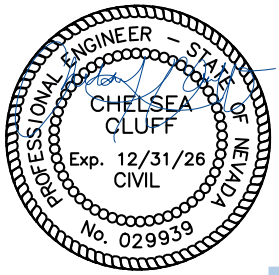
LUMOS & ASSOCIATES

MEMORANDUM

DATE:	2/2/2026
TO:	Ed James
FROM:	Chelsea Cluff, P.E.
SUBJECT:	30-Year Regional Drought and Water Sustainability Report



02/04/2026

Chelsea Cluff

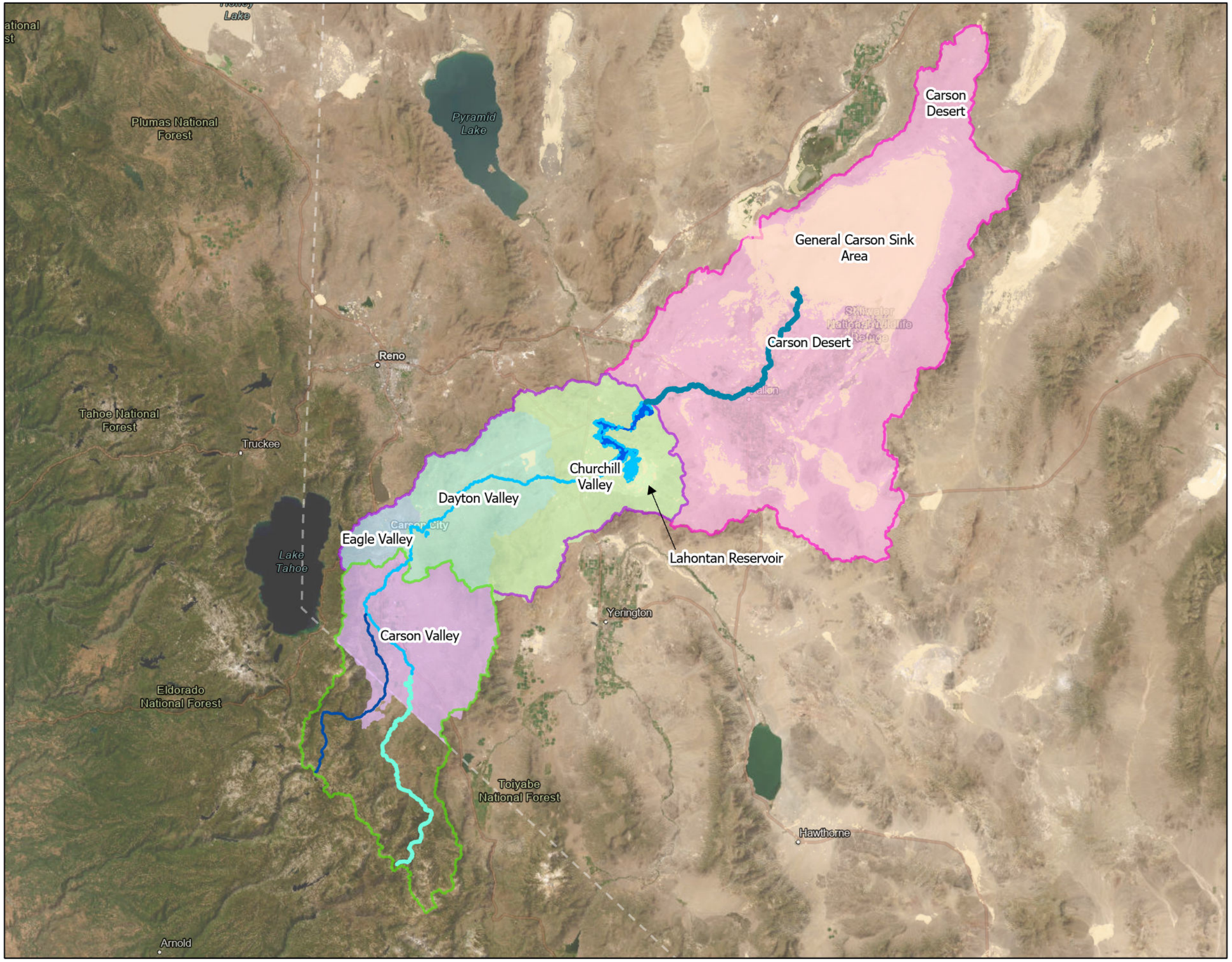
Digitally signed by Chelsea Cluff
DN: C=US, E=cluff@lumosinc.com, O=Lumos & Associates, CN=Chelsea Cluff
Date: 2026.02.04 09:46:33-08'00'

1.0 Executive Summary: 30-Year Regional Drought and Water Sustainability Report

The **30-Year Regional Drought and Water Sustainability Report**, prepared by the Carson Water Subconservancy District (CWSD) with the United State Geological Survey (USGS) and Lumos & Associates (Lumos), addresses evolving water resource challenges in the Upper and Middle Carson River Watershed amid climate variability, population growth, and Nevada's conjunctive water management policies. This report highlights trends of earlier snowmelt, declining streamflows, and increased reliance on groundwater through 2051. While most municipal purveyors have adequate capacity, water quality, and water rights, Minden and Gardnerville Ranchos GID will face deficits requiring new wells or treatment upgrades, and growth in Silver Springs and Stagecoach areas is constrained by perennial yield and infrastructure limits. Recommendations include integrating conjunctive management into Water Master Plans, implementing mitigation strategies such as reclaimed water recharge and interties, and planning regional infrastructure upgrades to ensure sustainable water supply under drought risk and regulatory changes.

1.1 Background

In 2023, CWSD received a grant from the Nevada Division of Emergency Management (NDEM) to develop a Carson River Watershed Regional Drought and Water Sustainability Plan. CWSD contracted with the USGS to update the Upper and Middle Carson River models in order to evaluate the impact groundwater pumping may have on surface flows. CWSD hired Lumos to support USGS data collection and analysis efforts for nine (9) water purveyors within the Upper and Middle Carson River Watershed. An overall map of the Carson River Watershed, with the Upper, Middle, and Lower sections delineated as they pertain to the analysis done in this report, is shown in Figure 1. Recent analyses (discussed in depth in Section 3.0) reveal trends within the Carson River watershed of earlier snowmelt and declining streamflow, creating uncertainty for water users. Nevada's adoption of conjunctive management (NRS 533.024) requires integrated planning for surface and groundwater resources, prompting CWSD to reassess traditional water management strategies in an effort to support water purveyors within the Carson River watershed.



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30-YEAR REGIONAL PLAN
CWSD
OVERALL BASIN MAP
FIGURE 1

LEGEND

- West Fork - Carson River
- East Fork - Carson River
- Lower Carson River
- Carson River
- Lahontan Reservoir

Carson River Basin Sections

- Lower Carson
- Middle Carson
- Upper Carson

Groundwater Basins

- Carson Desert
- Carson Valley
- Churchill Valley
- Dayton Valley
- Eagle Valley
- Carson Sink General Area

N

Paper Size: 11" x 17"

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Projection: Transverse Mercator
Grid: NAD 1983 UTM Zone 11N
Datum: North American 1983
Created by: dmarinrios

Date:	DEC, 2025
Project #:	10974.000
Revision:	0

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1.2 Purpose and Goals

This document serves as an interim resource bridge, which incorporates preliminary USGS model results and research findings, to inform municipal water users and assist in their master planning efforts. Municipal water use is the focus of this report; however, its effect on agriculture as well as other groundwater pumping trends in the Carson River Watershed are mentioned. This report translates the preliminary modeling insights into high-level actionable information for purveyors to consider when planning for potential impacts to groundwater pumping on streamflows. This document is not intended to be a stand-alone water master plan; it is a reference guide to aid community specific water master plans to:

- Support informed decision-making regarding their groundwater pumping;
- Mitigate potential impacts to surface water flows; and
- Mitigate risk for future water resource challenges

The goal is to improve water availability and reliability while minimizing conflicts and preventing long-term harm to these critical resources.

1.3 Changing Conditions in the Carson River Watershed

Recent runoff analyses show that, despite a significant increase in groundwater pumping over the past 40 years, the overall volume of water flowing at the Fort Churchill gage has remained relatively stable. This consistency is likely attributable to both earlier snowmelt-driven runoff and reduced irrigation use in Carson City and Lyon County within the Carson River Watershed. Additional details and citations are provided in Section 3.1.

The Watershed has recently experienced warmer temperatures and changes in precipitation frequency and magnitude, leading to earlier runoff and decreased surface flows (Desert Research Institute, 2011). With little upstream storage available, both municipalities and agricultural users are facing water resource impacts. The 2021 *Water Marketing Report* documented significant shifts in annual streamflow patterns (Lumos & Associates, 2021). Changing flow conditions in the Carson River underscore challenges for downstream users (see Section 3.1.2). As the region continues to grow, concerns are mounting over the ability to meet future water demands while not impacting downstream water users, especially during extended drought periods.

Notable changes include:

- More pronounced fluctuations between high and low flows
- A reduction in overall average streamflow
- A shift in the timing of peak flows, now occurring earlier in the year (see Section 3.1)

1.4 Conjunctive Management and the Need for Integrated Planning

Like much of the western United States, the Nevada Division of Water Resources (NDWR) is working to address the challenges related to the interaction of surface water and groundwater throughout the state. During 2017 legislative session, NDWR was authorized in NRS 533.024 (e) (The State of Nevada, 2017) to conjunctively manage the appropriation, use and administration of all waters of this State, regardless of the source of the water. Since this authorization, the Nevada State Engineer has begun exploring how to manage hydrologically connected water sources in Nevada, including the Carson River Watershed.

Surface water within the Carson River Watershed is governed by Nevada water law, federal Alpine Decree, and the Operating Criteria and Procedures for the Newlands Project (OCAP). The Federal Water Master is appointed to administer federal decrees. The Alpine Decree, adjudicated by the federal court in 1980, was based on historical flow conditions and water diversion patterns. A federally appointed Water Master is responsible for allocating water according to the Decree, based on annual runoff conditions.

As streamflow conditions continue to evolve, there is increasing focus on the integrated management of surface and groundwater resources. The State of Nevada has recently begun implementing conjunctive management, particularly in the Humboldt Basin within the Great Basin Watershed (NDWR, n.d.). However, the Nevada Division of Water Resources (NDWR) is still evaluating the full impacts of this approach.

NDWR is currently implementing conjunctive management strategy in the Carson River system for all new water right applications. At present, all water purveyors within the Carson River Watershed recognize the need to incorporate conjunctive-management principles into their water operations. Some municipalities, such as Carson City Water Utility are using them, but these concepts are not currently included in their Water Master Plans.

1.5 Study Timeline and Process

Data collection for the 30-Year Regional Drought and Water Sustainability Report began in May 2023. Lumos and CWSD met with nine (9) purveyors within the Carson River watershed upstream of the Lahontan Reservoir. Each meeting consisted of a discussion on the project scope and a request for current and future well capacities, locations, water quality, and water rights. The nine (9) purveyors included in the study are:

- Gardnerville Ranchos General Improvement District (GRGID)
- Gardnerville Water Company (GWC)
- Town of Minden
- Douglas County
- Indian Hills General Improvement District (IHGID)
- Carson City Water Utility
- Lyon County Utility
- Stagecoach General Improvement District (Stagecoach GID)
- Silver Springs Mutual Water Company (SSMWC)

This report focuses on the Upper and Middle Carson River, so water purveyors in Alpine County, Storey County, Churchill County, and the City of Fallon were not included in the analysis. Additionally, NDWR will study areas downstream of Lahontan Reservoir under the Nevada Water Initiative. This future effort will evaluate water sustainability in the Carson Desert Groundwater Basin. Alpine County was excluded from this analysis since the Markleeville Water Company has such a limited user base and demand. Storey County was excluded since its water is supplied from the Marlette Lake Water System, which falls outside the Carson River Watershed.

Following the initial meetings, each purveyor submitted data to Lumos, including:

- Total well pumpage (by well) from 2018 to 2022 (for SSMWC ten years of pumping data was used)
- Water meter usage by customer type (where available) from 2018 to 2022

- Water rights documentation
- Water quality data from 2018 to 2022

The data was analyzed to determine current production and 5-year well production averages for each purveyor. Based on this analysis, draft reports were developed for each of the nine purveyors.

To project future water demand over a 30-year period (2021–2051) in the draft reports, water purveyor-supplied annually compounded population growth rates were used when available. Where system-specific growth rates were not available, annually compounded population growth estimates from the Nevada State Demographer were used (see Section 2.0 for a breakdown of growth rates used per purveyor). These projections were then compared against current usage, supply, and held water rights to assess the long-term viability of each purveyor's water sources.

Draft reports were distributed to CWSD and the respective purveyors in November 2023 for review, which allowed purveyors to provide feedback on local issues and fine tune anticipated growth assumptions. In early 2024, follow-up meetings were held with each purveyor and CWSD to discuss the reports and identify key data trends.

