Draft Memorandum

To: Al Pfister
From: Brenna Mefford and Erin Wilson
Date: 7/19/2022
Re: San Juan Water Supply and Demand Analysis

Background

Wilson Water Group (WWG) completed an analysis of current and future water supply and demand through 2050 in the Upper San Juan River basin for the San Juan Water Conservancy District (District). The District's boundary includes both the Town of Pagosa Springs and rural areas of Archuleta County. Like many Colorado Mountain towns, the Town of Pagosa Springs and surrounding areas have seen unprecedented growth. Along with the growth the San Juan region has been experiencing a "millennial drought". The goal of this project was to document current and future demands for water from municipal, agricultural, and environmental and recreational users and to propose potential solutions for meeting any potential shortages in water supply in the future.

Municipal and Industrial Water Supply and Demand

Pagosa Area Water and Sanitation District (PAWSD) is the largest municipal water provider in the San Juan basin and serves the town of Pagosa Springs and the surrounding area. Most of PAWSD's service area overlaps with the District's service area as shown in Figure 1.

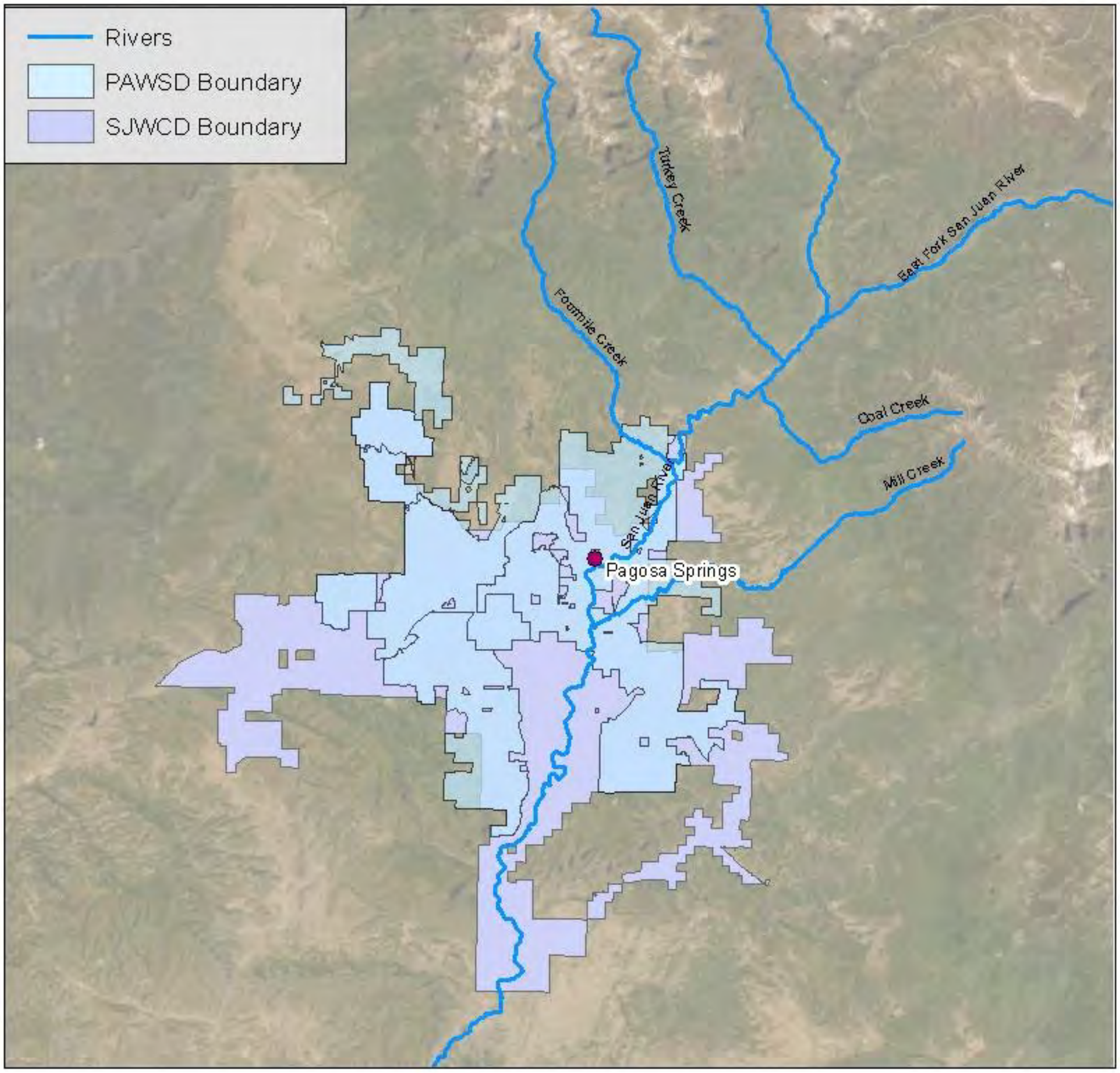

Figure 1. San Juan Water Conservancy District and Pagosa Area Water and Sanitation District Boundaries

The Town of Pagosa Springs owns water rights that are used to irrigate parks near the San Juan River. Archuleta County uses some of PAWSD water for road maintenance, and the use is included in PAWSD's total water use. Two large subdivisions use water outside of the town of Pagosa Spring: San Juan River Village and Aspen Springs. The San Juan River Village Water District uses well rights to provide water to roughly 170 taps , while the homes in Aspen Springs rely on water trucked from PAWSD fill stations. Both subdivisions consist of some full-time residents, but mainly second homes and short-term rental houses.

Pagosa Springs and the surrounding area saw larger than projected population growth over the past few years. To help develop estimates of current and future water demand, WWG reached out to the Town of Pagosa Springs, PAWSD, both subdivisions and Archuleta County to discuss the increase in population and potential future trends. WWG also discussed associated current and future water needs. Below summarizes the discussions:

- Over the past two years, Archuleta County has seen an increase in applications for building permits compared to previous years. However, due to the rising cost of building materials, some of the permits have been cancelled.
- Over the past two years, PAWSD has seen an increase in the number of requests for taps.
- The number of developers reaching out to the Town of Pagosa has increased in the past two years, and new developments have been planned. Developments include townhomes, condos, single-family homes, and possibly RV "subdivisions".
- Due to the rising cost of housing in Colorado, the Town of Pagosa is looking to build workforce housing to ensure that employees for the main tourism draws (skiing, rafting, hot springs, etc.) have access to affordable housing. Many locals and workers have been priced out of the competitive housing market and cannot afford to live where they work.
- During the pandemic shutdown, many second homeowners in Pagosa Springs were able to move permanently to Pagosa Springs and work remotely.
- As a result of the pandemic shutdown, more of the workforce are able to work remotely and are moving to Colorado mountain towns, including Pagosa Springs.
- A new HGTV show, Root Design, is likely to put a national spotlight on Pagosa Springs. While the effects of this show are unknown, it is expected that it will increase tourism as well as local population.
- Colorado's recent increase in wildfires have municipalities, including PAWSD, worried about how a large fire could affect their water intakes. A large wildfire around Pagosa Springs has the potential to cause PAWSD to shut down their water intakes on affected water ways to avoid the inflow of soot and debris caused by a fire. A fire in this area could continue to affect the town after the fire is extinguished, due to erosion and runoff during rain events in following years.
- The two largest subdivisions outside of the town of Pagosa Springs (San Juan River Village Metro District and Aspen Springs Metro District) are getting closer to the full build out. According to the San Juan River Village Metro District, over 74 percent of the taps have been purchased. There are not currently other proposed large subdivisions outside of the town of Pagosa; however, if the other two are fully developed, other large subdivisions could be proposed/developed. Note that WWG was not able to connect with anyone at the Aspen Springs subdivision but was able to talk with PAWSD about how Aspen Springs operates.

To determine current and future demand, WWG utilized PAWSD's 2020 Drought Management Plan. The Drought Management Plan noted that their average demand for raw and potable water produced from 2008 to 2017 was 2,246 acre-feet. However, from discussions with PAWSD, water demand on average has increased due to a greater than expected increase in population since the pandemic shutdown. PAWSD's average water demand from 2017 to 2021 was 2,536 acre-feet. WWG also talked to the San Juan River Village Metro District about water use. The district currently utilizes two gallery wells and is in the process of drilling a third. The district does not expect to need more wells to meet total build out demand. The total demand from the metro district is currently around 14 ac-ft per year.

To estimate future population growth, WWG looked at population growth estimates from the demographer's office, PAWSD, the Growing Water Smart Workgroup, and the Technical Update to the Colorado Water Plan (Technical Update). All these sources provided very different estimates of population growth. The demographer's office estimated lower growth, while the Technical Update, the Growing Water Smart Workgroup provided a range of low to high estimates. WWG reached out to representatives from the Town of Pagosa, PAWSD, and Archuleta County, and presented them with the different estimates from each source. Working with all three entities, WWG developed three population growth scenarios based on their local knowledge and the original estimates. Below are the three scenarios:

- Low: 1.7 % growth – This value is based on the 2019 Growing Water Smart Workgroups Average population growth for Archuleta County from 2020 to 2050.
- Medium: 2.6% Growth - This value is based on the 2019 Growing Water Smart Workgroups High population growth for Archuleta County from 2020 to 2050.
- High: 5% For ten years, then 2% through 2050 – This value is based on conversations with the Town of Pagosa, PAWSD, and Archuleta County. Since the beginning of the Pandemic, the area around Pagosa Springs has seen unexpected growth estimated to be around 5% per year. The town expects this growth to continue for the foreseeable future; but is likely not sustainable to 2050. Therefore, this scenario represents growth decreasing after 10 years.

