota section are equally important for understanding existing and potential future angling opportunities across the San Miguel watershed.

4 NEXT STEPS

The flows in the San Miguel River are largely unaltered compared to other western U.S. rivers. However, some segments of the mainstem and several tributaries are heavily utilized for municipal, industrial and agricultural use. The high-level analyses presented here indicate that E&R gaps do exist for maintenance of riparian and fishery health on some segments. An alternate conceptualization of whitewater boating and angling use gaps based on a comparison to natural streamflows would also indicate gaps for these uses at some locations and at some times of the year. Hydrological scenario modeling indicates significant potential for changes to hydrological behavior and the environmental and recreational attributes that streamflows support. The specific impacts to E&R needs associated with climate change vary depending on the attribute of interest, the location in the watershed, and the time of year. Several other issues also appear to limit fishery health and recreational use. Reductions in stream network connectivity caused by irrigation diversions and road crossings may limit access to important habitat for some native and sport fish at some times of year. This appears particularly relevant on tributaries. Entrainment of fish in diversion canals may negatively impact native fish populations. Several diversion structures on the San Miguel River near Naturita also present challenges to boat passage in their existing configuration, possibly limiting recreational use even when sufficient flows for boating are present.

The next phase of the San Miguel Pilot Project considers these issues in an effort to identify projects, processes, and collaborative management opportunities (collectively termed "cooperative measures") for meeting and protecting existing consumptive *and* E&R needs in the San Miguel watershed. Ongoing stakeholder dialog will help ensure that planning activities remain aligned with local and regional perspectives. The planning process will continue to refine its focus and direction through community input on questions including, but not limited to, the following:

1. "What are our water use and management priorities?"

2. "What aspects of fishery and recreational use management are we most concerned about?" and

3. "What kind of water future do we envision for our children growing up in the San Miguel watershed?"

Stakeholders groups that should be involved in the next planning phase include: agricultural producers, water administrators, local municipalities, natural resource agencies, local and national environmental or conservation organizations, recreational advocates, and other water rights holders. Stakeholders will help articulate management goals for the San Miguel River and its tributaries. These goals will help guide the identification of cooperative measures and the evaluation of their outcomes. Cooperative measures considered by the Pilot Project may include market-based water use/conservation programs, ditch efficiency upgrades, diversion structure reconstruction, phreatophyte control, water storage projects, and channel modifications, among others. Stakeholders will then help evaluate the relative effectiveness and feasibility of each identified cooperative measure. The final planning outcome will be a prioritized list of recommendations for action in the San Miguel watershed.

4.1 Setting Goals

Surveys, meetings, one-on-one meetings and other approaches will be used to characterize local values related to water uses that support human communities and the environment. Those interactions will help describe a set of planning goals that reflect high-priority issues warranting focused consideration. Goals will respond to the location, behavior, condition, and/or function of the primary attribute(s) of interest to local stakeholders. Planning goals will be used to guide the selection of management alternatives. They also provide a benchmark for evaluating progress toward or away from desired outcomes after some action is taken.

4.2 Identifying and Evaluating Opportunities

Water is a limited resource and balancing consumptive and non-consumptive use needs generally involves tradeoffs. This is certainly the case in the San Miguel watershed where the most acute impacts on E&R needs are tied to surface water storage and diversion for agricultural use and power production. The responses of physical and legal water demands to hydrological conditions determine the allocation of water among the various uses present in the system. For agricultural uses, the infrastructure used to convey water, the irrigation application method, and the distance of fields from stream systems all influence the timing and location of surface and groundwater return flows. Interaction between water availability and use efficiencies can conspire to create demand shortages at different locations over the course of a year (Figure 41).