Finalized reports, including 30-year demand projections, were delivered to the USGS in May 2024. As USGS developed a groundwater model, Lumos and CWSD collaborated to refine well locations and confirm well permit numbers. The USGS groundwater model was divided into two segments:

- Upper Carson Model: Includes purveyors upstream of Carson City. Also denoted as "Carson Valley" in preliminary model results from USGS.
- Middle Carson Model: Includes purveyors from Carson City to Silver Springs

The USGS shared initial modeling results for the Upper Carson Model with water purveyors on August 18, 2025, and preliminary results for the Middle Carson Model were provided to CWSD on October 1, 2025. USGS was preparing a technical report summarizing the final modeling outcomes, but the federal government shutdown prevented USGS from delivering the final model results and technical report.

The USGS will continue refining the model and preparing a final report. This information will be incorporated into the capture model funded by Churchill County and other local entities. The USGS estimates that the capture model will be completed in 2028. This document will interpret and present the preliminary findings received by the USGS as of October 1, 2025. Further details regarding the groundwater model and its results are provided in Section 3.4. A draft of the 30-Year Drought Plan (30-Year Plan) was distributed to all nine (9) purveyors along with other entities such as the Federal Water Master, and Nevada Bureau of Recreation for review on October 21, 2025. Following the completion of the review process, the final 30-Year Plan and Water Sustainability Report will be presented to the CWSD Board, along with the relevant counties and water purveyors within the Carson River Watershed. The final report must be submitted to the Nevada Department of Emergency Management by the end of January 2026 to satisfy grant funding requirements. Figure 2 illustrates the project timeline to create the 30-Year Plan shown below.

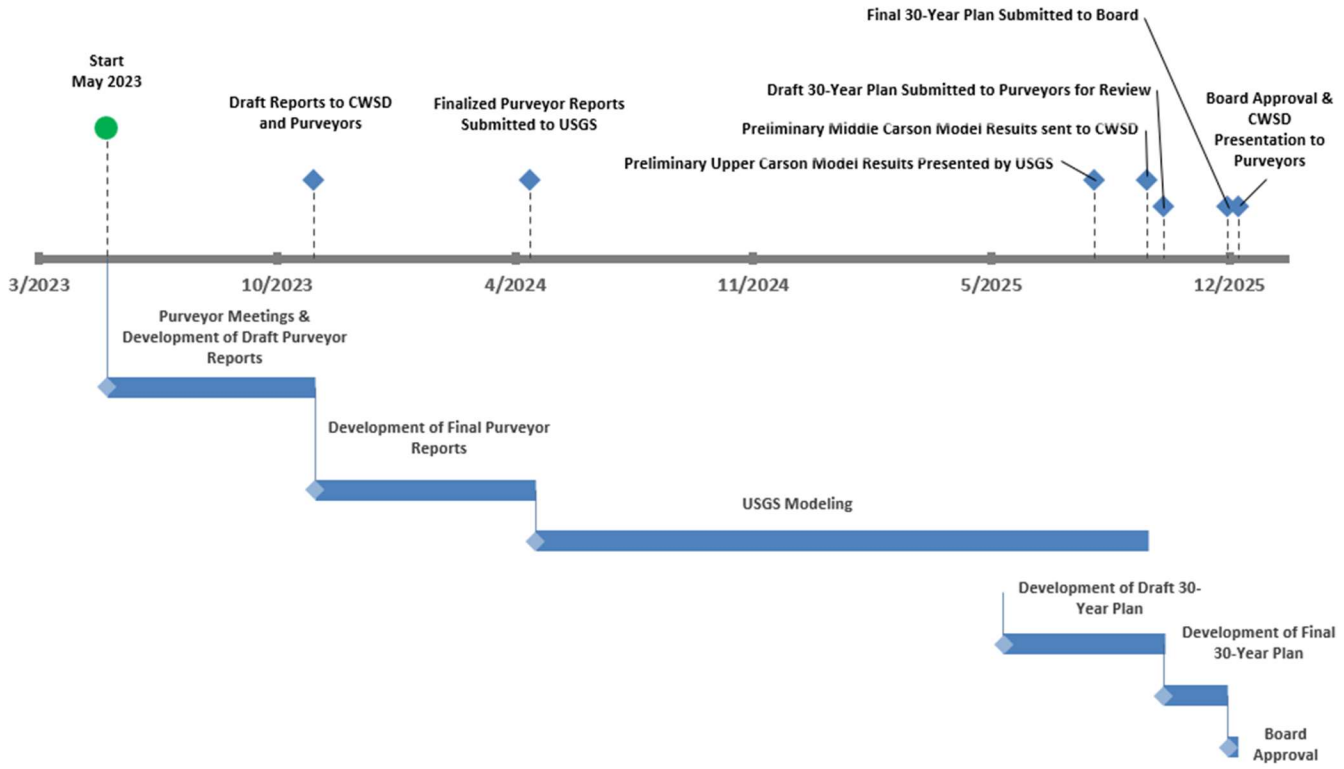

Figure 2: Overall Project Timeline for 30-Year Plan

2.0 Summary of Initial Reports

The initial reports compiled by Lumos provided each water purveyor with a high-level technical memorandum assessing long-term water resource sustainability. These reports analyzed 30-year projections of municipal growth, groundwater pumping data, water quality, and available water rights. Annually compounded growth rates were derived from purveyor-provided future connection counts, master plans, or Nevada State Demographer estimates. Findings indicate that while most purveyors have sufficient capacity through 2051, Minden and Gardnerville Ranchos GID will face deficits requiring new wells or treatment upgrades. Silver Springs and Stagecoach can meet projected demand but are constrained by perennial yield limits and domestic well impacts. Additional challenges for these two purveyors include infrastructure limitations, such as arsenic treatment capacity at SSMWC. Overall, the reports highlight potential shortfalls and emphasize the need for regional coordination and strategic planning to ensure sustainable water supply.

Annually compounded growth rate assumptions used for each purveyor, with the source of each purveyor-approved growth rate, are summarized below:

- GRGID: 0.54% (Douglas County estimates)
- GWC: 0.54% (Douglas County estimates)
- Town of Minden: 0.54% (Douglas County estimates)

- Douglas County
    - North County, East Valley, West Valley, Clear Creek, and Montana areas: 0.54% (Douglas County estimates)
    - Sierra County Estates: 0.3% (purveyor-provided)
    - Foothill: 0.6% (purveyor-provided)
    - Fairgrounds: 0% (purveyor-provided)
- IHGID: Varies from 0.8% to 0.0% by 2038 (State Demographer / Douglas County estimates)
- Carson City Water Utility: Varies from 0.7% (starting in 2025) to 0.1% by 2040 (State Demographer)
- Lyon County Utility: 0.8% (Nevada State Demographer)
- Stagecoach GID: 0.43%, based on 186 projected connections distributed evenly through 2051 (purveyor-provided)
- SSMWC: 0.43%, based on 154 projected connections distributed evenly through 2051 (purveyor-provided)

Table 1 summarizes the projected 2051 water demands based on the growth rates and compares these demands to current water supply (provided by municipal wells). Well capacity was determined using an assumption of 16-hour pumping period. Lyon County requested a 21.6-hour pumping period be used to more accurately portray their municipal operation. The results of the analysis reveal the following:

- Minden and GRGID are projected to exceed their current pumping capacities and will require additional wells by 2051 to meet their future needs.
    - For Minden, this shortfall includes water exported via the intertie to meet future growth in North Douglas County and IHGID. Carson City's intertie demand will not increase in the future since it is already utilizing most of its available capacity.
    - If Wells 5 and 8 were brought back online, GRGID could meet future demand, but they are offline due to arsenic contamination. To bring them online, arsenic would need to be treated. Developing new well sites would be the other option. As of the publishing date of this report, GRGID is in the process of exploring both of these opportunities.
- GWC, Carson City, and Lyon County are well-positioned to meet projected demand through 2051.
- Douglas County's four hydraulically disconnected systems (Fairgrounds, Foothills, Sierra County Estates, and North County) and IHGID have enough pumping capacity through 2051 under current growth assumptions. However, Douglas County may need to secure additional resources beyond the 30-year planning horizon, as their projected surplus is between 0.10 and 1 MGD. IHGID is hindered geographically for future growth, therefore additional water resources may not be necessary to secure outside the planning horizon.
- SSMWC and Stagecoach GID are projected to have adequate well capacity and water rights to support growth through 2051. However, their growth is limited by the perennial yield of their respective basins, as detailed in Section 2.1.1.

Table 1: Projected 30-Year Growth and Average Water Needs per Purveyor

Purveyor	Maximum Available Water (MG/day)	Projected Average 2051 Demand (MG/day)	Deficit / Surplus (MG/day)
GRGID[1]	4.41	6.24	-1.84
GWC	6.62	2.59	4.03
Minden[2]	13.70	16.40	-2.80
Douglas County – North County, East Valley, West Valley, Clear Creek, and Montana[3]	3.98	3.88	0.10
Douglas County – Sierra County Estates	0.43	0.16	0.27
Douglas County - Foothills	0.32	0.32	0.00
Douglas County – Fairgrounds[4]	0.19	0.08	0.11
IHGID	2.30	1.89	0.41
Carson City	20.26	17.29	2.97
Lyon County	13.98	5.36	8.61
Stagecoach	1.01	0.61	0.40
Silver Springs[5]	1.01	0.95	0.06

Notes:
[1] Flows do not include Wells #5 and #8.
[2] Combined values for Town of Minden and Regional Intertie flows.
[3] Flows do not include North County Well #1.
[4] Flows do not include Fairgrounds Well #1.
[5] Typically only two (wells) are in operation at one time due to limitations regarding the arsenic treatment plant, providing a maximum of 1,750 gpm (1.01 MGD)

Key

	Additional Surplus for Future Growth (greater than 2 MG/day of production surplus)
	Enough Surplus for Future Growth (between 0 and 1 MG/day of production surplus)
	Deficit (negative production surplus)

It is important to note that all growth projections are based on the best available data at the time of this report and are subject to change due to unforeseen events, unknown industrial or large-scale developments, or economic shifts. While actual future growth may deviate from these projections, this analysis is intended to serve as a high-level estimate for purveyors and to highlight potential future water resource shortfalls in order to support long-term infrastructure and supply planning.

Water rights and well water quality were analyzed in the purveyor specific reports provided by Lumos & Associates. Eight (8) of the nine (9) purveyors provided water quality data to Lumos, of which all eight (8) had limited water quality concerns. Purveyors such as GRGID, Douglas County, Minden and Carson City proactively monitor wells by performing spot samples of specific contaminant levels of concern. All nine (9) of the purveyors had adequate water rights to match projected growth. For specific discussion around water quality and water rights for each purveyor, please refer to individual purveyor memos (shown as 2023 Lumos memos in References).

2.1 Water Supply Limitations Impacting Growth in Silver Springs and Stagecoach

Growth in the Silver Springs and Stagecoach areas is limited by the availability of groundwater, which is constrained by the perennial yield of the local aquifers, nearby domestic well use, and groundwater treatment limitations (SSMWC only). Silver Springs and Stagecoach may not be subject to conjunctive management due to their sole reliance on groundwater and distance of their wells from the Carson River. However, these two entities are going to be more affected by perennial yield than conjunctive management.

2.1.1 Perennial Yield Constraints

Perennial yield refers to the maximum amount of groundwater that can be sustainably extracted from a basin on an annual basis without causing long-term depletion.

- In the Churchill Valley Basin, which serves the Silver Springs area, the estimated perennial yield is 1,600 acre-feet annually (AFA) (Nevada Division of Water).
- In the Stagecoach area, subbasin of Dayton Valley Basin, the estimated perennial yield is 800 AFA (Nevada Division of Water).

Perennial yield estimates are found in the NDWR groundwater pumping reports. Perennial yield calculations do not include potential groundwater recharge from other sources such as septic systems or irrigation return flows.

2.1.2 Impact of Domestic Wells

In the Churchill Valley Groundwater basin and Stagecoach subbasin of Dayton Valley Groundwater basin, domestic wells have the potential to be a combined larger user compared to the local water purveyors. While domestic wells do not directly affect the production capacity of the SSMWC or the Stagecoach GID, they draw from the same groundwater basins, contributing to the overall demand on limited water resources.

- There are approximately 1,788 domestic wells;
    - 1,348 in Silver Springs
    - 440 in Stagecoach

Since domestic wells are not metered, the NDWR assumes 1 AFA per well in the groundwater pumping reports. The National Environmental Education Foundation (NEEF) claims the average Nevada residents use is 134 gallons per day (gpd), or 0.15 AFA, (National Environmental Education Foundation, 2021) in and around their home. As a conservative median, CWSD estimates the water use in Silver Springs area is between 0.3 to 0.6 AFA/well. To simplify the Middle Carson Model, the USGS is assuming 0.5 AFA/well in their modeling efforts.

2.1.3 Infrastructure and Treatment Limitations

For SSMWC, future growth is further constrained by the capacity of its arsenic treatment facility, constructed in 2010. Naturally occurring arsenic concentrations are high in local groundwater, so all of SSMWC's extracted water must be treated.

- The arsenic treatment facility is currently limited to a maximum flow rate of 1,750 gallons per minute (gpm), or 1.01 million gallons per day (MGD).
- While additional wells are available, the arsenic treatment system's capacity would need to be increased before more wells are activated.