These three population ranges provide the District with a range of municipal demands for planning purposes. As was experienced during the pandemic shutdown, growth can start and stop suddenly, therefore it is best to use a range of municipal water demands versus focusing on one forecasted population estimate. Table 1 shows the current and projected population and demand estimates for each of the three scenarios. Note that the current population (10,025) is based on the Colorado Demographer estimate for Archuleta County for 2020 and reduced by 25 percent to represent PAWSD's service area.

Table 1. Current and 2050 population estimates, GPCD and demand for municipal water in the PAWSD service area.

	Current (2020)	**2050 Projections**		
		Low (1.7%)	**Medium (2.6%)**	**High (5% for ten years, 2% after)**
Population	10,025	16,623	21,652	24,979
GPCD	226	226	226	226
Demand	2,536 AF	4,208 AF	5,481 AF	6,323 AF

Based on Table 1, the population PAWSD serves could increase by roughly 6,500 to 14,900 resulting in an increase in demand for water from PAWSD. Note that GPCD was held constant for this analysis. PAWSD may continue implementing water conservation practices that could impact GPCD, however it is hard to predict what conservation practices could be implemented, or the impact of those practices. WWG felt it was best to be conservative with the GPCD estimates and not try and estimate how GPCD could change in the future. Changes in GPCD due to drought or conservation practices are captured in the Technical Update.

Currently there are no industrial users that are self-supplied in Archuleta County. There are industrial water users that are supplied by PAWSD, and their demands are included in PAWSD's demands. PAWSD does not currently provide data for different types of water users.

Agricultural Water Supply and Demand

Significant future demands for agricultural water in the San Juan basin would depend on an increase in current irrigated acreage. The State of Colorado's irrigated acreage assessments, updated on an approximate 5-year basis, shows that irrigated acreage has decreased by 13 percent since 1990 in Water District 29 of the San Juan basin. The recent Technical Update also projected no increase in irrigated acreage through 2050. However, in below average hydrologic years, there are late irrigation season water supply limitations that could benefit from water stored during the runoff period.

WWG used the Colorado Decision Support System (CDSS) consumptive use model to estimate the potential crop demand of current irrigated acreage and actual crop consumptive used based on irrigation diversions recorded by the Division of Water Resources over the past 30 years. Even though most irrigation shortages are due to physical and legal water limitations, some shortages may be due to irrigation practices, such as limiting irrigation to allow for grazing. For this analysis, it was assumed that irrigation shortages were due to water supply limitations. Figure 2 shows annual irrigation shortages in the District for the last 30 years.

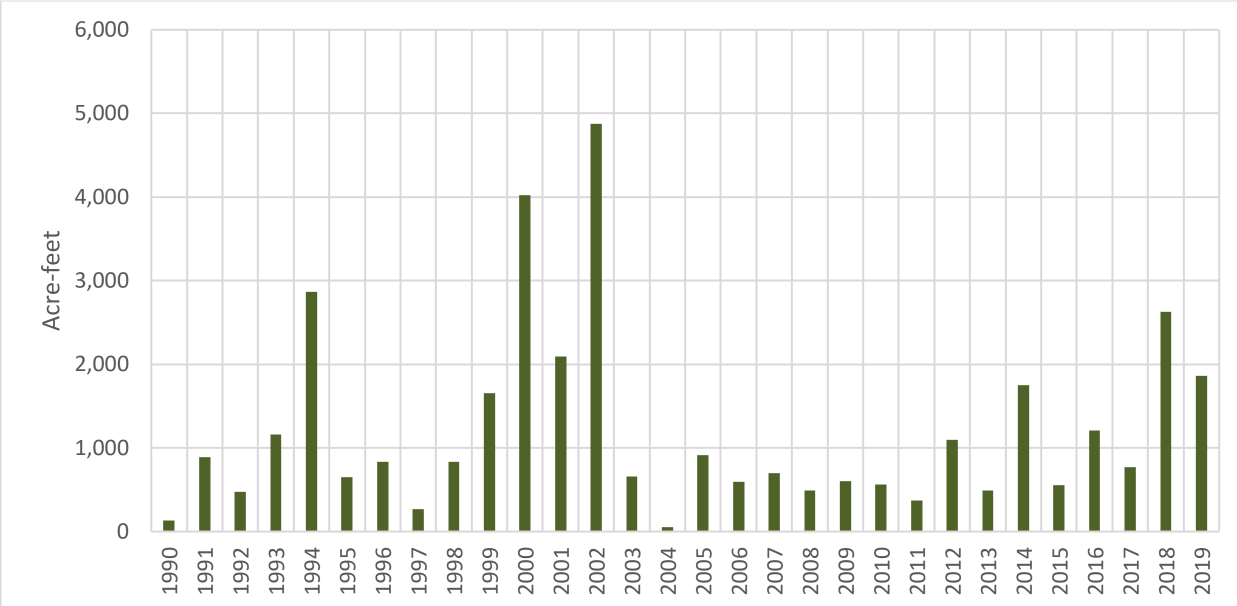

Figure 2. Irrigation shortages in the District Boundary over the past 30 years

As shown in Figure 2, annual irrigation shortages ranged from around 50 acre-feet in 2004 to almost 5,000 acre-feet in 2002, with an annual average shortage of 1,200 acre-feet over the period 1990 through 2019. As expected, higher shortages occur in dry years such as 2002, 2018, and 2019. Access to storage could help agricultural producers in the District reduce irrigation shortages during drought years. The estimated shortages were used as a potential demand on future District storage. Note that the irrigation rights are senior to conditional water rights in the basin; therefore, the development of conditional water rights will not increase potential agricultural demand of District storage.

Environmental and Recreational Water Supply and Demand

Similar to the West Fork Water Rights Alternative Study, WWG determined how often the instream flow through the town of Pagosa Springs is met and how often the environmental flow bypass stipulations imposed on the District's Dry Gulch conditional water rights in Case No. 04CW85 would have been met based on recent hydrology. In addition, WWG reviewed environmental and recreational needs identified in the San Juan Watershed Enhancement Partnership (WEP) Phase II Report on Non-Consumptive Needs Assessment (WEP Phase II Report). The WEP Phase II Report was completed in June of 2021 and provided flow thresholds for boating, angling, and sediment transport that WWG used to estimate environmental and recreational demands. There are a wide range of flow demands for the identified environmental and recreational needs; therefore, the demands and shortages were analyzed individually.

CWCB Instream Flow Demands

The CWCB instream flow reach on the mainstem of the San Juan River begins at the confluence of the East and West Forks of the San Juan River and extends to the town of Pagosa Springs.

The instream flow water right is 50 cfs from March 1 to August 31 and 30 cfs from September 1 to February 29, fora total annual demand of roughly 29,000 AF. The San Juan at Pagosa Springs streamflow gage (USGS ID 09342500) was used to determine how often the mainstem instream flow rights is satisfied. Figure 3 shows the daily instream flow shortages over the last 30 years. The CWCB instream flow right is a very junior water right in the basin, with a 1980 appropriation date. Unlike the shortages to senior agricultural uses, as shown in Figure 3, the need for District storage to meet the environmental demands would increase if upstream conditional water rights were developed.

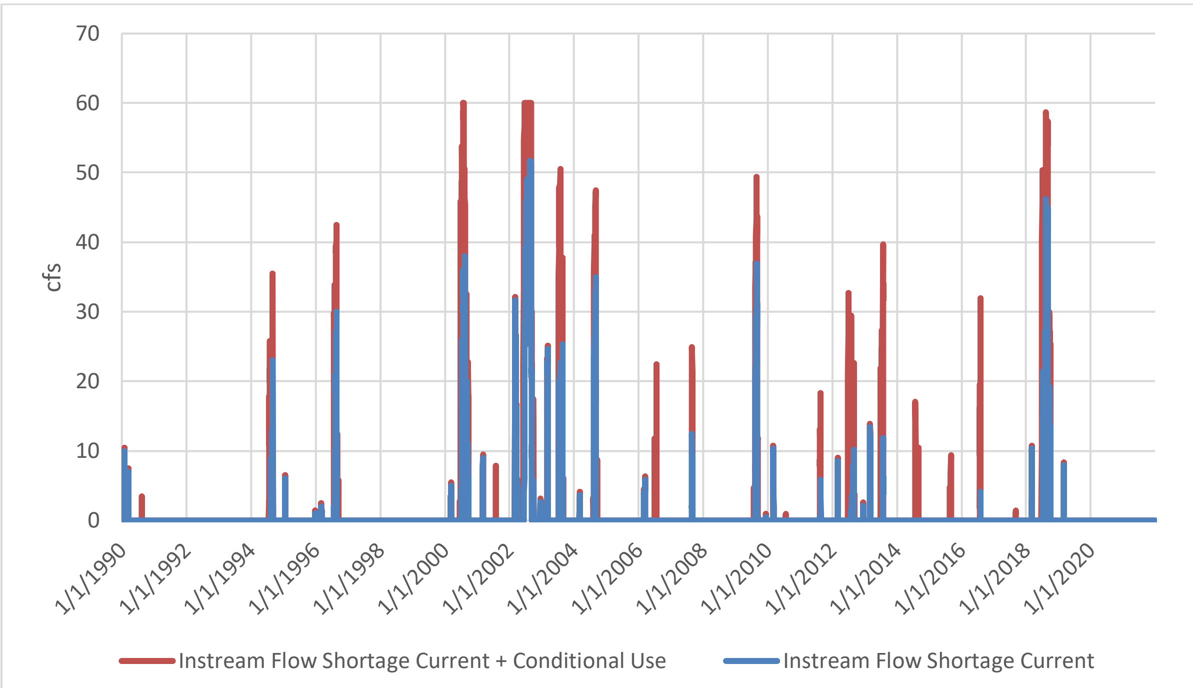

Figure 3. Daily San Juan River Instream Flow Shortages

As shown in Figure 3, in most years the current instream flow right is satisfied. Instream flow shortages generally occur in July and August only in dryer years with limited late season precipitation. This coincides with the period that municipal and agricultural demands are greatest and the typical high season for tourists in Pagosa Springs that like to enjoy recreation on the San Juan River. Annual shortages range from 0 acre-feet in most years to 4,368 acre-feet in 2002 (6,746 acre-feet if upstream conditional rights were developed).