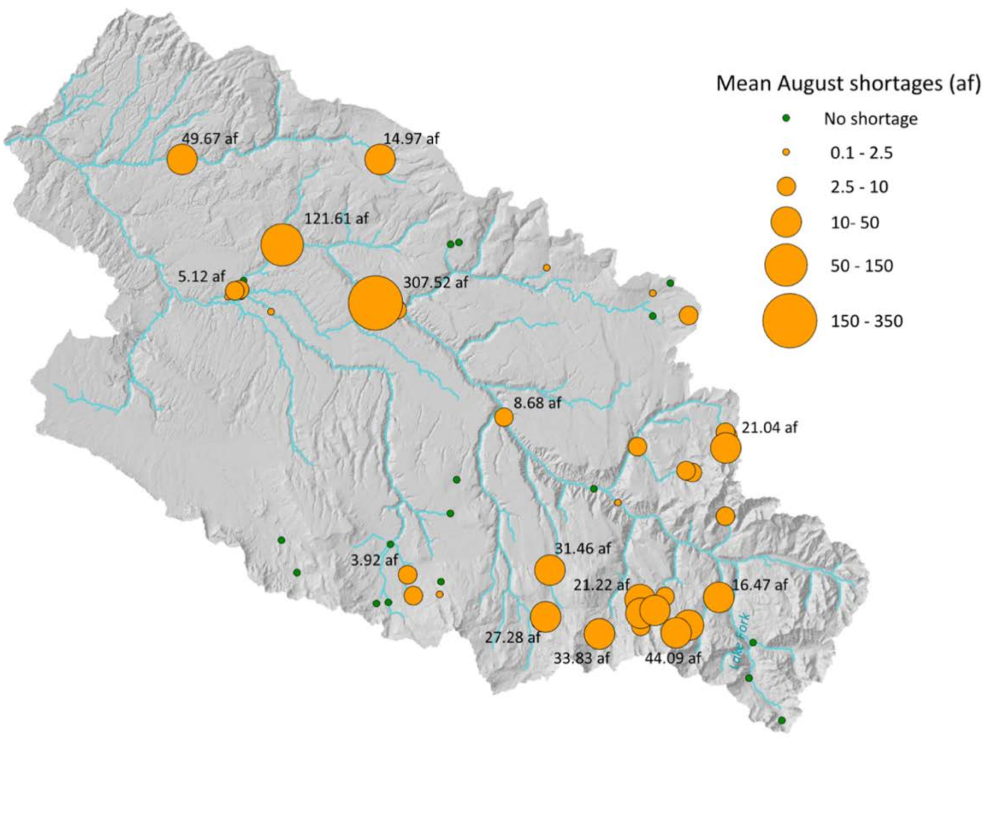


Figure 41. Simulated average August shortages experienced by surface water uses across the San Miguel watershed under average conditions.

Understanding the location, magnitude, and frequency of water use shortages affecting environment, agriculture, municipal use, and recreation can be useful for identifying locations and times when opportunity exists for implementing cooperative measures. Understanding water use shortages affecting a diversity of users also assists in identifying those locations and times where and when water availability and other constraints may limit the feasibility or effectiveness of cooperative measures. The first phase of the San Miguel Pilot Project included analysis of streamflow and water diversion data and development of simulation modeling tools. These data sets and tools provide stakeholders with a framework for evaluating the existence of shortages as they are affected by different hydrological conditions. Furthermore, these tools can be used in a predictive manner to determine whether water supply gaps increase or decrease following the implementation of various cooperative measures.

It is unlikely that any single management alternative will represent a panacea for optimizing water use and management between consumptive and environmental and recreational water needs. Rather, each alternative will likely represent a unique set of environmental, capital, and social costs and benefits. Stakeholders will be asked to consider these factors and help prioritize implementation of identified cooperative measures over the short, medium, and long-term.

4.3 Appropriate Use of Assessment Results

This San Miguel Pilot Project is a demonstration planning effort for the Southwest Basin in Colorado that aims to bring together scientific and engineering evaluations and local stakeholder values/concerns to produce a list of high-priority cooperative measures that produce multiple water-use benefits. This report details work completed during the initial phase of planning. Critically, the evaluations and results presented here represent appraisal level assessments that intend to characterize historical and current conditions at a relatively coarse level across the entire San Miguel watershed.

The first phase of the San Miguel Pilot Project relied heavily on existing data sets, studies, and research to evaluate conditions across the San Miguel watershed. Some new data was collected from locations across the watershed during the first phase of work. In some areas, however, data remains scarce and the types of assessment activities that can be completed are limited. These data limitations produce some uncertainty in results. This is particularly true when it comes to understanding use preferences among anglers and in modeling streamflows in small tributaries. Understanding the limitations of this assessment is critical for appropriate contextualization the information presented here during future planning processes and discussions.