2.1.4 Planning for the Future

To support long-term growth in Churchill Valley communities, new infrastructure will likely be necessary and may require imported water. While the complexities of water rights and transfer mechanisms are beyond the scope of this report, the need for regional coordination is clear. For Silver Springs and Stagecoach to address these challenges and ensure sustainable development, a regional plan with a collaborative and strategic approach will be critical for both purveyors.

3.0 Data Analysis Post-Preliminary Model Results

3.1 Long-Term Runoff Trends

3.1.1 USGS Scientific Investigations Report (2023)

In 2023, the USGS completed a report assessing potential effects of changes in water use in the Middle Carson River (USGS, 2023). Included in the report was an analysis of the changes in the mean daily flows shown by the Carson River and Fort Churchill stream gauges (ft^3/s). The trendline of this data showed a decline in stream flows (see Figure 3 and Figure 4 below).

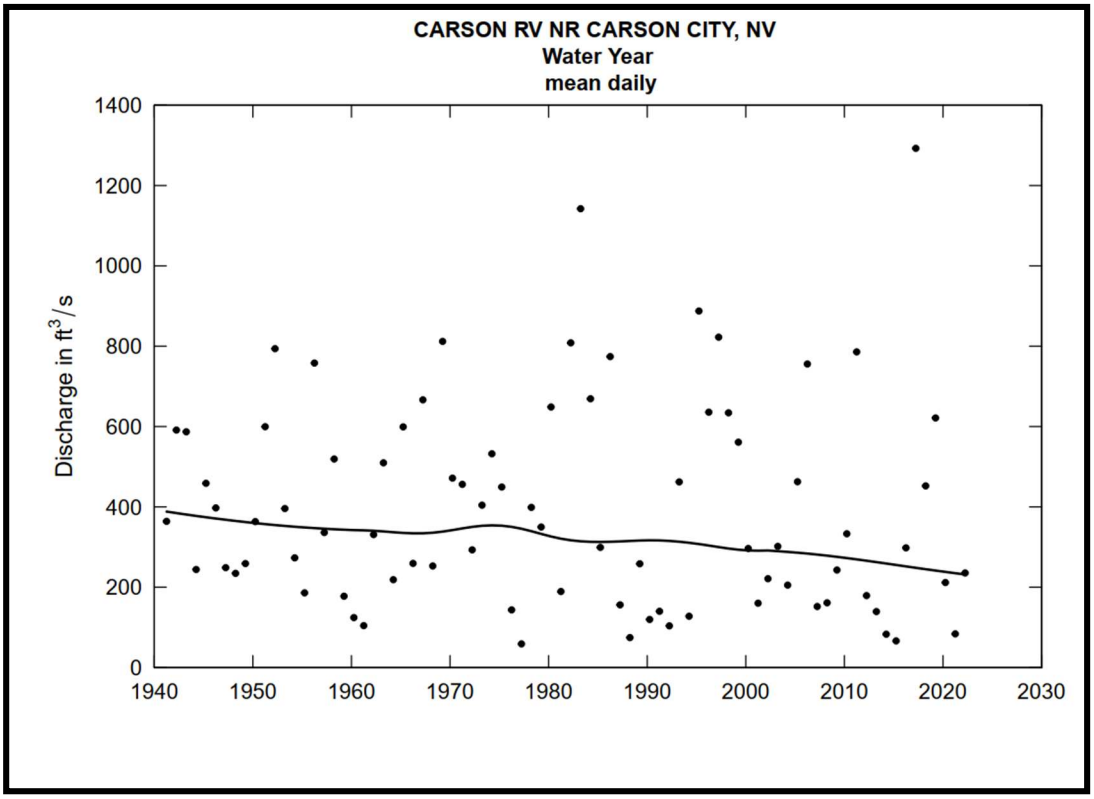

Figure 3: Carson River Stream Gauge Annual Discharge (USGS, 2023)

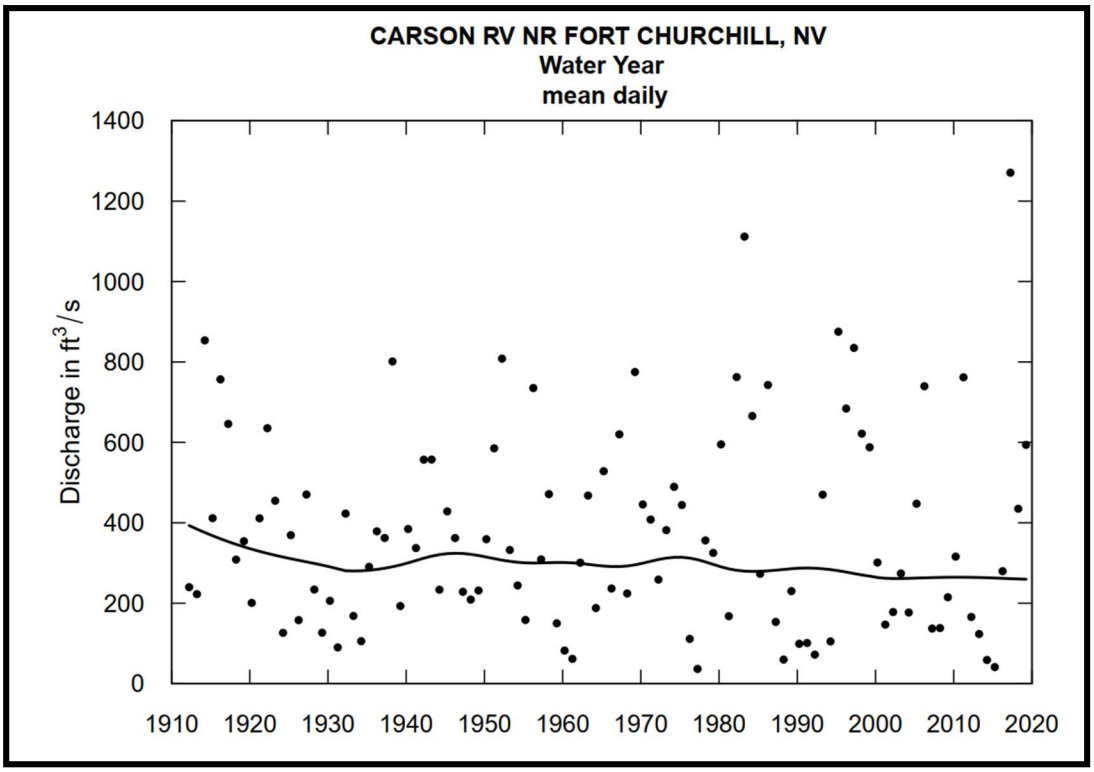

Figure 4: Carson River Fort Churchill Stream Gauge Annual Discharge (USGS, 2023)

CWSD staff conducted the same analysis for the East Fork Gardnerville Gauge and the West Fork Woodfords Gauge. This analysis showed a similar decline in stream flow (see Figure 5 and Figure 6 below).

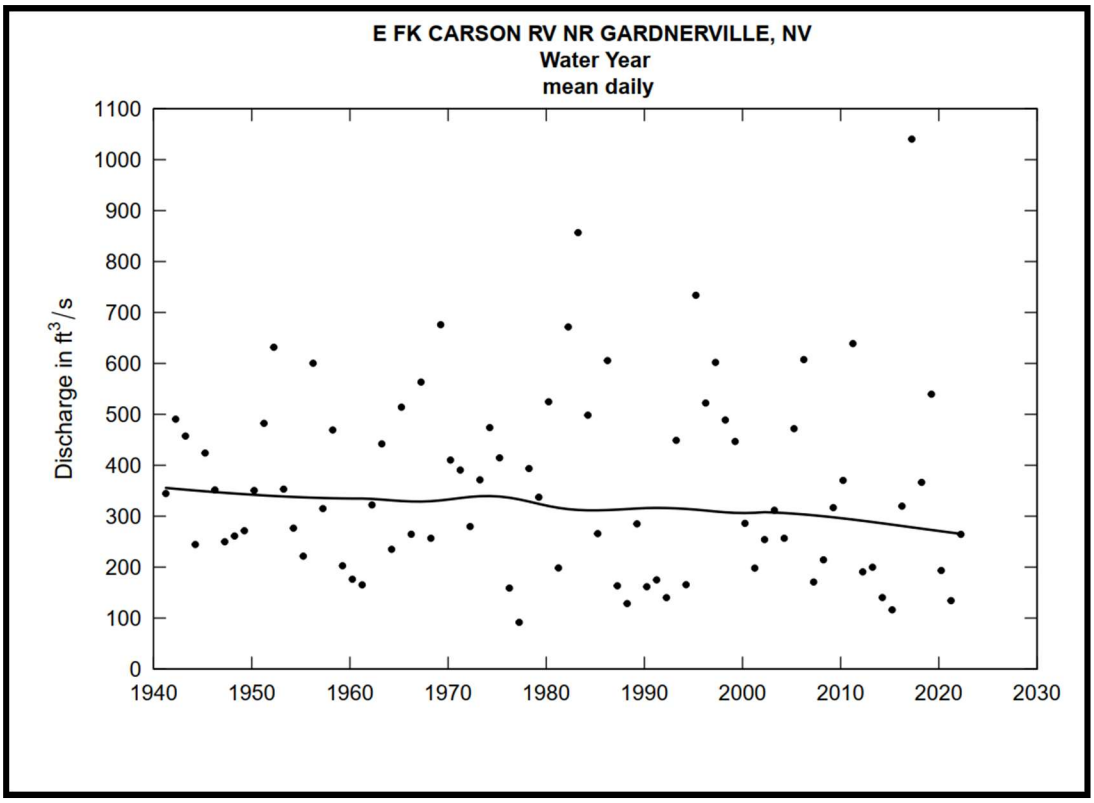

Figure 5: East Fork Carson River Stream Gauge Annual Discharge (CWSD)

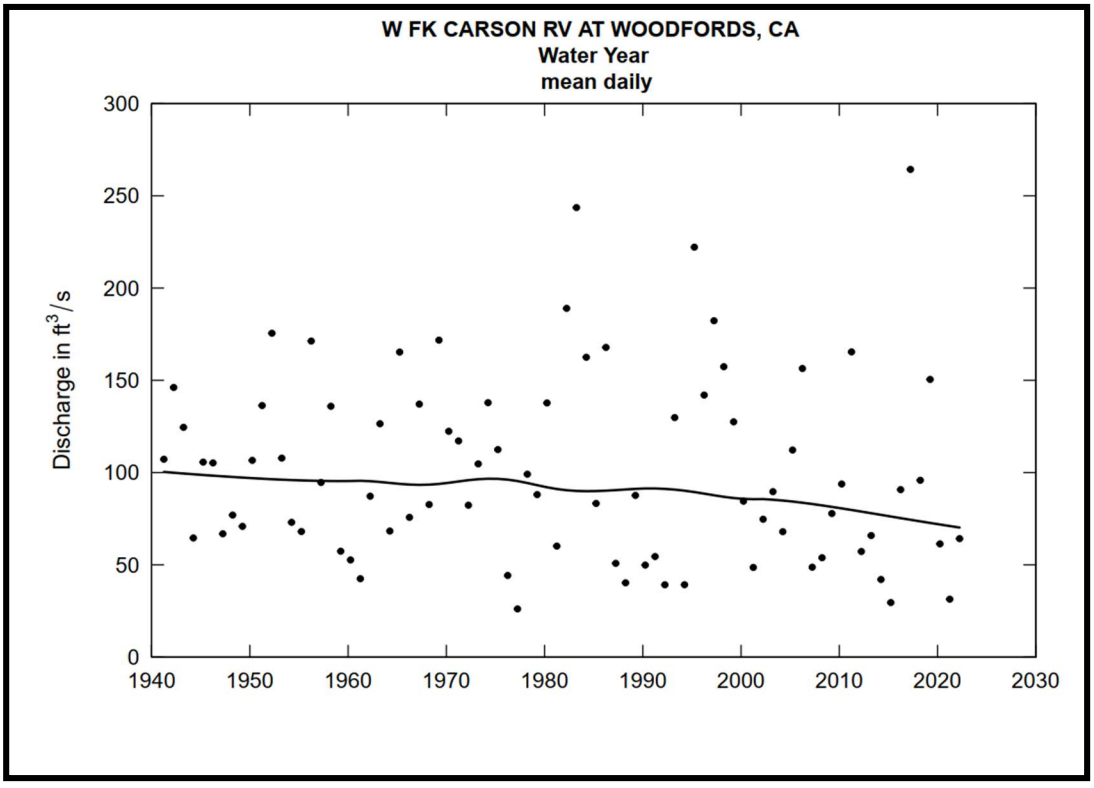

Figure 6: West Fork Carson River Stream Gauge Annual Discharge (CWSD)

Figure 3 through Figure 6 illustrates that the decrease in stream flow to the Carson City and Fort Churchill gauges are being holistically affected along all portions of the watershed (Upper to Lower). It can be assumed that these trends are occurring due to a combination of natural stream flow changes and human impacts.

3.1.2 Lumos Water Marketing Report

Lumos & Associates produced a Water Marketing Report in 2021 for CWSD. The *2021 Water Marketing Report* serves to inform the need for the 30-Year Plan.