Dry Gulch Stipulated Bypass Requirements

Environmental flow bypass stipulations were added as a requirement for development of the Dry Gulch water rights during the 2004 diligence proceedings. These stipulated flows are double the current instream flow right on the mainstem of the San Juan River (100 cfs from March 1 to August 31 and 60 cfs from September 1 to February 29), providing a total annual demand of roughly 58,000 AF. Backup documentation on the basis for these flows could not be found, however these stipulated flows may be justified and necessary to meet environmental needs, therefore could be protected under a new instream flow filing or water acquisition. Colorado Parks and Wildlife (CPW) and CWCB would need to perform an analysis to determine if the flows are necessary to preserve or improve the natural environment to a reasonable degree. Figure 4 shows the daily shortages on the mainstem San Juan River if the stipulated flow rates were justified. As shown, the need for District storage to meet these flow shortages would increase if upstream conditional water rights were developed.

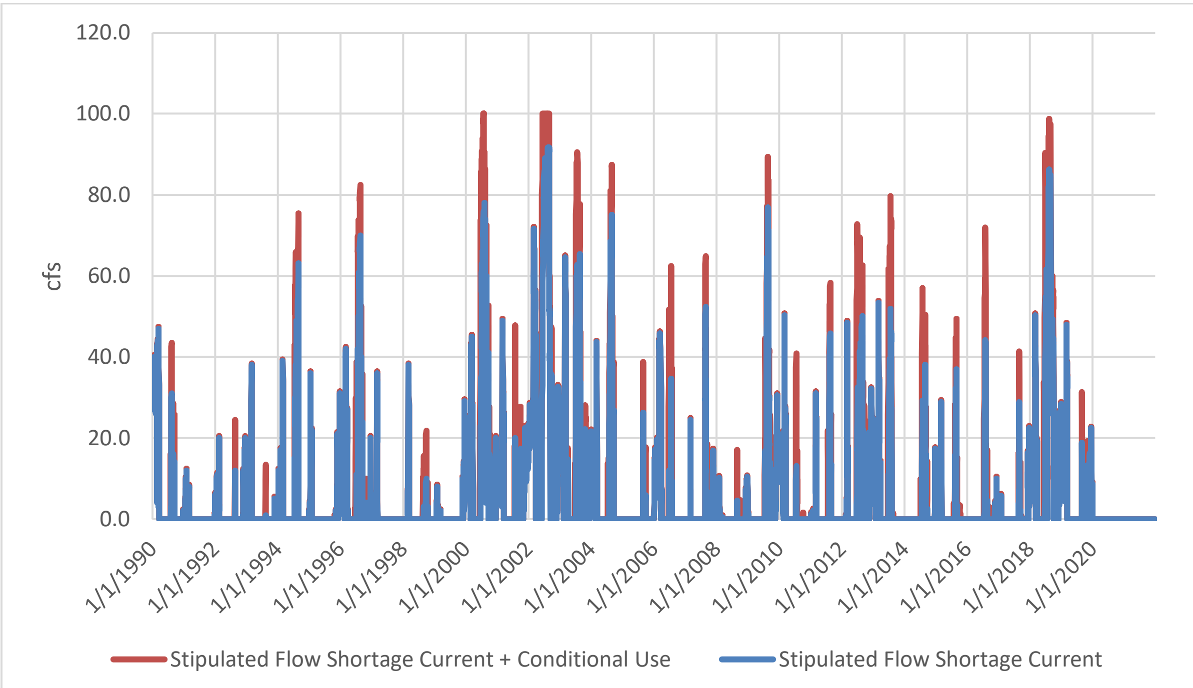

Figure 4. Daily San Juan River Environmental Stipulated Flow Shortages

The environmental stipulated flows result in increased shortages compared to the current instream flow demands in late summer and winter months in both hydrologically dry and hot years. Annual shortages range from 0 acre-feet in many years to 21,482 acre-feet in 2002 (24,679 acre-feet if upstream conditional rights were developed). The average annual shortage over the 30-year analysis period is 3,327 acre-feet.

Recreational Flows

The WEP Phase II Report documented user preference flows for recreational angling and whitewater rafting on the San Juan River. The San Juan basin offers exceptional fishing and whitewater opportunities that bring in tourists to the area. The town of Pagosa Springs relies on tourism as a source of revenue and therefore it is important to understand the flow preferences and how they are met. The WEP Phase II Report documented user preference flow ranges (minimum tolerable, lower acceptable, lower optimal, upper optimal, upper acceptable) for different types of angling including wade fishing, bank-fishing, and float fishing. They also documented user preference flows for and different types of whitewater recreation, including rafting, kayaking, tubing, and standup paddle boarding. WWG utilized the lower acceptable flows to investigate how often they are or are not met for rafting, tubing, wade-fishing and float fishing. Note that the other angling and whitewater activities listed in the WEP Phase II Report had flows the fell within the activities/flows WWG analyzed. Below is a summary of the flows for each activity from the WEP Phase II report and the assumptions WWG made for the analysis.

- Wade Fishing
  - WEP Phase II Report, Lower Acceptable: 100 cfs
  - Assumed fishing could occur from March 1 to November 31. The WEP Phase II report did document some winter fishing, however it was minimal.
- Float Fishing
  - WEP Phase II Report, Lower Acceptable: 300 cfs
  - Assumed fishing could occur from March 1 to November 31. The WEP Phase II report did document some winter fishing, however it was minimal.
- Tubing
  - WEP Phase II Report, Lower Acceptable: 30 cfs
  - Assumed Tubing could only occur from June through August. Tubing cannot occur till after the runoff, the air temperature needs to be warm enough, and there needs to be enough water to not get caught on the rocks on the bottom of the river.
- Rafting
  - WEP Phase II Report, Lower Acceptable: 250 cfs
  - Assumed Rafting could only occur from May through August. This assumption was based on information in the WEP Phase II Report and on rafting outfitters' websites. Note that in many years rafting currently cannot occur past June in the "Town Run" area due to low water conditions.

Table 2 documents the annual demand for each activity and the minimum, maximum and average shortages that have occurred from 1990 through 2021 at the San Juan River at Pagosa Springs stream gage. Figure 5 shows the annual shortage for each activity from 1990 through 2021

Table 2. Annual Demand and Maximum, Minimum, and Average Shortages for Recreational Angling and Whitewater Activities at the San Juan River at Pagosa Springs Stream Gage.

Activity Type	**Annual Demand (AF)**	**Shortage (AF)**		
		Minimum	Maximum	Average Annual
Wade Fishing	54,548	0	24,143	4,611
Float Fishing	163,645	9,351	126,483	54,468
Tubing	5,475	0	1,908	72
Rafting	60,995	0	46,099	11,751

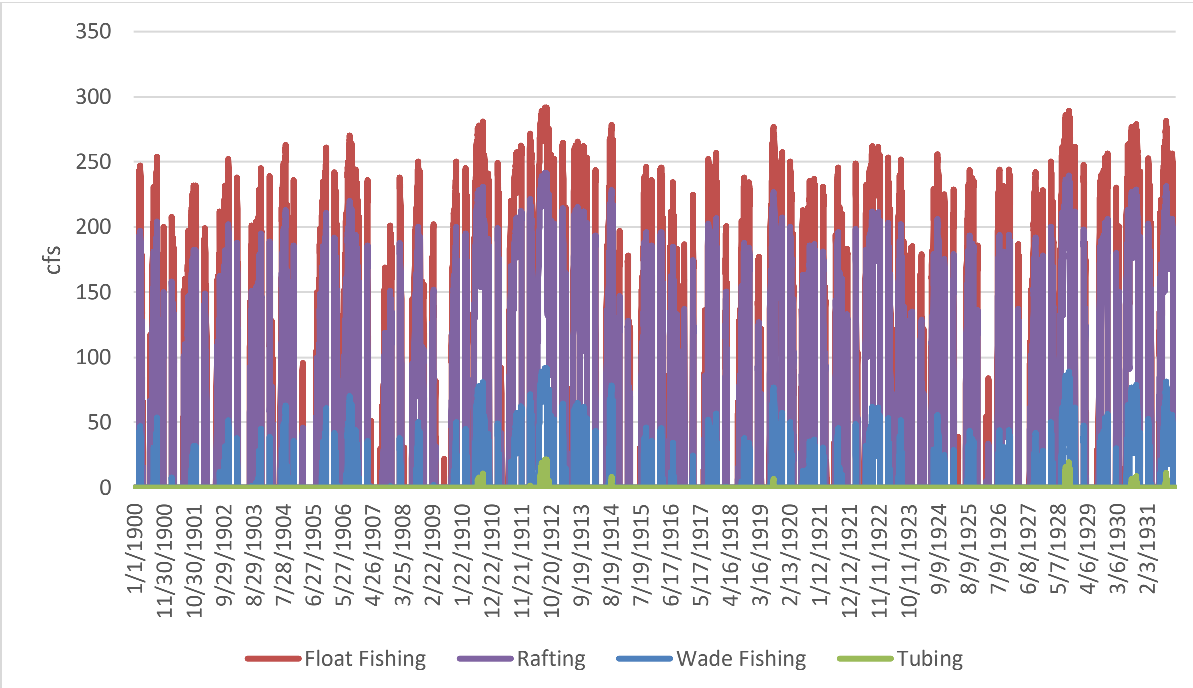

Figure 5. Daily San Juan River Recreational Flow Shortages

Float fishing has the highest demand and the highest shortages of the recreational activities in the WEP Phase II Report and tubing has the lowest demand and lowest shortages. The WEP Phase II Report noted that even though the report utilized a focus group of local experts to develop the flow thresholds, whether a flow is suitable for fishing or floating is considered a matter of opinion and is dependent on skill level, knowledge, and other factors.