In most cases, this document does not contain assessment results of sufficient detail to support new water rights filings or take the place of 1041 permit application review or any component of the National Environmental Policy Act (NEPA) process that may be required for a new water development project. Instead, this document should be used only as foundational information in support of planning-level discussions that identify high-priority projects, processes and management actions that help support a diversity of water uses. Subsequent planning phases are expected to include more detailed, site-specific evaluations.

4.4 Expected Outcomes

The completion of the San Miguel Pilot Project will yield a list of projects, processes, and management actions that enjoy a broad base of community support, exhibit limited legal/political/administrative constraints, have identifiable champions for implementation, and present logical funding sources. This list of prioritized actions will guide future action in the San Miguel watershed and may be used by the SWBRT to describe IPPs during the next update to the Southwest Basin Implementation Plan.

5 REFERENCES

"2005 Report Card: The Ecological Health of the San Miguel River Watershed." The Nature Conservancy; San Miguel Watershed Coalition, n.d.

"2006 Report Card Update: San Miguel River Watershed," 2006.

"2010 Irrigated Parcels, Division 4." Colorado Division of Water Resources, n.d.

Allred, Tyler M., and E.D. Andrews. "Hydrology, Geomorphology, and Sediment Transport of the San Miguel River, Southwest Colorado." U.S. Geological Survey, n.d.

Blevins, J. "Telluride Crushing Summer Business for Third Consecutive Year." *Denver Post*, April 27, 2016. http://www.denverpost.com/2014/09/17/telluride-crushing-summer-business-for-third-consecutive-year/.

Bureau of Reclamation. "San Miguel River Instream Flow Assessment," 1996.

Cavendish, Mary G., and Margaret I. Duncan. "Use of the Instream Flow Incremental Methodology: A Tool for Negotiation." *Environmental Impact Assessment Review* 6, no. 4 (1986): 347–63.

Chapman, Shannen S., Glenn E. Griffith, James M. Omernik, Alan B. Price, Jerry Freeouf, and Donald L. Schrupp. "Ecoregions of Colorado." Environmental Protection Agency, U.S. Geological Survey, Colorado Division of Wildlife, Colorado Department of Public Health, U.S. Department of the Interior, Natural Resources Conservation Service, U.S. Forest Service, n.d.

Colorado Decision Support System: HydroBase Online. Colorado Division of Water Resources., 2008. http://cdss.state.co.us/onlineTools/Pages/Online-ToolsHome.aspx.

Colorado Decision Support Systems: State of Colorado Stream Simulation Model: Southwest Basin. Colorado Division of Water Resources., 2015.

Colorado Water Conservation Board. "Southwest Basin Nonconsumptive Needs Assessment: Environmental and Recreational." 2010.

Cooper, David J, and Peter A. Conovitz. "Surface and Groundwater Interactions along the Middle and Lower San Miguel River, CO: Implications for Plant Water Sources, Plant Water Status, and the Susceptibility of Riparian Vegetation to Impacts from Changing River Base Flows." Bureau of Land Management, June 2001.

Dare, Matthew, Michael Carrillo, and Clay Speas. "Common Trout Species and Conservation Assessment for the Grand Mesa, Uncompahgre, and Gunnison National Forests." Grand Mesa, Uncompahgre, and Gunnison National Forests, March 2013.

EDAW, Inc. "San Miguel River Instream Flow Assessment Recreation Study." Bureau of Land Management, August 1998.

Espegren, D. "Development of Instream Flow Recommendations in Colorado Using R2Cross." Colorado Water Conservation Board., January 1996.

Ferrick, M.G., and D.M. Murphy. "Investigation of River Ice Processes on the San Miguel River, Colorado." Hanover, NH.: US Army Cold Regions Research and Engineering Laboratory, n.d.

Fey, Nathan. "Assessing Boatable Days to Describe Stream-Flow Influenced Recreational Attributes." American Whitewater, n.d.

Friedman, Jonathan M., Gregor T. Auble, Edmund D. Andrews, Gwen Kittel, Richard F. Madole, Eleanor R. Griffin, and Tyler M. Allred. "Transverse and Longitudinal Variation in Woody Riparian Vegetation along a Montane River." *Western North American Naturalist* 66, no. 1 (January 2006): 78–91. https://doi.org/10/dsn3z4.