Historical flow data for the Carson River was separated into two (2) distinct time frames:

- 1940 to 1979 (40 years)
- 1980 to 2018 (38 years)

Flows are separated because each of the two timeframes show strongly correlated trends based on changing weather patterns. For example, the *2021 Water Marketing Report* plotted Annual Average Discharge and Peak Discharge rates per year over the 78-year timeframe, as shown in Figure 7 (Lumos & Associates, 2021). Prior to 1980 (shown by the vertical blue line in Figure 7), variations in average annual flows were much smaller in amplitude than after 1980. This information is further highlighted by Table 2, which shows that not only did the frequency of high and low flow events (defined as flows above the 90th percentile and below the 10th percentile, respectively) increase after 1980, but the magnitude of these events were seen to increase by at least 100%. For example, Table 2 lists the 90th percentile average annual flow for the Carson River Gauge near Carson City as 732 cfs. Between 1940 to 1979 average annual flows only exceeded 732 cfs three (3) times but between 1980 to 2018 average annual flows exceeded 732 cfs eight (8) times, which was more than double the frequency seen historically. Additionally, between 1940 and 1979 the highest annual average flow was approximately 800 cfs but between 1980 and 2018 the largest annual average flow increased 167% to approximately 1,300 cfs. Trends for this specific example correlate to the information provided in Figure 7.

The Water Marketing Report concluded that the measured Carson River flows have become more variable and exhibit more extreme peak flows and a higher frequency of lower flows. This has led to a decreasing trend in yearly average instream flows. The data analyzed in the *2021 Water Marketing report* is based on flows captured at the following gauges: East Fork Gardnerville Gauge, West Fork Woodfords Gauge, Carson City Gauge, and the Fort Churchill Gauge.

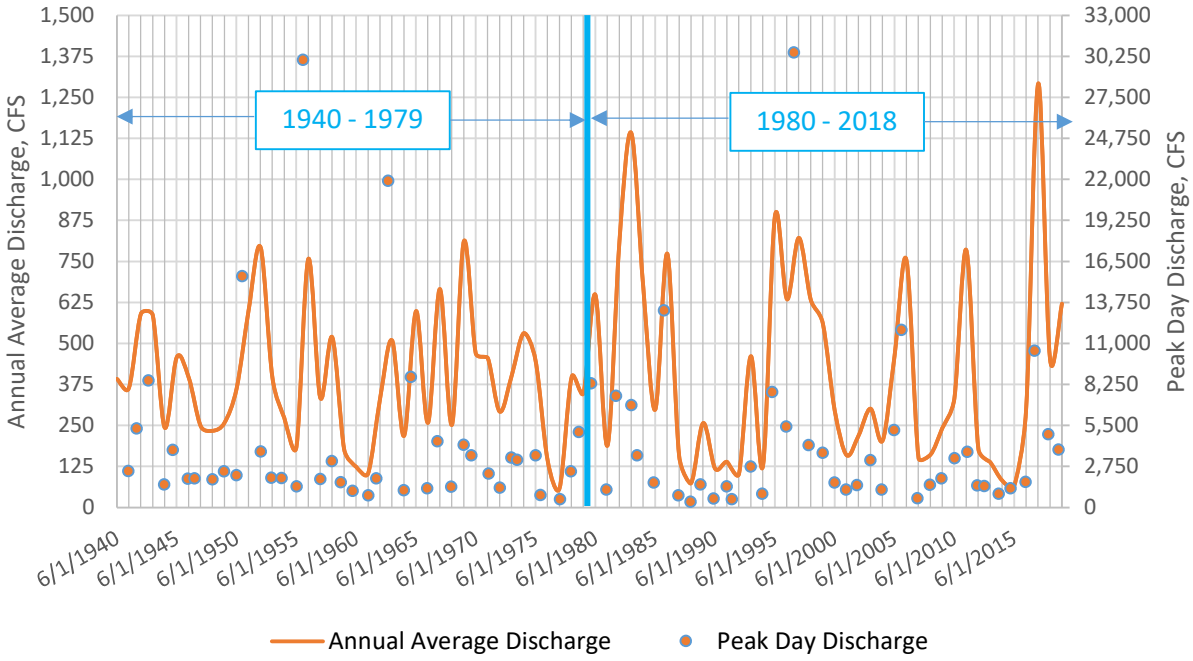

Figure 7: Carson River near Carson City Historical Data (USGS #10311000) (Lumos & Associates, 2021)

Table 2: Trends in Instream Flow (Lumos & Associates, 2021)

	Gauges			
	West Fork at Woodfords	East Fork near Gardnerville	Carson River near Carson City	Carson River near Fort Churchill
90th Percentile Flow (CFS)	167	600	732	710
Number of Years Annual Average Flow Exceeded 90th Percentile Flow				
1940 to 1979	3	3	3	3
1980 to 2018	6	8	8	8
% Increase in Extreme High Flow	100%	167%	167%	167%
10th Percentile Flow (CFS)	40	135	76	50
Number of Years Annual Average Flow was Less Than 10th Percentile Flow				
1940 to 1979	1	1	1	1
1980 to 2018	3	2	2	1
% Increase in Extreme Low Flow	200%	100%	100%	0%

Changes in annual instream flows for the Carson River were also studied in a report published by the Desert Research Institute (DRI) and CWSD (Desert Research Institute, 2011). This report used similar timeframes that were used in the *2021 Water Marketing Report* (1940-1974 and 1975-2009 versus 1940-1979 and 1980-2018, respectively) and found that both the East and West Fork gauges showed a significant increase of instream flow during March and April with a correlating decrease of instream flow in June and July, as seen in

Figure 8a and Figure 8b, respectively. This analysis conveys that weather patterns are shifting to bring earlier runoff in the year than was experienced historically.

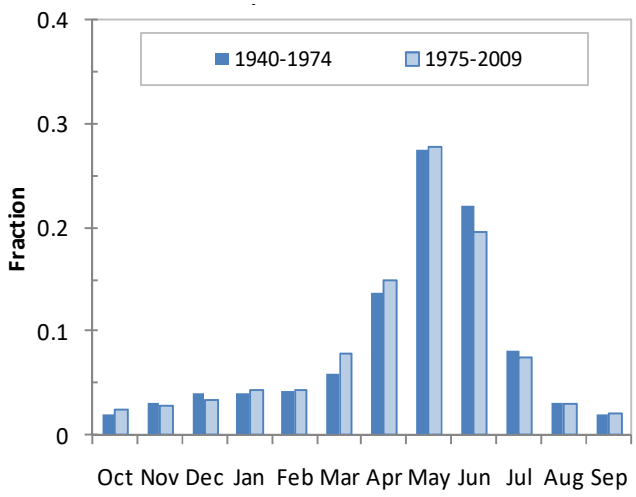

Figure 8a: Distribution of Total Annual Streamflow at East Fork (Desert Research Institute, 2011)

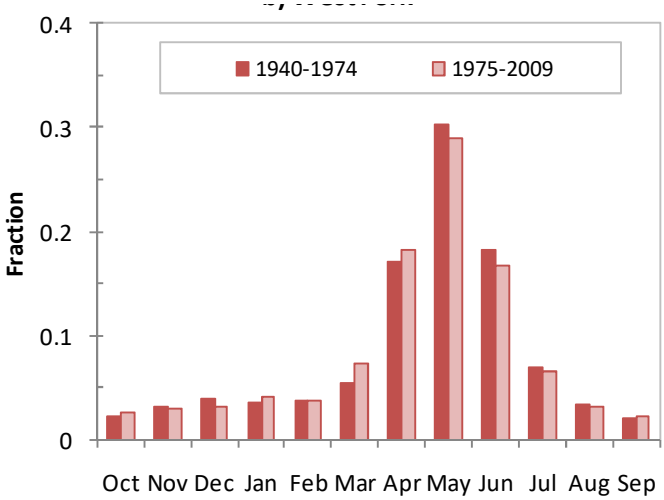

Figure 8b: Distribution of Total Annual Streamflow at West Fork (Desert Research Institute, 2011)

Furthermore, it has also been shown that surface water trends in the Carson River System affect the nearby aquifers. As shown in the Groundwater Sustainability in Gardnerville Ranchos Report (Desert Research Institute, 2025), high flows in the Carson River during the winter season led to a slight increase in groundwater levels in the following spring season. Declining surface water levels overall will eventually lead to a decrease in groundwater levels in the GRGID area. These groundwater trends are more notable closer to the Carson River, illustrating the impact that seasonal variations in river flow have on the surrounding groundwater tables, which purveyors rely on for groundwater pumping.

This section's studies indicate trends of instream flows becoming more variable with more extreme high flows and more prolonged periods of low flows. With this increased variability, runoff patterns may be more difficult to predict and to subsequently determine future impacts. The overall decrease in instream flow seen in these trends and lack of water storage upstream of the Lahontan Reservoir may impact upstream surface irrigators and drive a need to pump more groundwater.

3.2 Alpine Decree

The Alpine Decree states that *"the Water Master shall begin to direct the distribution of water on such date that he determines there is not enough water…"*. While general seasonal dates are referenced in the decree, the Water Master has full discretion to begin or end the irrigation season earlier or later based on actual conditions. This flexibility has been exercised numerous times in the past. It is also worth noting that regulation can occur at any point during the irrigation season. For example, in an extremely dry year, the irrigation season might begin with regulation due to low flow conditions. On the West Fork, although the rotation between Nevada and California is very specific to begin the first Monday in June (as prescribed in the Anderson Bassman Decree), if flows in the river are insufficient to satisfy all priorities, then the Water Master will regulate diversions within each segment based on priorities. In an exceptionally wet year with a large and extended runoff,

regulation on both the East and West forks may occur much later and in some extreme cases, may not occur at all if the flows never reach a level that would require restrictions.

The Carson River is actively managed year-round by Water Master staff; however, to simplify the analysis of runoff changes, the dataset is divided into three distinct time periods. The first period is the *non-irrigation season* (October 1 to March 31). The second period covers the *early irrigation season* (April 1 to June 30), when there is typically enough water to meet most upstream irrigation demands and to supply inflow to Lahontan Reservoir. The third period represents the *late irrigation season* (July 1 to September 30), when water supplies are usually insufficient to meet all upstream demands, and the Federal Water Master regulates water by segments. Actual annual water allocations depend on each year's observed runoff.

3.3 Flows Trends in the Upper and Middle Carson River

As part of this study, the CWSD analyzed the impacts of Carson River flows on groundwater pumping using a 20-year moving average from 1940 to 2020 for the East Fork, West fork, Carson River, and Fort Churchill gauges. The data was categorized according to the three time periods:

- Non-irrigation season (October–March, shown in Figure 9);
- Early Irrigation season – not under regulation (April–June, shown in Figure 10);
- Late Irrigation season – under regulation (July–September, shown in Figure 11).

The data shown in the figures starts in 1960, since it is the first year that calculates an average of the previous 20 years (1940-1960). Streamflow for every year after 1960 is representative of the average of the previous 20 years (1941-1961, 1942-1962, etc.)

Most runoff trends at the East Fork, West Fork, and Carson City gages show declines across the non-irrigation, early-irrigation, and late-irrigation seasons, with the exception of the East Fork during the non-irrigation period. In contrast, flows at the Fort Churchill gauge increase across all three seasons. Of the twelve trend estimates, only three have p-values below 0.05: the East Fork late-irrigation season, the West Fork late-irrigation season, and the Fort Churchill late-irrigation season. Having a p-value (probability value) less than 0.05 suggests that trend lines are statistically significant and the results are not as likely to happen by chance.

Trendlines for all three gauges are shown in Figure 9, Figure 10, and Figure 11, respectively. All other time periods (October through June) for the remaining gauges presented as not statistically significant and are available for review in Appendix A.

These findings may suggest that current groundwater pumping capture upstream of Lahontan Reservoir has been mitigated by several factors. These factors include shifts in runoff patterns, secondary recharge from reclaimed water into groundwater basins, and a reduction in irrigated lands in Carson City and Lyon County. This is one reason why NDWR is focusing on only new water applications for conjunctive management on the Carson River.