Sediment Transport Target Flows

The WEP Phase II Report also documented optimum sediment transport characteristics for sites on the mainstem San Juan River. Aquatic habitats and nearshore ecosystems rely on sediment transport to provide nutrients and to create and/or maintain aquatic habitats. Too much sedimentation can be detrimental to habitats and severely alter a river, while too little sediment transport can lead to nutrient depletion. Table 9 in the WEP Phase II report provides flow management targets for transport thresholds and peak flow (effective discharge) events. The report states that transport flows should occur, on average, for 30 or more days each year and the peak flow events should occur for three-days at a frequency of roughly every two years. Table 3 shows the targeted flows for the San Juan River at Pagosa Springs.

Table 3. WEP Phase II Report Recommended Flow Targets for Sediment Transport

Location	Phase II Transport Threshold (cfs for minimum of 30 days/year)	Peak Flow - Effective Discharge (cfs for 3 days every 2 years)
San Juan River in Pagosa Springs	1,225	2,410

WWG identified how often the transport threshold and peak flow targets were met historically and how often a shortage occurred. Figure 6 shows the number of days each year that the transport threshold flow was met. Figure 7 shows daily streamflow from 1990 through 2021 and the peak flow effective discharge. Typically, when the peak flow reaches the target threshold it occurs for three days or more.

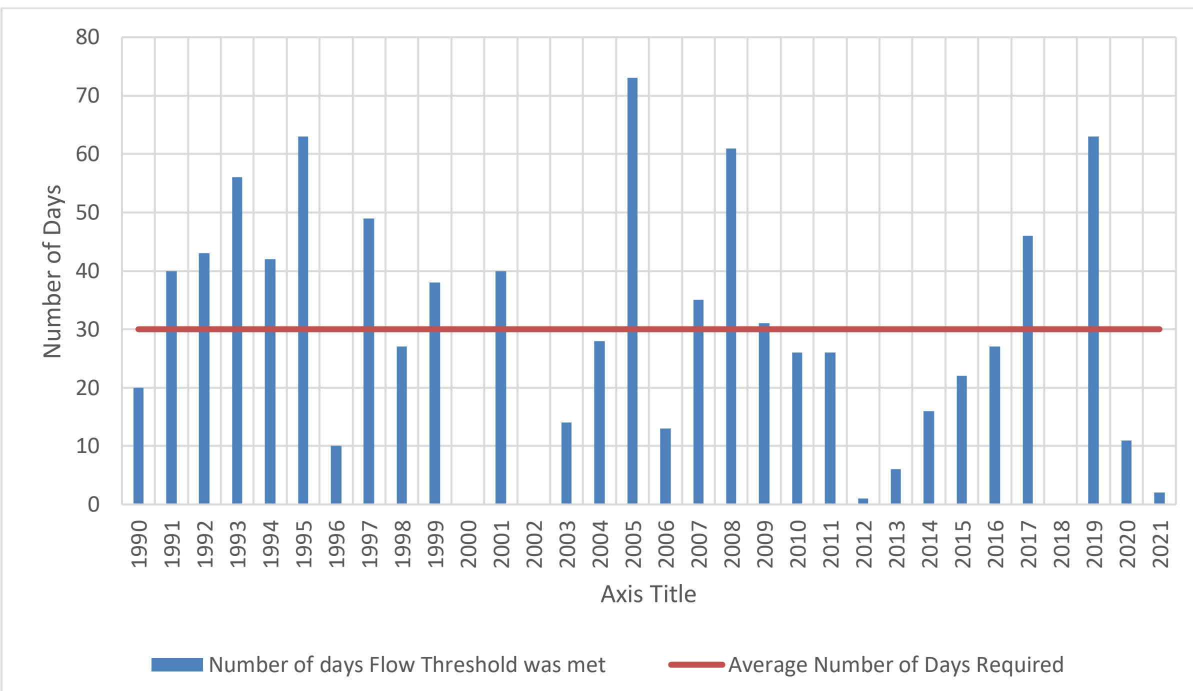

Figure 6. Number of Days Each Year that the WEP Phase II Transport Flow Threshold was Met

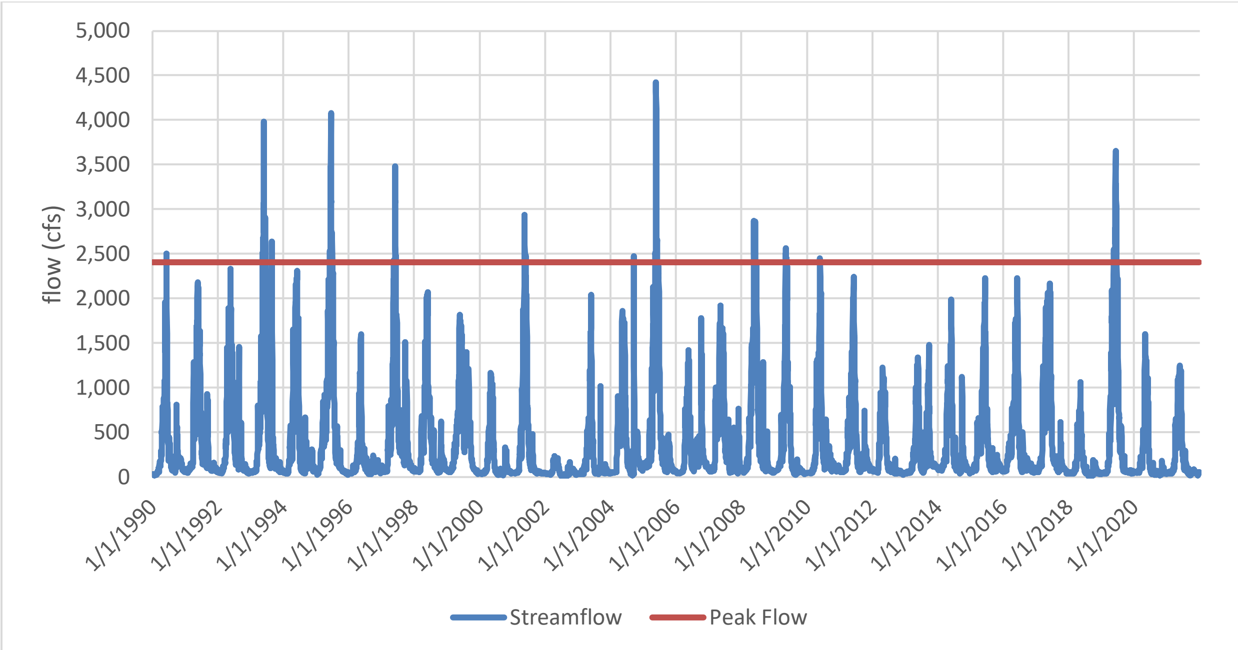

Figure 7. Daily streamflow at the San Juan at Pagosa Springs and the Peak Flow (effective discharge) target flow

Both the transport flow and peak flow targets were met more frequently in the 1990s corresponding to wetter hydrologic years. From 2010 through 2021, the flow targets have been met less frequently, corresponding to the recent "millennial drought". Table 4 shows the average annual shortages for both the Phase II Transport Flow Threshold and the peak flow effective discharge target flow from 1990 to 2021.

Table 4. Phase II Transport Flow Threshold and Effective Discharge Annual Demand and Average Annual Shortage at the San Juan at Pagosa Springs Stream gage.

Flow Type	Annual Demand (AF)	Average Annual Shortage (AF)
Phase II Transport Flow Threshold	72,893	7,927
Peak Flow Effective Discharge*	14,340	910

*Note that the Peak Flow Effective Discharge only needs to be met roughly every two years.

Due to the wide range of environmental and recreational flows, WWG creating three scenarios to investigate environmental and recreational flow needs.

- Minimum – The minimum environmental and recreational demands are based on release to assure the mainstem instream flow at the San Juan River at Pagosa Springs stream gage is always met. This demand also would meet the demand for the lower acceptable range for tubing. This demand does not meet the lower acceptable demands for wade fishing, float fishing, or rafting. It also does not meet the Dry Gulch stipulated environmental flows or the sediment transport flows.