"Issue Assessment Nos. 1, 2 & 41, Ice Accumulation Downstream of the Ames Powerhouse, Quality of the Sport Fishery Potentially Affected by the Project, Quality and Health of the Native Fish Communities." Water/Terrestrial Resource Work Group., 2005.

Johnson, B., M. Beardsley, and J. Doran. "FACStream Manual 1.0: Functional Assessment of Colorado Streams.," 2016. http://nebula.wsimg.com/bcd02501d43f467a7334b89eefea63d1?AccessKeyId=70CECFD07F5CD51B8510&disposition=0&alloworigin=1.

Kittel, Gwen M., and Nancy D. Lederer. "A Preliminary Classification of the Riparian Vegetation of the Yampa and San Miguel/Dolores River Basins." Colorado Department of Health, Environmental Protection Agency, The Nature Conservancy, February 29, 1993.

Kowalski, Dan. "Native and Sport Fish of the San Miguel and Dolores Rivers." December 15, 2010.

Lyon, Peggy, and John Sovell. "A Natural Heritage Assessment: San Miguel and Western Montrose Counties, Colorado." Colorado Natural Heritage Program, March 2000.

Madole, R.F., and D.P. VanSistine. "Geology and Recent History of the San Miguel River Valley, Southwestern Colorado." Montrose District Office: Bureau of Land Management, 2000.

Mahoney, J., and S. Rood. "A Device for Studying the Influence of Declining Water Table on Poplar Growth and Survival." *Tree Physiology* 8 (1998): 305–14.

Meyer, Peter, and R Meuler. "Formulas for Bed-Load Transport." In *Proc., 2nd Meeting of International Association for Hydraulic Research*, 26. Stockholm, 1948.

Oliver, Ann, and Carrie Lile. "Southwest Basin Implementation Plan." Southwest Basin Roundtable, April 17, 2015.

Poff, N. LeRoy, J. David Allan, Mark B. Bain, James R. Karr, Karen L. Prestegaard, Brian D. Richter, Richard E. Sparks, and Julie C. Stromberg. "The Natural Flow Regime." *BioScience* 47, no. 11 (December 1997): 769–84. https://doi.org/10/dr5rhj.

"Range-Wide Conservation Agreement and Strategy for Roundtail Chub, Bluehead Sucker, and Flannelmouth Sucker." Utah Department of Natural Resources, September 2006.

"San Miguel River: Legal and Institutional Analysis," February 2000.

San Miguel Watershed Coalition. "San Miguel Watershed Plan: A Collaborative Management Framework for the San Miguel Basin," 1998.

"San Miguel Watershed Rapid Assessment." U.S. Department of Agriculture, March 2010.

"State of the San Miguel Watershed 2014." San Miguel Watershed Coalition, 2014.

"Technical Update to the Colorado Water Plan." Colorado Water Conservation Board, 2019. https://www.colorado.gov/pacific/cowaterplan/analysis-and-technical-update.

The Nature Conservancy. "Save the Native: San Miguel Tamarisk Monitoring Update 2014," May 2014.

Wolman, M. G. "A Method of Sampling Coarse River-bed Material." *EOS, Transactions American Geophysical Union* 35, no. 6 (1954): 951–56.

Young, Michael K. "Colorado River Cutthroat Trout: A Technical Conservation Assessment." Ft. Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, 2008. https://doi.org/10.2737/RMRS-GTR-207.

APPENDIX A: ANNOTATED BIBLIOGRAPHY

APPENDIX B: MAPS OF THE SAN MIGUEL WATERSHED

APPENDIX C: HYDROLOGICAL ASSESSMENT OF THE SAN MIGUEL WATERSHED

APPENDIX D: RIVER CHANNEL CHARACTERISTICS IN THE SAN MIGUEL WATERSHED

APPENDIX E: RIPARIAN VEGETATION IN THE SAN MIGUEL RIVER CORRIDOR

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APPENDIX G: RECREATIONAL USES OF THE SAN MIGUEL RIVER AND MAJOR TRIBUTARIES