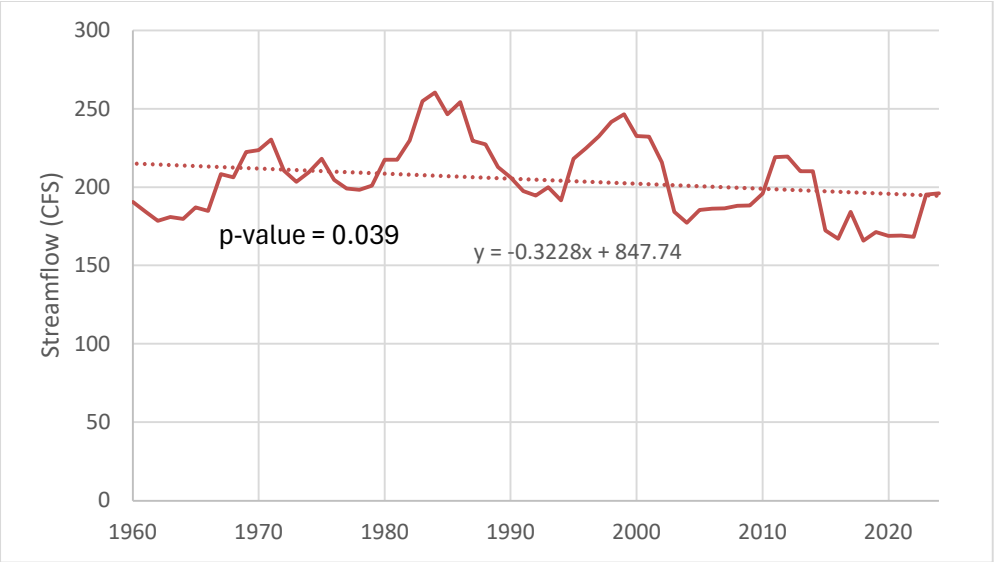

Figure 9: East Fork Carson River Streamflow near Gardnerville: July through September (20 year Moving Average)

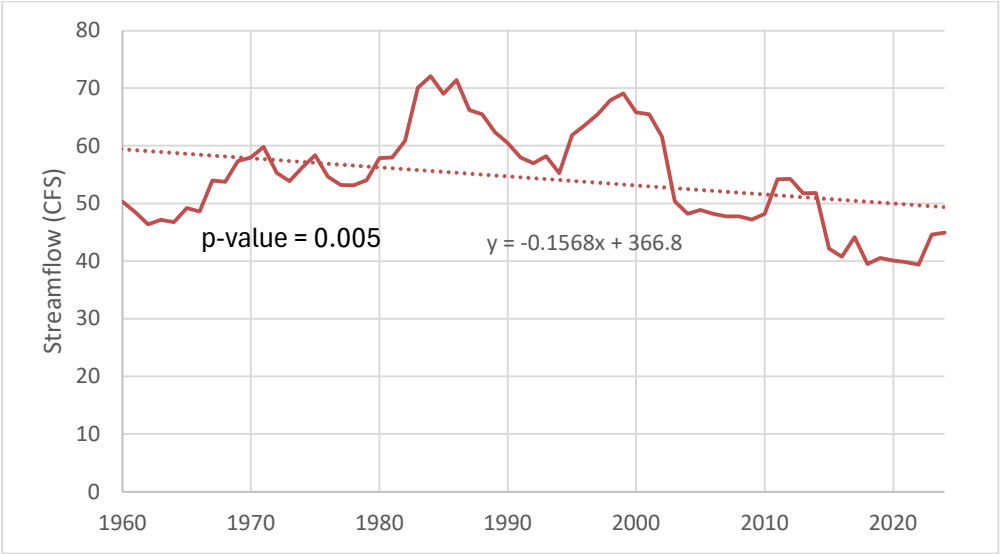

Figure 10: West Fork Carson River Streamflow at Woodfords: July through September (20 year Moving Average)

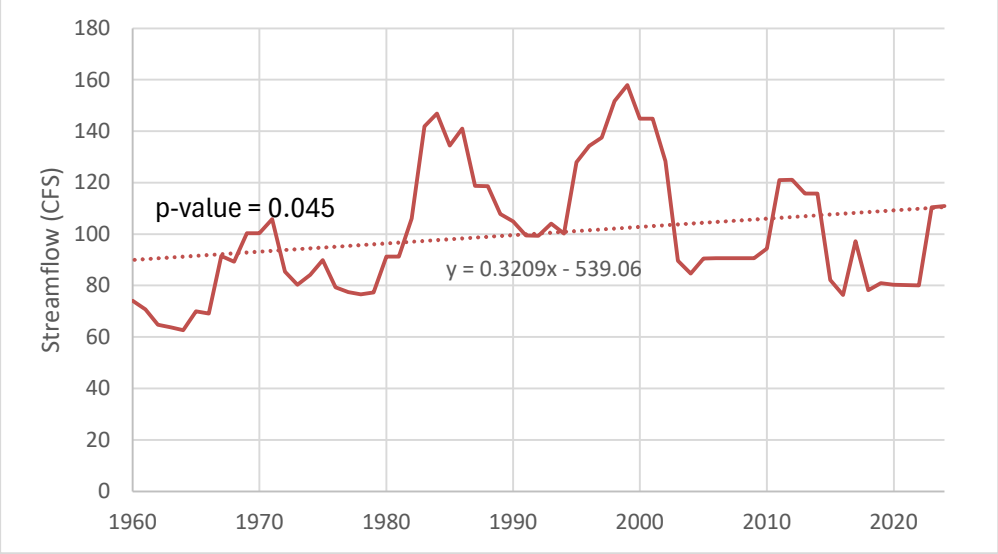

Figure 11: Carson River Streamflow near Ft. Churchill: July through September (20 year Moving Average)

3.4 Future Municipal Demands (USGS model results)

Preliminary USGS model results (Garner & Davis, 2025) for the Middle and Upper Carson River Basin only accounts for future municipal groundwater pumping data. It does not include increases from other groundwater pumping such as domestic wells, commercial, stock watering, etc.

As outlined in the project timeline in Section 1.5, the initial results are incomplete and cannot be updated within the scope of this schedule due to unforeseen federal obstacles. This document aims to interpret the findings available as of October 1st.

The data provided by the USGS is preliminary and subject to revision. It has been shared specifically to support this report, with the understanding that neither the USGS nor the U.S. Government shall be held liable for any damages arising from either authorized or unauthorized use of the information. The 2025 U.S. Government shutdown concluded November 12, 2025, so it is anticipated that the USGS will review, revise, and officially publish their findings. That final published version will serve as the definitive reference. Until then, the data presented here should be considered provisional.

The groundwater model results developed by the USGS for this study to date are shown in the following figures, representing two different scenarios.

- Model Baseline:
    - Groundwater pumping rates from 2020 were projected over the 30-year planning horizon (2021 – 2051). This was done to be able to gauge the changes in groundwater pumping due to projected growth throughout the Upper and Middle Carson.

- Model Scenario:
    - Groundwater pumping was increased based on the growth projections discussed in Section 2.0. For discussion on how stream flow baseline and model scenarios were developed, reference the separate USGS report (Garner & Davis, 2025).

Preliminary results show steady pumping growth for both Upper Carson (Carson Valley) and Middle Carson (Eagle Valley, Dayton Valley, and Churchill Valley), as shown in Figure 12 and Figure 13, respectively. It is important to note that the chart for Carson Valley (Upper Carson) within Figure 12 shows an inaccurate jump in 2032. This inaccuracy is due to a model error that will be fixed in the finalized report from USGS. Groundwater pumping in the Carson Valley (Upper Carson) is projected to increase steadily to supplement growth in the region.

Groundwater pumping in the Middle Carson is projected to drop in 2026 due to the Quill Water Treatment Plant (WTP) capacity upgrades. Quill WTP treats surface water that is distributed to the Carson City service area. Source water for the Quill WTP comes from stream flows from the Marlette Lake Water System (MLWS) which is outside of the Carson River Watershed, and Ash and Kings Canyons. This water from Quill WTP will alleviate impacts to both surface and groundwater in the basin; thereafter, groundwater pumping in the Middle Carson will steadily increase. Groundwater pumping volume will reach close to the same in 2051 that was seen in 2020 (baseline). It should be noted that the pumping data used for the Middle Carson model represents the total municipal groundwater extraction from Carson City to Silver Springs. While total groundwater pumping in Carson City is expected to decrease once the Quill Water Treatment Plant resumes operation, municipal groundwater use in Lyon County is projected to increase over the next 30 years.

Future studies should be conducted as projected planning numbers become reality, allowing for more accurate model results.

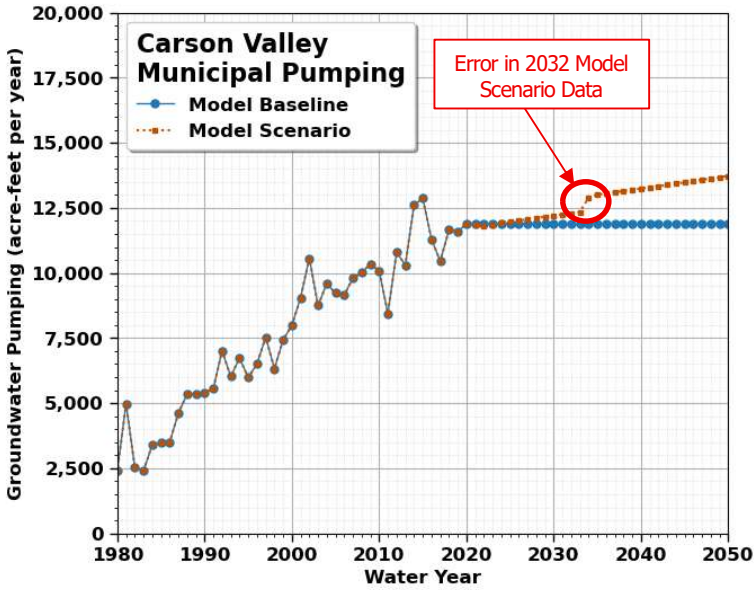

Figure 12: Anticipated Future Municipal Pumping – Carson Valley (Garner & Davis, 2025)

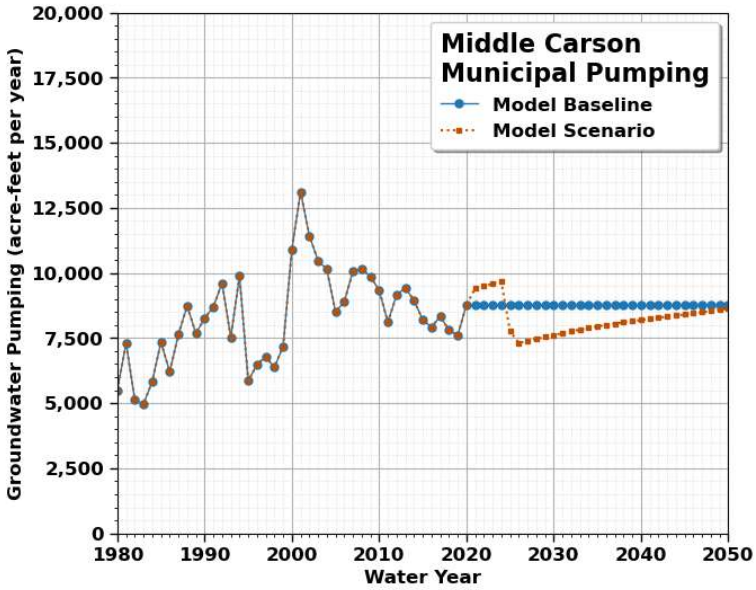

Figure 13: Anticipated Future Municipal Pumping – Middle Carson (Garner & Davis, 2025)

Figure 14 plots the USGS preliminary model's projected change in the Carson River's monthly streamflow (in cfs) at the Ft. Churchill stream gauge from 2021 to 2050. Negative values in Figure 14 represent reduced streamflow in the Carson River, attributed to the increased groundwater pumping projected by this analysis. Large spikes and dips are attributed to modeling errors that will be fixed in the finalized report from USGS.

The USGS model showed Carson River streamflow changes at the Ft. Churchill gauge capture similar trends shown in Figure 13, where stream flows are reduced by over 2 cfs until Quill WTP comes online in 2026. After 2026, stream flows stabilize towards baseline flows by 2028 and the trend remains consistent, (reduced by around 0.5 cfs) until 2051. Current streamflow is trending lower than the baseline scenario due to a temporary increase in well pumping while Quill WTP is off-line for plant upgrades. Through 2051, the USGS preliminary model indicates a slight decrease in stream flows; therefore, the current impacts modeled for the Middle Carson River Basin are mitigated in part by the Quill upgrades.