- Mid-Range – The middle environmental and recreational demand is based on meeting the Dry Gulch stipulated environmental flows and meeting the lower acceptable range for wade fishing from March to November. By meeting the lower acceptable range for wade fishing, it also meets the lower acceptable range for tubing and the instream flows.
- Maximum – The maximum environmental and recreational demand is based on meeting the maximum demand for all categories for each month. For December through February, the maximum demand is the stipulated environmental flows. In March, April, and July through November, the maximum demand is the lower acceptable flow for float fishing (300 cfs). The May and June maximum demand is the sediment transport demands (1,225 cfs for 30 days), assumed to be from May 16 to June 14.

Figure 8 shows the daily shortage of each of the three environmental and recreational demands, based on the streamflow at the San Juan River at Pagosa Springs stream gage. Table 5 summarizes the average annual shortages for the three demands.

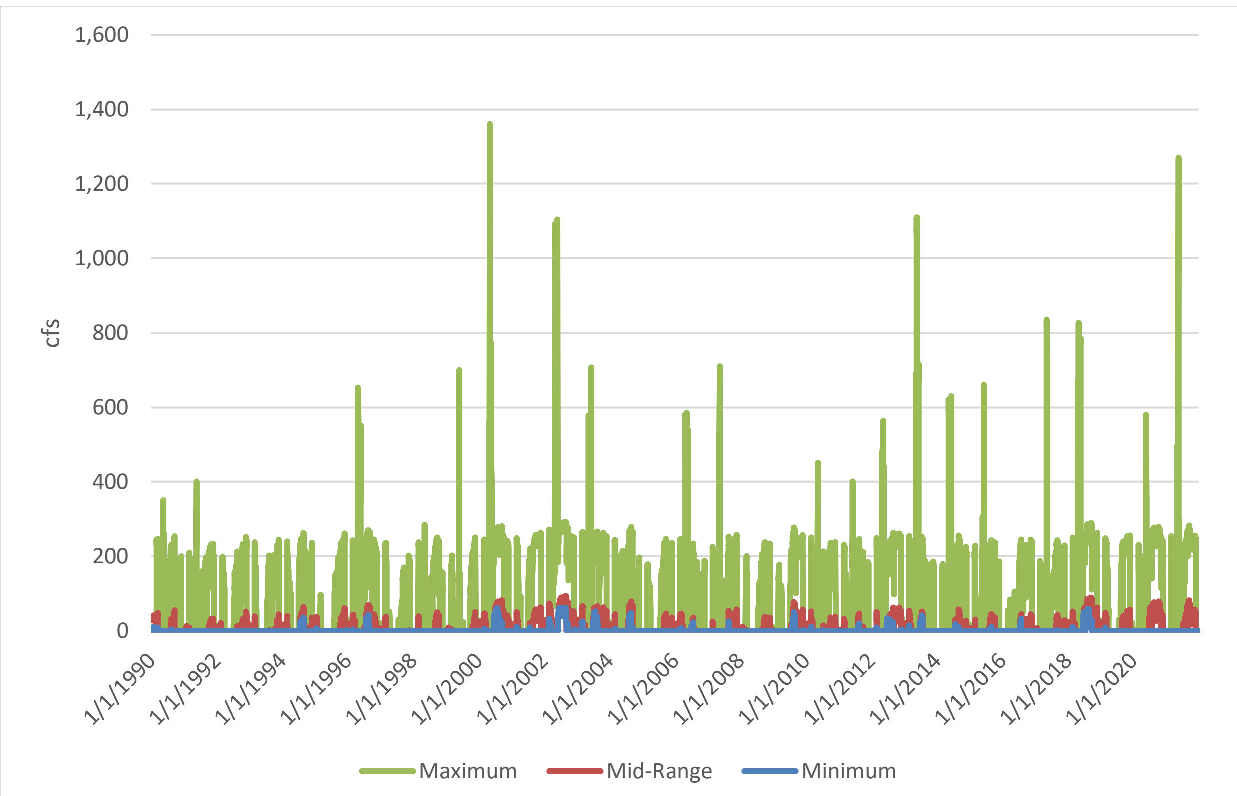

Figure 8. Range of Environmental and Recreational Shortages from 1990 to 2021, Based on the San Juan River at Pagosa Springs Stream gage.

Table 5. Average Annual Shortages for the Three Environmental and Recreational Demands

	Minimum	Mid-Range	Maximum
Average Annual Shortages	1,288	6,298	68,571

The shortages shown in Figure 8 and Table 5 range from 0 acre-feet to 185,705 acre-feet (2002) under the three scenarios.

Total Demands and Shortages

The estimated municipal, agricultural, and environmental and recreational demand above were combined to determine a projected range of 2050 demands. The range is presented based on Low, Medium, and High demands as follows:

- Low Demand – Low municipal growth, minimum environmental and recreational demands, and historical agricultural shortages.
- Mid-range Demand – Medium municipal growth, mid-range environmental and recreational demands, and historical agricultural shortages.
- High Demand – High municipal growth, high environmental and recreational demands, and historical agricultural shortages.

Figures 9, 10 and 11 show the estimated 2050 shortages for Low, Mid-range, and High demands and how they fluctuate based on historical climate and streamflow conditions.