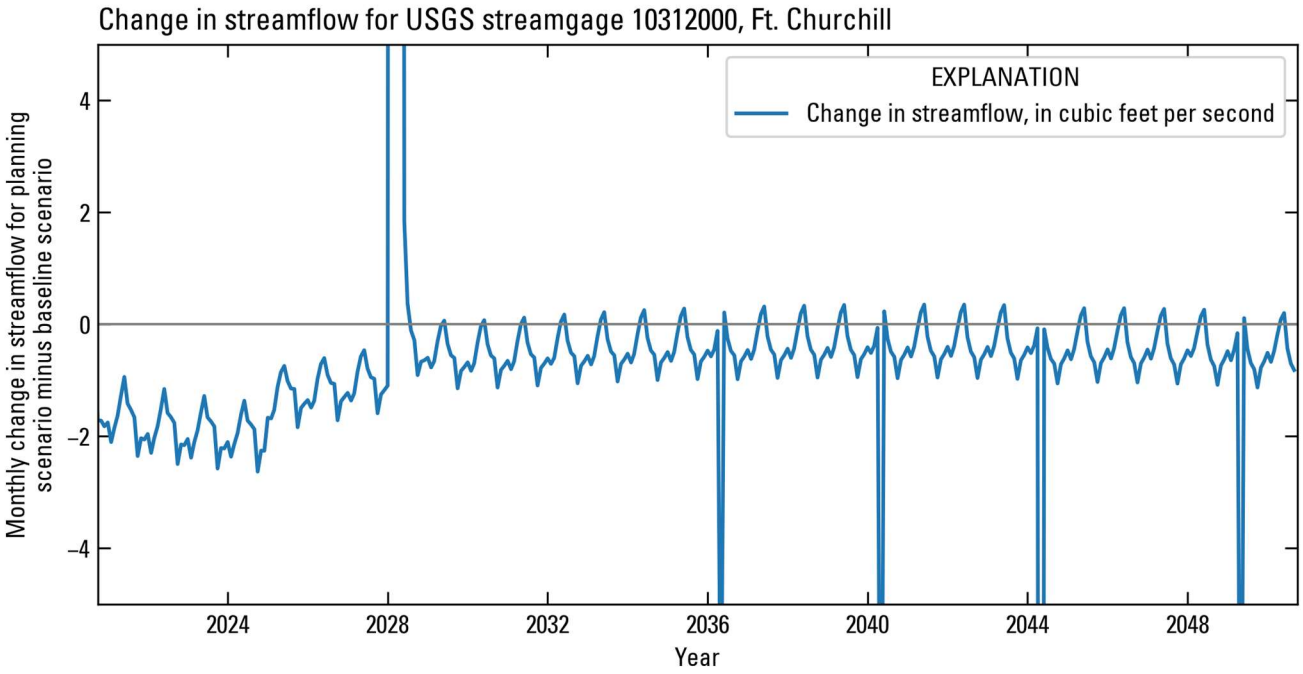

Figure 14: Middle Carson River Basin 2021 - 2050 Change in Streamflow from Baseline (Garner & Davis, 2025)

Figure 15 illustrates similar changes in streamflow at the Ft. Churchill gauge based on volume (ac-ft) per year, where negative values represent a reduction in streamflow volume per year based on the increased groundwater pumping projected by preliminary USGS model. Large spikes and dips are attributed to modeling errors that will be fixed in the finalized report from USGS. Figure 15 shows that prior to the Quill WTP coming online in 2026, annual streamflow is reduced by about 1,400 ac-ft/yr. After Quill WTP comes back online, annual streamflow averages stabilize and are slightly below the 2020 streamflow baseline from 2028 through 2051.

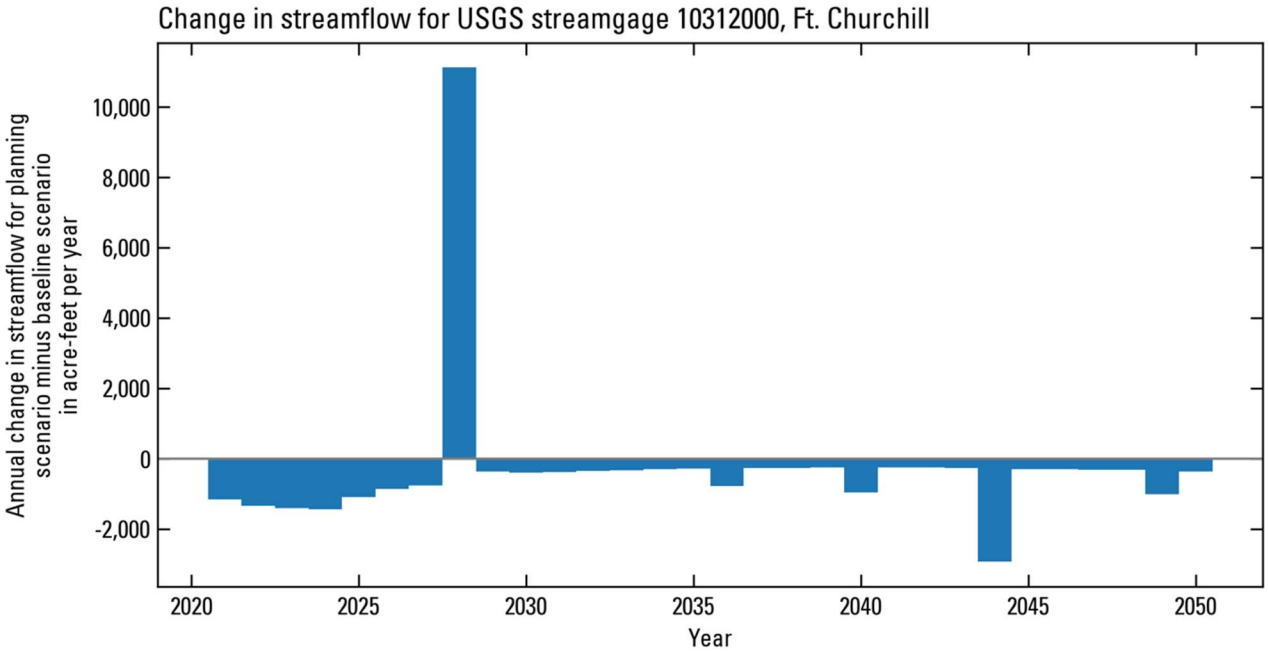

Figure 15: Middle Carson River Basin 2021 – 2050 Change in Streamflow Volume (Garner & Davis, 2025)

Overall, the USGS preliminary model indicates projected population growth will increase reliance on groundwater pumping in the Upper and Middle Carson, which will drive modest but persistent reductions in Carson River streamflow through 2051. The Quill WTP upgrades provide meaningful but partial mitigation by temporarily reducing groundwater demand beginning in 2026. However, this is only a temporary solution to the continued growth in the watershed. Additionally, known model errors and preliminary assumptions warrant treating these results as provisional. Trends in the preliminary results that were discussed within this section were not analyzed for statistical significance and the final future USGS report should be referenced for final trends and the correlating statistical significance of these identified trends.

3.5 Drought and the Carson River Watershed

3.5.1 Nevada Drought

Droughts are a recurring feature of the Carson River Watershed. The Alpine Decree, which governs water allocation, is based on historical flow data and defines water distribution during dry, wet, and average runoff years. Most municipal water suppliers rely solely on groundwater sources. During the 2014–2015 drought, none of the municipal water providers in the Carson River Watershed experienced shortages due to a lack of water supply. Historically and in the future, droughts primarily affect surface water irrigation right holders. However, drought conditions can influence groundwater recharge from surface water diversions and river losses. Current USGS modeling results cannot accurately determine how future droughts will affect aquifer recharge within the watershed. Additional studies will be necessary to better define how future droughts may impact recharge amounts.

3.5.2 Potential impact of Consecutive Dry Years

As discussed in Section 3.4, preliminary USGS modeling suggests that projected growth will increase reliance on groundwater systems, leading to moderate declines in groundwater levels and streamflow. When combined with climate-driven runoff variability and the requirements of the Alpine Decree, drought conditions could further reduce water availability in the Upper and Middle Carson River basins. This has the potential to significantly affect the outlying communities that rely on groundwater sources as their only water source. More significant groundwater depletion has been noted in communities farther away from the Carson River, such as the communities of Ruhenstroth and Johnson Lane areas, whose groundwater is not recharged from the Carson River, but the Pinenut mountain range. (USGS, 2012) (USGS, 2024).

Given the limitations of the USGS study and the high variability in climate data used to assess drought impacts, the full range of potential watershed effects remains uncertain. Water purveyors who incorporate drought uncertainty into their master planning should refer to the mitigation possibilities outlined in Section 4.1 and include an appropriate safety factor to account for the possibility of multiple consecutive dry years.

4.0 Relating Model Results to Possible Mitigation

4.1 Identifying Offsets and Mitigation Measures for Groundwater Pumping in Water Resource Planning

As Nevada's State Engineer move toward implementation of conjunctive water use management, each water purveyor will need to develop and refine specific mitigation strategies to address groundwater pumping impacts. As streamflow conditions continue to evolve, there is increasing focus on the integrated management of surface and groundwater resources. How NDWR applies NRS 533.024 for conjunctive management in the Carson River system may change current operations of municipal water management and Water Master Plans built off the assumption that the same operations will continue.

Currently, NDWR is assessing how new groundwater right applications might affect surface water flows within the Carson River watershed. If groundwater pumping impacts are identified, mitigation will be required to protect downstream users. More clarity on interpretations set by other conjunctive management cases will be used to determine additional measures that the Carson River watershed should consider.

At the time this report is published, CWSD has provided mitigation measures that align with the Alpine Decree, which outlines different requirements depending on the time of year when constraints occur. Detailed discussion on the three relevant seasonal periods can be found in Section 3.2.

Potential mitigation strategies include, but are not limited to:

- Non-Irrigation Season (October 1 to March 31):
    - Release dedicated surface water rights from upstream reservoirs
    - Increase recharge using reclaimed water
- Early Irrigation Season – Not Under Regulation (April 1 to June 30):
    - Release surface water from upstream reservoirs
    - Increase reclaimed water recharge
    - Use dedicated surface irrigation water rights

- Late Irrigation Season – Under Regulation (July 1 to September 30):
    - During this period, downstream users cannot place a call for water.
    - Mitigation may be necessary within the Carson River Segment where groundwater pumping occurs or in response to any resulting groundwater depletion.
    - Coordination with the Federal Water Master and NDWR will be essential to determine appropriate mitigation actions.

Additional mitigation strategies to reduce overall impact for water purveyors to consider are listed below:

- Relocate groundwater pumping sites further from the river.
- Reduce water demand through enhanced conservation efforts.
- Interconnect local water systems to optimize regional supply and delivery.

4.2 Supporting Purveyors in Adapting to Evolving Water Policies

As water purveyors update their Water Master Plans, it is important to integrate conjunctive management principles to ensure sustainable future groundwater and surface water supplies. This includes evaluating new well locations and identifying future water sources in the context of potential policy changes.

This report establishes a framework for water purveyors to consider for conjunctive management. It provides tools and guidance to monitor both surface water and groundwater usage and supports integrated, regional water planning.

This report provides a broad overview of how increased municipal demand could affect flows in the Carson River. Further modeling and regulatory development will be needed to accurately quantify those impacts and define appropriate purveyor-specific mitigation strategies.

4.3 Other Groundwater Pumping Impacts

The NDWR has collected groundwater-pumping data for Carson Valley, Eagle Valley, Dayton Valley, and Churchill Valley groundwater basins. The record lengths and pumping trends vary by basin, but several common drivers influence pumping demand, which include:

- Municipal growth,
- Irrigation needs, and
- Climate variability (wet vs. dry years).

Below is a basin-by-basin synthesis based on historical groundwater pumping inventories issued by NDWR and discussions between CWSD and groundwater users in these basins.

4.3.1 Carson Valley Groundwater Basin (1987-2021)

- Longest data record among the four basins.
- Overall trend: Groundwater pumping has increased steadily.
- Key drivers of increased pumping:
  - Municipal demand from population growth.
  - Irrigation demand, which rises during dry years when surface water is limited.
- Hydrologic variability:
  - Dry years: Farmers increase pumping to offset reduced surface-water availability.
  - Wet years: More surface water is available, reducing groundwater pumping.
- Intertie with Carson City:
  - Since 2017, Carson City has taken just under 3,000 AF/year from Carson Valley.
  - No plans to increase withdrawals due to pipeline capacity and water-rights limitations.

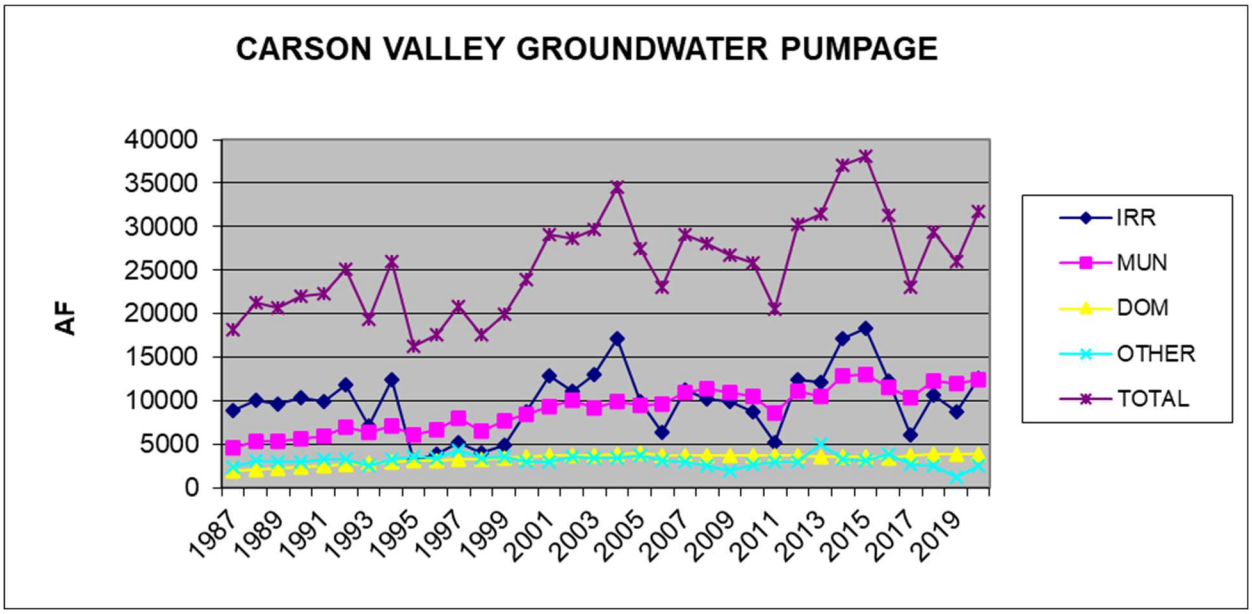

Figure 16: Carson Valley Groundwater Pumpage (Carson Water Subconservancy District, 2025)

4.3.2 Eagle Valley Groundwater Basin (1994-2022)

- Largest user: Carson City.
- Pumping trend:
  - Peaked in the early 2000s, followed by a general decline.
  - Decline attributed to:
    - Water-conservation efforts,
    - Use of additional imported water from Carson Valley.
- Short-term increases:
  - 2020–2021: Higher pumping due to COVID-19 behavior shifts (more people staying home).
  - Recent uptick: Caused by rehabilitation work at the Quill Treatment Plant.
- Future outlook:
  - Once Quill plant rehabilitation is complete, pumping is expected to decrease again.