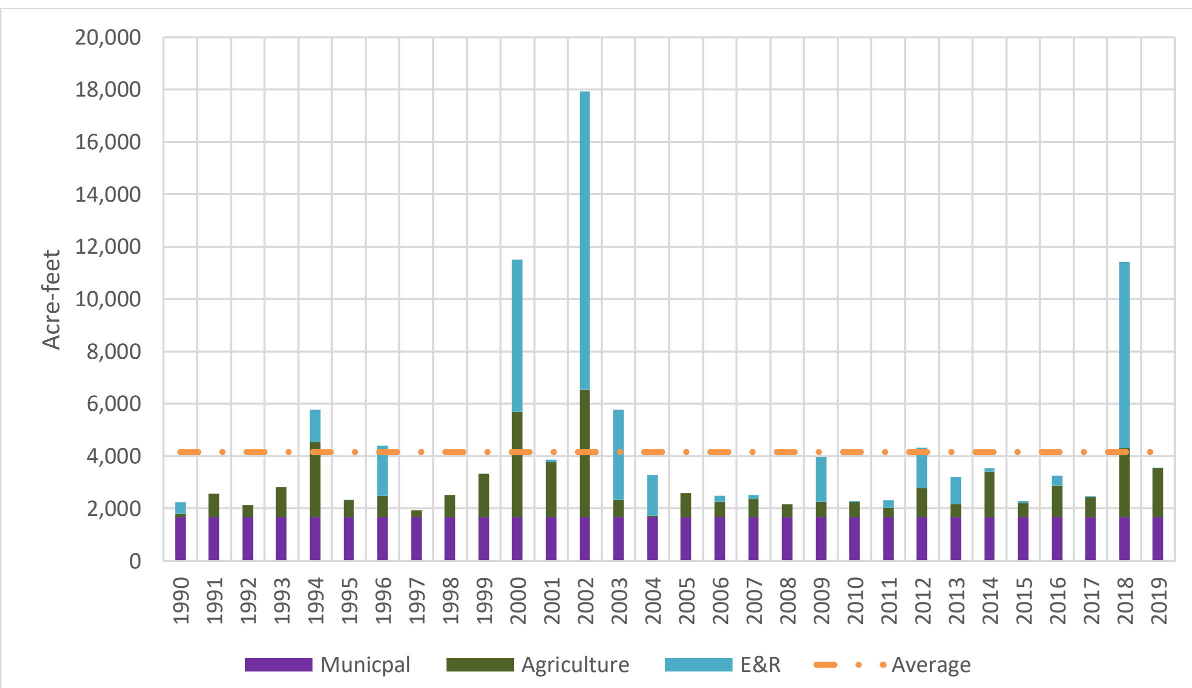

Figure 9. Low Demand Annual 2050 Projected Shortages

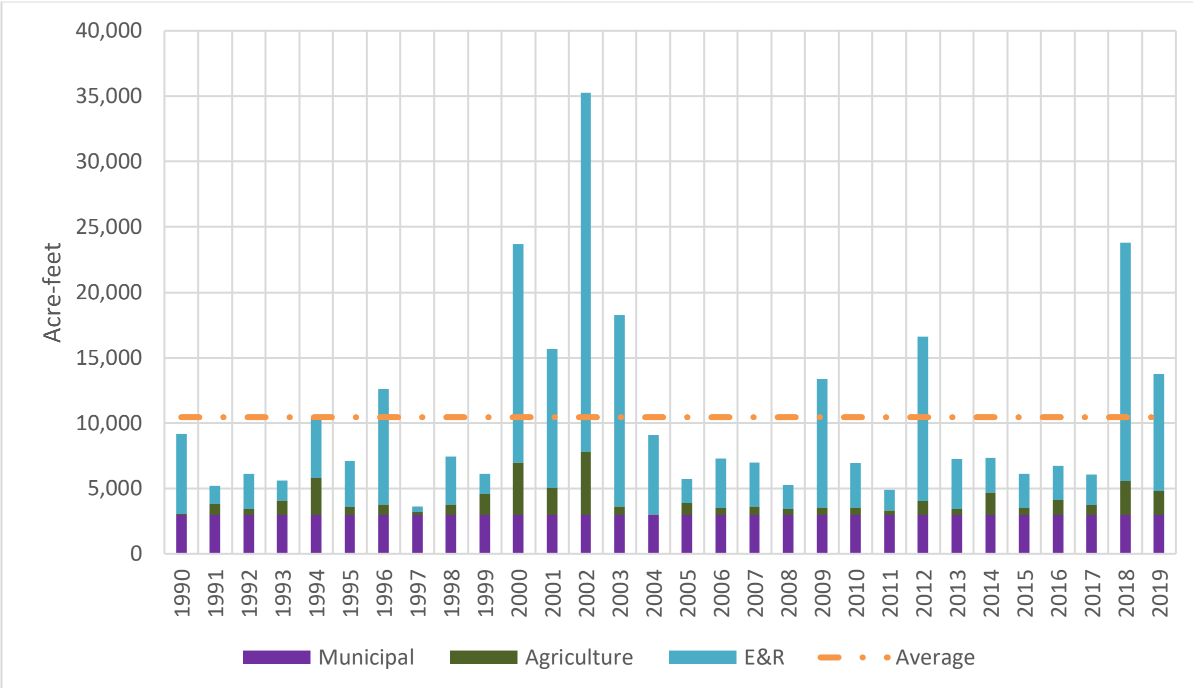

Figure 10. Mid-Range Demand Annual 2050 Projected Shortages

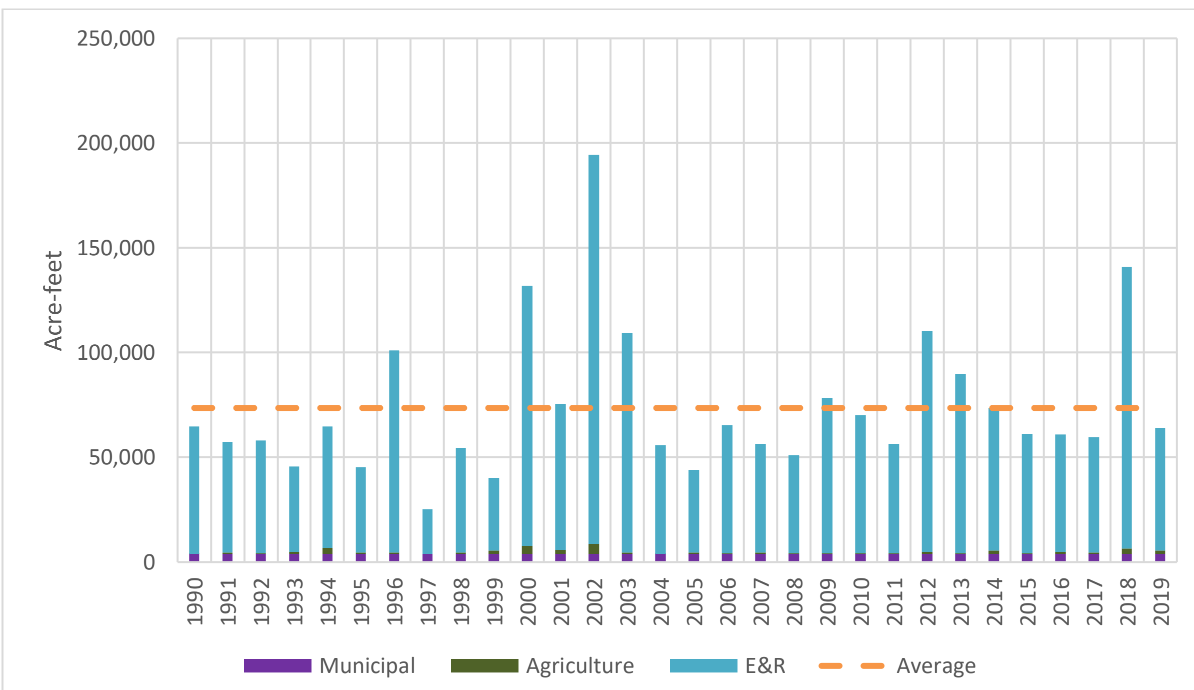

Figure 11. High Demand Annual 2050 Projected Shortages

Figures 9, 10 and 11 show an average annual future shortage that ranges from around 4,100 acre-feet to 73,000 acre-feet. A reservoir could help the Upper San Juan basin meet these projected shortages. The size of the reservoir depends both on the demand level and District's goals for meeting shortages. For example, the reservoir could be sized to meet the average of all shortages (average yield), to meet municipal shortages in all years (municipal yield), or to meet all shortages even in the driest years (firm yield).

Potential Reservoir Sizes

Depending on future demands, a reservoir could be sized to meet any of the above demands. The limiting factors in reservoir sizing are the legally and physically available water to fill the reservoir, the 50 cfs filling constraint, and the demands driving reservoir releases. WWG did a water availability analysis to determine the potential range of reservoir sizes that would be needed to meet the range of projected shortages shown above. The water availability analysis assumed that water could be diverted into a reservoir at a maximum of 50 cfs based on the Dry Gulch Reservoir water right and that the Dry Gulch environmental flow stipulations had to be met when the reservoir was filling. The reservoir was assumed to be full at the start of the modeling period. The goals of the reservoir analysis were to meet municipal demands all years and to meet other shortages except in dry years. Table 6 provides the potential reservoir sizes based on the Low and Mid-Range Demand projected shortages. Note that because the annual High Demand shortages are greater than water available for filling (limited by 50 cfs), the reservoir inflow cannot keep up with the reservoir releases; therefore, a reservoir cannot meet the High demand shortages regardless of size.

Table 6. Potential Reservoir Sizes Based on the Projected Low and Mid-Range Annual 2050 Demand Shortages to Meet Municipal Shortages in all Years

	Low	Mid-Range
Potential Reservoir Size	1,600	10,000

Figures 12 and 13 show the projected reservoir daily content for the potential Low and Mid-Range Demand reservoir sizes.

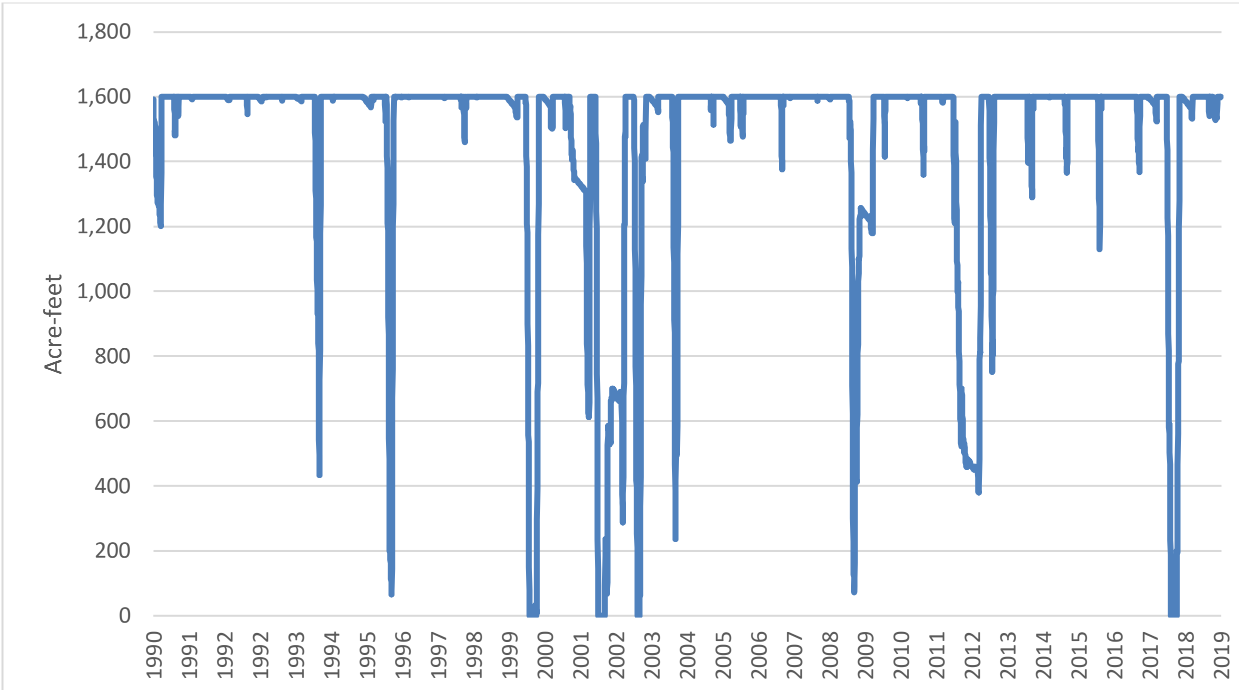

Figure 12. Reservoir Capacity over the Model Period for the Reservoir Meeting Low Demand Municipal Shortages (1,600 ac-ft)

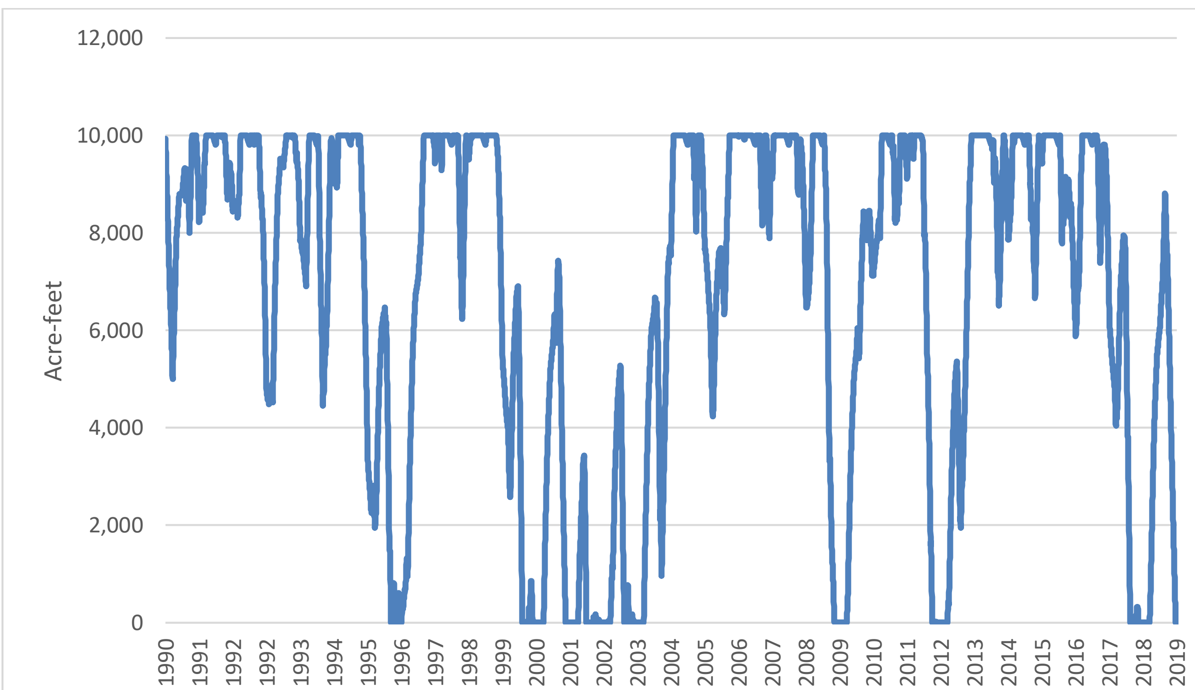

Figure 13. Reservoir Capacity over the Model Period for the Reservoir Meeting Mid-Range Demand Municipal Shortages (10,000 ac-ft)

Figure 12 shows that a low demand reservoir can meet all low Demand shortages (instream flow, irrigation shortages, and municipal demands) except in significantly below average years (4 years out of 30 years). The mid-range reservoir (Figure 13) can meet municipal demand shortages in all years; but cannot meet shortages to all demands in below average years (11 years out of 30 years). If the District chooses to build a reservoir, more discussion should occur to determine the most critical demands that should be considered for reservoir sizing.

Alternative Measures to Meet Projected Demands

A reservoir is the historically most common option to meet additional demands; however, there are other potential opportunities to improve streamflow to meet additional demand. Healthy ecosystems provide some natural water storage, and recent research has focused on ways to increase natural water storage. Improved natural water storage theoretically improves baseflows later in the summer after peak runoff. Brissette (2017) considered the affects of stream restoration as a tool to increase storage and baseflow discharge. The results from this study showed increased alluvial aquifer recharge and underflow in the restore reach, versus continued alluvial aquifer drainage in the degraded reach. Increased alluvial aquifer recharge could theoretically improve late season flows. Another study (Goeking et al., 2020) considered the affects of forest health on water yield. Goeking et al. found that the hypothesis that forest cover loss results in more water due to decreased evapotranspiration may not be completely true as other studies have shown that forest disturbance can actually decrease snowpack and streamflow. The analysis suggests that healthier forests could lead to increased water yield. Westbrook et. al (2006) looked at the benefit of beaver ponds in small mountain streams and how they benefit the streamflow by keeping the water table elevation higher and reducing the rate at which the water table declines. This could have the effect of keeping late season stream flows higher.

Note that there has not been extensive research into these natural methods for maintain higher streamflow, and information from the studies are often site-specific. Therefore, it is unclear how much additional streamflow would occur or be maintained within the District if there was increased effort at stream restoration, improved forest health, or introduction and protection of existing beaver habitats. However, researchers agree that these options would improve overall stream health.

Another potential option to meet demands is through temporary voluntary agricultural fallowing. Temporary fallowing could benefit streamflow and meet other demands during drought years. A multi-year field research project near Kremmling, Colorado is investigating effects of temporary fallowing of perennial grass fields on both streamflow and producer hay yield in the year of fallowing and subsequent years. This study supplements several fallowing investigations performed by Dr. Joe Brummer and Dr. Perry Cabot with Colorado State University over the past 10 to 15 years. Those studies include fallowing of grass fields near Steamboat Springs, Kremmling, Gunnison, Montrose, Cimarron, and Orchard Mesa.

The combined studies indicate that some high-productive grass hay fields were able to recover from fallowing by the next year; however, many fields, especially low-productive fields, did not return to full crop yield for three years. Dr. Cabot, who is leading the Kremmling project research team, believes that recovery of the fallowed fields could be site specific and dependent on the type of grass and the soil profile. Understanding how temporary fallowing affects the following year yield is important for farmers and ranchers to weigh the risks when participating in a temporary fallowing program. Note that investigation is still on-going and a final report for the current Kremmling project is not yet available. However, Dr. Cabot did indicate that if the District is interested in considering fallowing as an option to meet demands in dryer years, site specific information is critical to understanding both potential consumptive use savings, and potential extended year impacts to crop yield.

WWG recommends that the District continue to monitor results of research in these areas, as they may provide alternatives that could help the District meet demands in the future.

Future Water Needs from the Technical Update to the Water Plan

The Colorado Water Plan considered five water supply and demand scenarios for projected year-2050 that consider population change, agricultural water needs, potential conservation measures, social values, and climate conditions. The five scenarios are the basis of the analyses and modeling completed for the Technical Update to the Water Plan. The results from the Technical Update are included in this analysis as another potential scenario for 2050 water use in the District boundary. This analysis includes results from three of the five scenarios that bracket the Technical Update demand and supply potential futures:

1. Business as Usual
2. Cooperative Growth
3. Adaptive Innovation

Figure 12 graphically shows and compares the scenarios and key drivers.

Figure 14. Graphical Explanation Selected Colorado Water Plan scenarios

Technical Update Municipal Demands

Municipal water use demands were estimated from the Technical Update documentation by using the population and GPCD estimates for Archuleta County. Archuleta County population was reduced by 25 percent because PAWSD serves approximately 75 percent of Archuleta County. The reduced population and the GPCD were used to estimate current and 2050 demands in the PAWSD service area. Table 6 shows the population, GPCD, and demand estimates for the PAWSD service area for current (year 2015 for the Technical Update analysis) and 2050 conditions for the three scenarios. Note that the technical update did not identify any industrial water use in Archuleta County.

Table 7. Technical Update 2015 and 2050 estimates for Population, GPCD, and Municipal Demand in the PAWSD Service Area

	Current (2015)	Business As Usual	Cooperative Growth	Hot Growth
Population	9,313	19,928	18,857	28,711
GPCD	220	197	189	216
Shortages (AFY)	2,295	4,398	3,992	6,947

As shown, the Technical Update demands is slightly lower than the current (2022) municipal demand estimate discussed above, reflecting increased municipal use from 2015 to 2022. The Hot Growth scenario is greater than the 2050 population estimates shown in Table 1, which is based on the best available information from PAWSD, the town of Pagosa Springs, and Archuleta County; while the Business As Usual and Cooperative Growth scenarios are within the range of the population projects WWG utilized.

Technical Update Agricultural Demands

The Technical Update agricultural water demands include a regional assessment of irrigated acreage lost due to urbanization; assumed in all scenarios that 3,800 acres removed for the southwest region. The Technical Update documentation did not report how much of that acreage was due to urbanization around Pagosa Springs. However, based on Pagosa Springs current population compared to other towns in the southwest region it was estimated that roughly 20 percent (760 acres) could be removed around Pagosa Springs. The Technical Update also assumed that in Cooperative Growth and Hot Growth scenarios crop demands increased due to warming climate. Cooperative Growth crop demands increased by 38 percent and Hot Growth crop demands increased by 47 percent; however, shortages increased from Business as Usual by a factor of 221 and 266 percent respectively.

Table 7 shows the estimated agricultural demand and shortages from the Technical Update within the District.

Table 8. Technical Update Agricultural Demands and Shortages within the District

	Business As Usual	Cooperative Growth	Hot Growth
Total Demand	15,000	20,800	22,100
Total Shortage	1,120	3,600	4,100

Technical Update Environmental Demands

The Technical Update did not estimate environmental and recreational demand or supply outside of decreed instream flows; whereas WWG incorporated WEP Phase II Report environmental demands into historical analysis above. WWG estimated the shortages to the instream flow based on the streamflow estimates at the San Juan River at Pagosa Springs stream gage from the Technical Update documentation. Note that the Technical Update streamflow is on a monthly time steps, where as WWG's analysis was done on a daily time step for environmental and recreational demands.

Table 9. Instream Flow Average Annual Demand and Shortages based on Streamflow from the Technical Update

Instream	**Demand (AF)**	**Shortages (AF)**		
		Business As Usual	Cooperative Growth	Hot Growth
Mainstem San Juan River	29,018	114	825	1,457

Total Demands and Shortages

Based on the information in the Technical Update, WWG developed projected 2050 annual demands from the three scenarios. Figures 16 to 18 show the Technical Updates estimated the projected 2050 annual demand shortages for municipal, agriculture and environmental and recreation for the three different scenarios.