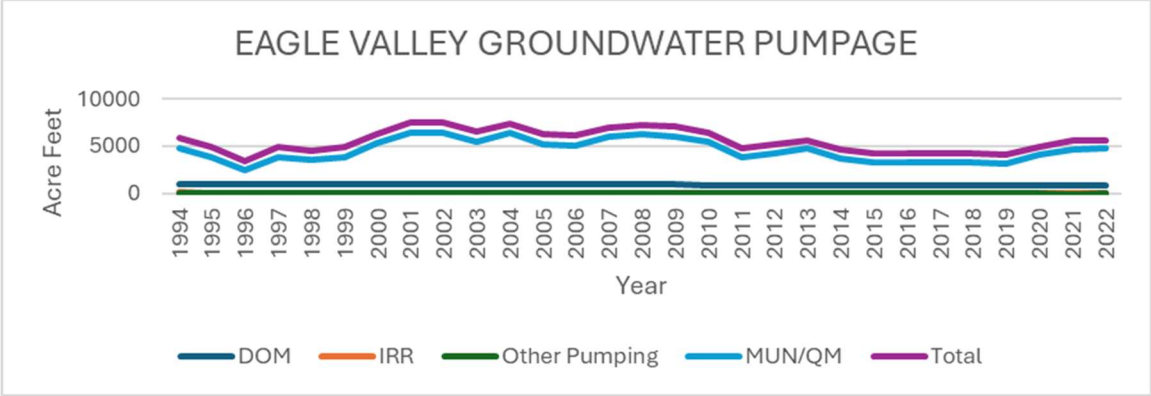

Figure 17: Eagle Valley Groundwater Pumpage (Carson Water Subconservancy District, 2025)

4.3.3 Dayton Valley Groundwater Basin (2003-2021)

- Largest use category: Municipal groundwater pumping.
- Trends:
    - Municipal pumping: Slight decline due to water conservation and reduced outdoor use.
    - Irrigation pumping: Varies significantly with wet vs. dry years.
    - Total pumping: Has decreased overall but is projected to increase in the future because of expected development growth in the Dayton area.

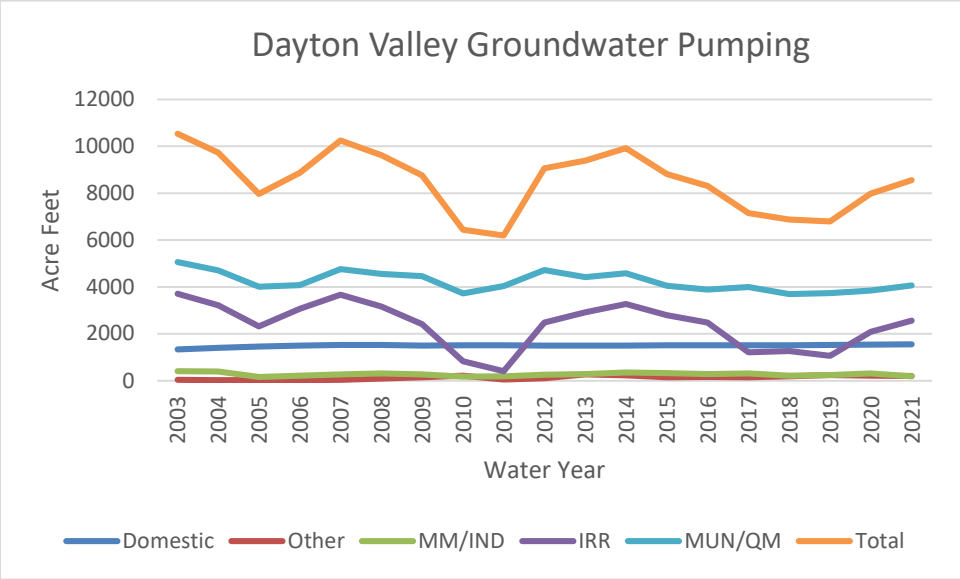

Figure 18: Dayton Valley Groundwater Pumping (Carson Water Subconservancy District, 2025)

4.3.4 Churchill Valley Groundwater Basin (2204-2021)

- Largest groundwater user: Domestic wells, with NDWR assuming 1 AF/year per domestic well.
- Trends:
    - Municipal use: Slight decline due to conservation; projected to increase modestly over the next 30 years due to growth.
    - Irrigation pumping: Fluctuates with wet and dry years.
- Overall outlook: Generally stable pumping with small future increases from municipal and domestic wells.

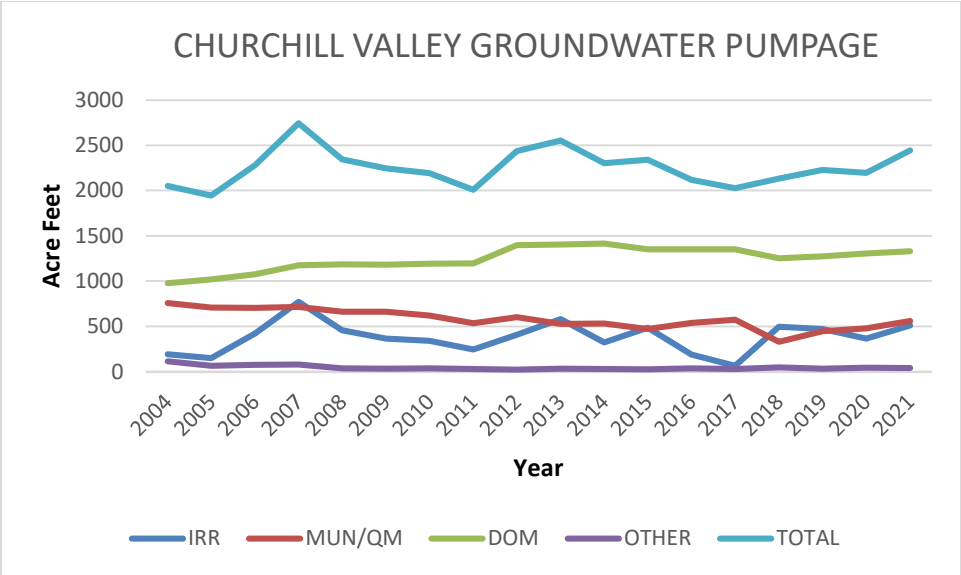

Figure 19: Churchill Valley Groundwater Pumpage (Carson Water Subconservancy District, 2025)

5.0 Key Takeaways

This 30-Year Regional Drought and Water Sustainability plan was funded through a grant from the Nevada Department of Emergency Management (NDEM) to the Carson Water Subconservancy District (CWSD). It was prepared with input from CWSD, Lumos and Associates (Lumos), the United States Geological Survey (USGS), and multiple stakeholders. This document serves as a reference and focuses exclusively on municipal water sustainability over the next three decades. Key findings include:

- **Carson River Flows:** Streamflow data from 1940–2021 show a slight overall decline, driven by climate variability and human influences. Variability in flows has increased, with more extreme peak events and longer drought periods. Shifts in weather patterns have also caused peak runoff to occur earlier in the year.
- **Groundwater Pumping:** Although total groundwater pumping in the Upper and Middle Carson River area has increased, its effect on flows measured at the Fort Churchill gauge remains minimal. Reduced irrigation in the Middle Carson River region, reclaimed-water recharge, and altered runoff patterns may be offsetting impacts. Municipal groundwater use in these areas is projected to increase by less than 5,000 acre-feet over the next 30 years.
- **Conjunctive Management:** Since the adoption of NRS 533.024.1(e) in 2017, the Nevada Division of Water Resources (NDWR) manages all waters of the state conjunctively. For new permits or changes to existing rights, NDWR ensures proposed uses do not conflict with any existing rights, regardless of water source. Where conflicts among existing rights are supported by data, the State Engineer may implement conjunctive management strategies to reduce or eliminate those conflicts.
- **Quill Water Treatment Plant (Quill WTP):** Upon completion of upgrades to Carson City's Quill WTP, groundwater pumping in the Eagle Valley basin will decline. This reduction will help offset anticipated increases in municipal pumping elsewhere in the Middle Carson River area.

- **Wet/Dry Years (Alpine Decree):** Carson River surface water is administered by the U.S. Federal Water Master in accordance with the Alpine Decree (1980). Through the Alpine Decree, the U.S. Federal Water Master is able to allocate surface water resources in both wet and dry years.
- **Drought:** Due to limitations in the USGS study and high climate variability, the full range of future watershed responses remains uncertain. Nonetheless, historical data suggests droughts will likely become more frequent and prolonged. Because municipal systems largely rely on groundwater, they are expected to meet projected demands over the next 30 years.
- **Regional Systems and Sustainability:** All nine water purveyors included in this study possess sufficient water rights to accommodate future growth. While each faces some water-quality considerations, none anticipates quality constraints that would limit their ability to meet demand. While most purveyors have sufficient capacity through 2051, system upgrades – particularly to distribution networks and well capacity – may be required. This is especially true for Minden and GRGID, which are estimated to exceed their current pumping capacity by 2051. In Silver Springs and Stagecoach, perennial yield and secondary recharge are limiting factors; major developments in these areas will likely require imported water. .

References

Carson Water Subconservancy District. (2025). Analysis of Total Groundwater Pumping Trends in the Upper and Middle Carson River Basins.

Desert Research Institute. (2011). *Streamflow Changes in the Carson River System.*

Desert Research Institute. (2025). *Assessing Groundwater Sustainability in Gardnerville Ranchos, Nevada, from 2024 to 2043 through Scenatio-Based Groundwater Modeling.*

Garner, C., & Davis, K. (2025). Preliminary Results: Effects of Water-Management Scenarios on Water Levels and Streamflow in the Carson River Basin. USGS.

Lumos & Associates. (2021). *Carson River Water Marketing.*

Lumos & Associates. (2023). *Carson City Public Works Memorandum*.*

Lumos & Associates. (2023). *Douglas County Memorandum*.*

Lumos & Associates. (2023). *Gardnerville Ranchos General Improvement District Memorandum*.*

Lumos & Associates. (2023). *Gardnerville Water Company Memorandum*.*

Lumos & Associates. (2023). *Indian Hills General Improvement District Memorandum*.*

Lumos & Associates. (2023). *Lyon County Memorandum*.*

Lumos & Associates. (2023). *Silver Springs Memorandum*.*

Lumos & Associates. (2023). *Stagecoach Memorandum*.*

Lumos & Associates. (2023). *Town of Minden Memorandum*.*

National Environmental Education Foundation. (2021, June 06). *Home Water Use in the United States*. Retrieved from neefusa.org: https://www.neefusa.org/story/water/home-water-use-united-states#Nevada

NDWR. (n.d.). *Humboldt River Region*. Retrieved from Nevada Division of Water Resources: https://water.nv.gov/index.php/programs/humboldt/

Nevada Division of Water. (n.d.). Water Resources within the Churchill Valley and Dayton Valley Hydrographic Basins.

The State of Nevada. (2017). NRS 533.024.