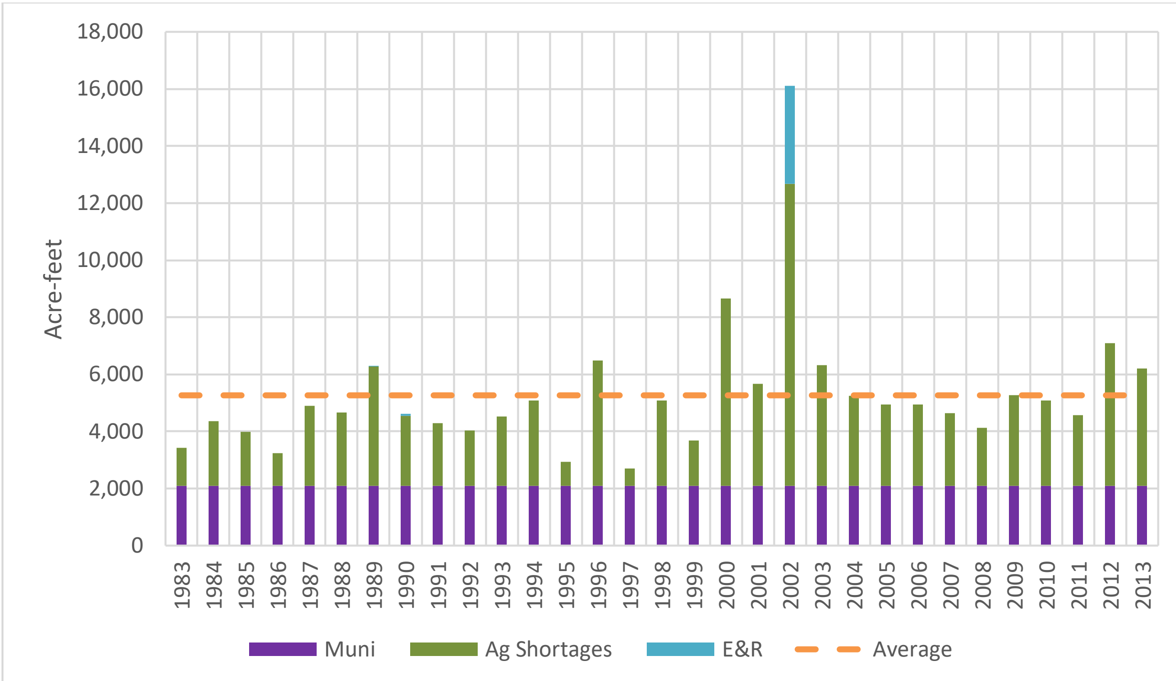

Figure 15. 2050 projected Annual Shortages for Business-as-Usual Scenario

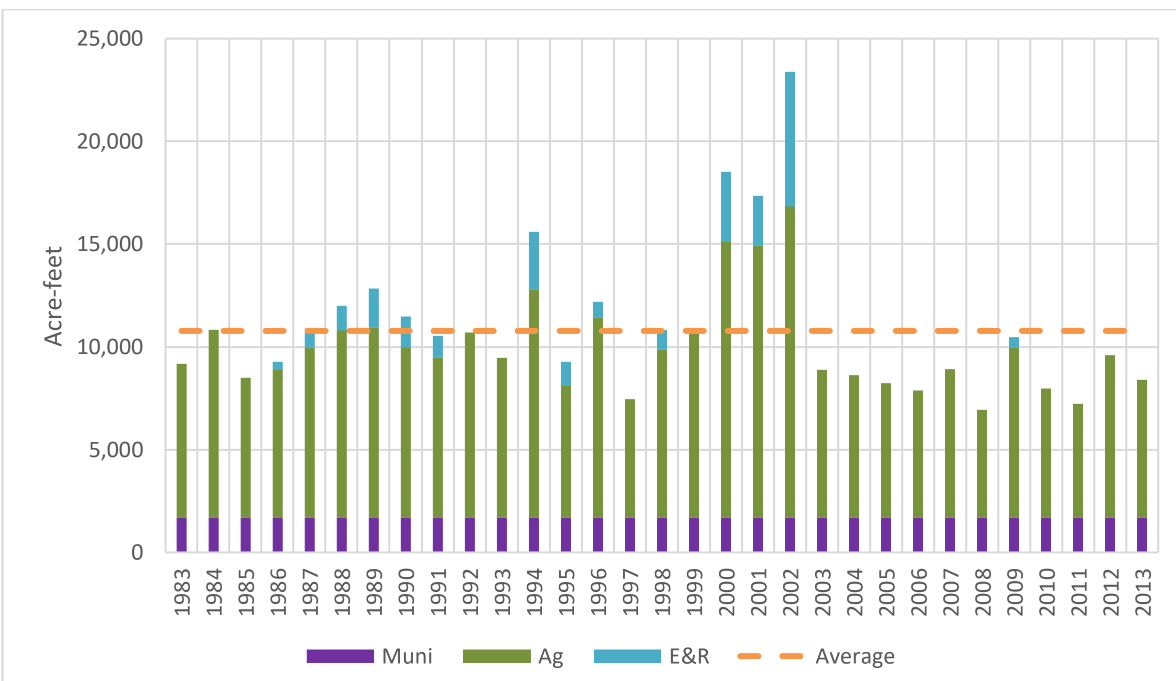

Figure 16. 2050 projected Annual Shortages for Cooperative Growth Scenario

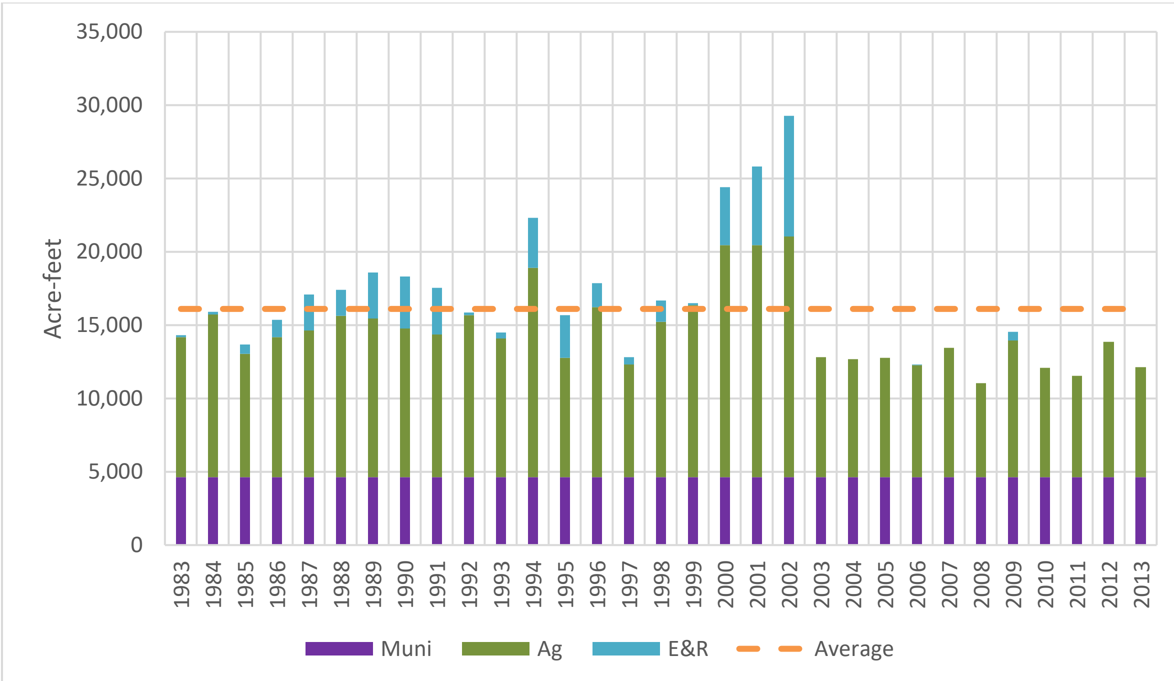

Figure 17. 2050 projected Annual Shortages for Hot Growth

The average annual demands shown in Figures 16 to 18 range from around 5,200 (Business-As-Usual) to 16,100 ac-ft (Hot Growth). The Technical Update was completed on a monthly time-step and did not consider the full range of environmental and recreational shortages included in the WEP Phase II Study. Therefore, reservoir sizing was not considered based on the Technical Update Scenarios.

Summary

The following summarizes observations from the San Juan demand and water availability analysis.

- Municipal demands could more than double if the pace of population growth in PAWSDs area continues at current rates.
- Under historical climate conditions, agricultural demands are not expected to increase and may actually decrease due to urbanization.
- The WEP Phase II report provided target flows for environmental and recreational demands, which provide a wide range of demands. Meeting all the environmental and recreational target flows in the WEP Phase II report even with new storage is not feasible, as a junior reservoir will need to fill during runoff which could impact some of the target flows. However, a reservoir could be used to meet some of the late season target flows.
- The range of target flows reported in the WEP Phase II report could allow the District to work with the town of Pagosa Springs to identify environmental and recreational flow targets that would benefit both tourism and the environment.
- Reservoir sizing is dependent on the demands determined to be critical by the District. For example, a 3,000 acre-feet reservoir would meet all future municipal demand

shortages (Low, Mid-Range, and High). A 10,000 acre-feet reservoir would meet future municipal and mid-range agricultural and environmental demands in all years except very dry years. There is no feasible reservoir to meet the full High Demand shortages.

- The two largest concerns that will affect all water uses continue to be earlier runoff and the potential for a catastrophic fire. Having storage to help capture earlier runoff could continue to be important in the future and having storage could help mitigate the effects of a fire.
- Other alternatives including stream restoration, fallowing, and forest health have the potential to improve stream flow and the District should continue to monitor on-going projects to see how the results could be applicable in the Upper San Juan basin.
- The Technical Update results show that the selected climate change scenarios, along with growth in and around Pagos Springs, could cause potential 2050 potential consumptive demands and associated shortages to be larger, for the demands shown included in the Technical Update.

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