USGS. (2012). *Scientific Investigations Report 2012–5262: Assessing Potential Effects of Changes in Water Use With a Numerical Groundwater-Flow Model of Carson Valley, Douglas County, Nevada, and Alpine County, California.*

USGS. (2023). *Scientific Investigations Report 2023-5008: Assessing Potential Effects of Changes in Water Use in the Middle Carson River Basin.*

USGS. (2024). *Open-File Report 2024-1045: Assessment of Water Levels, Nitrate, and Arsenic in the Carson Valley Alluvial Aquifer and the Development of a Data Visualization Tool for the Carson River Basin, Nevada.*

*Contact CWSD for specific information or a copy of noted references

APPENDIX

APPENDIX A: Carson River Streamflow

Carson Office

308 N Curry, Suite 200, Carson City, NV 89703

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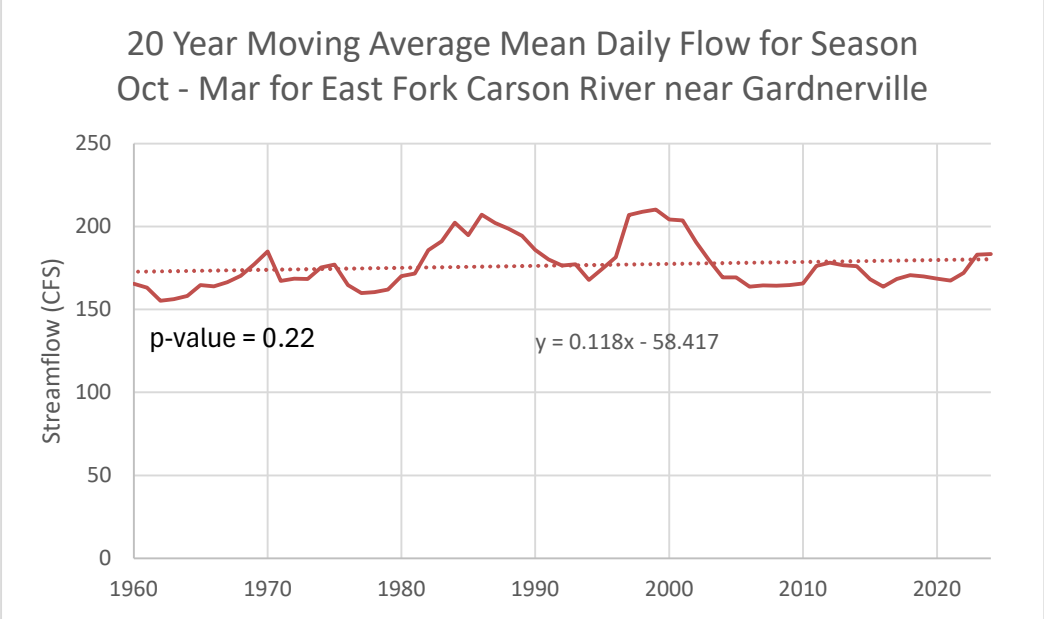
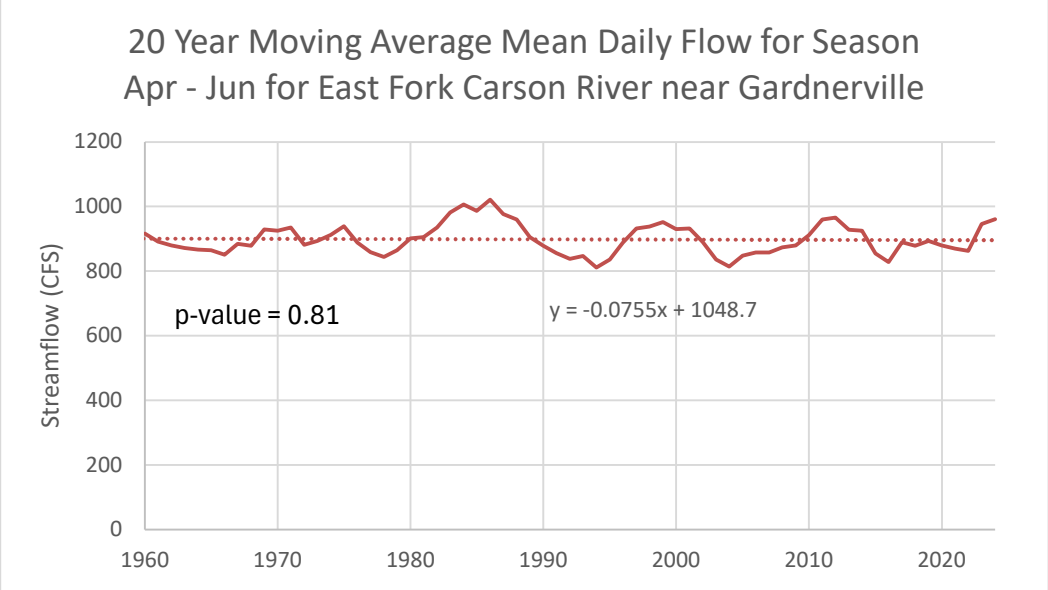
www.lumosinc.com





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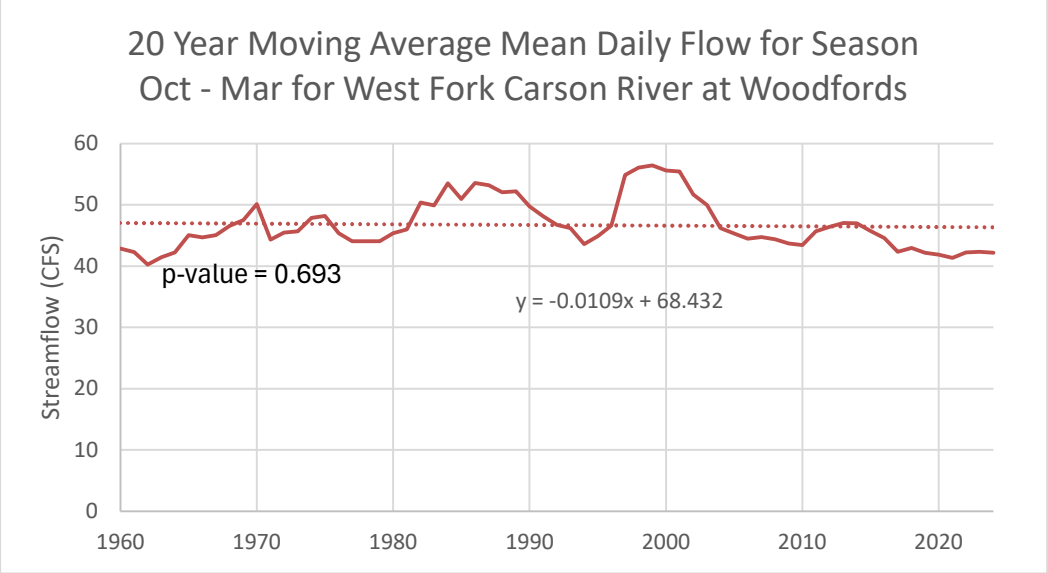

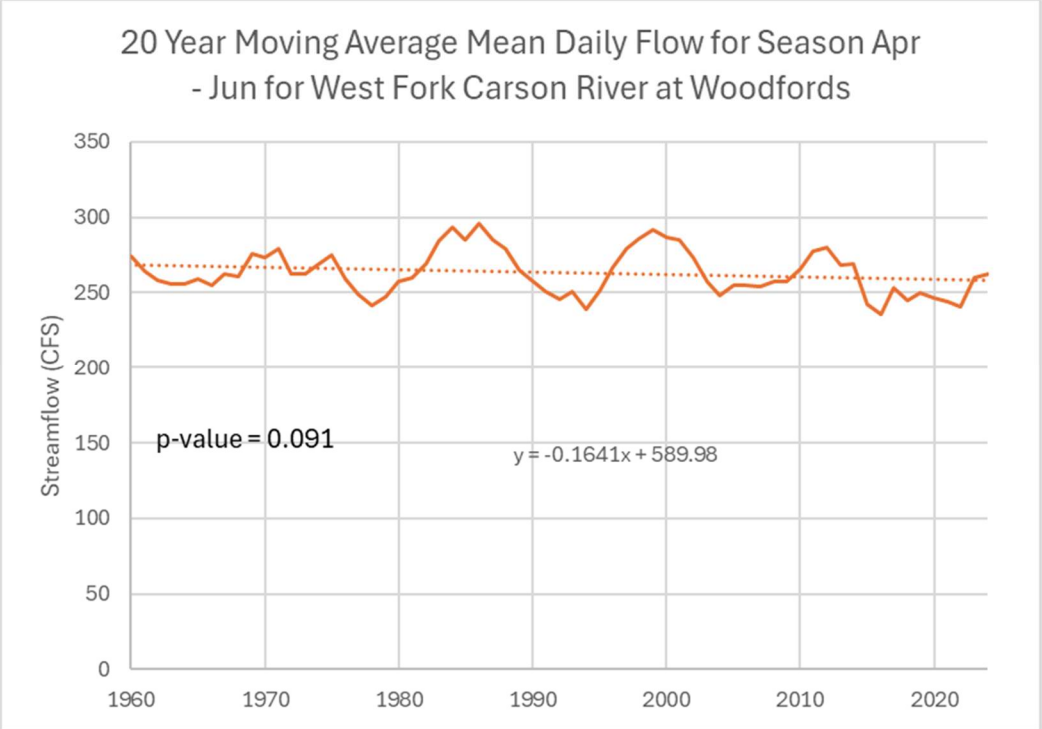

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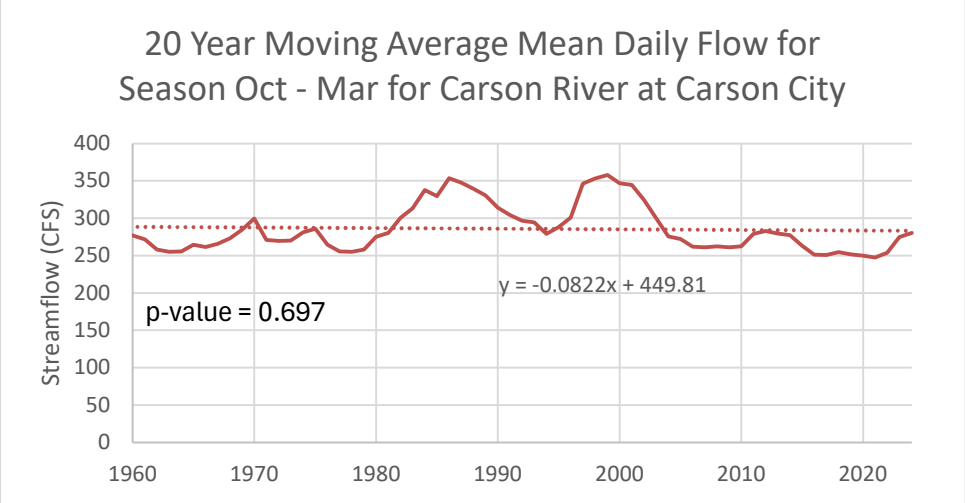

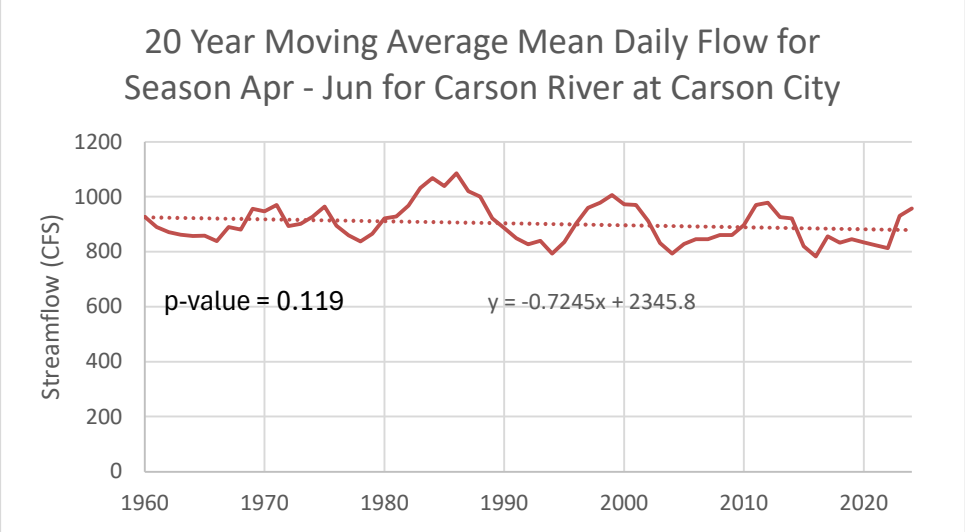

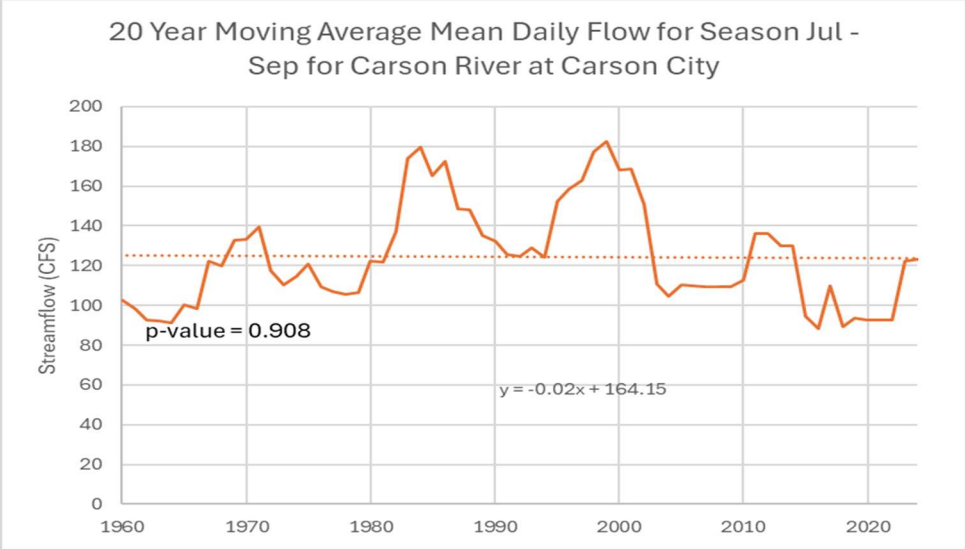

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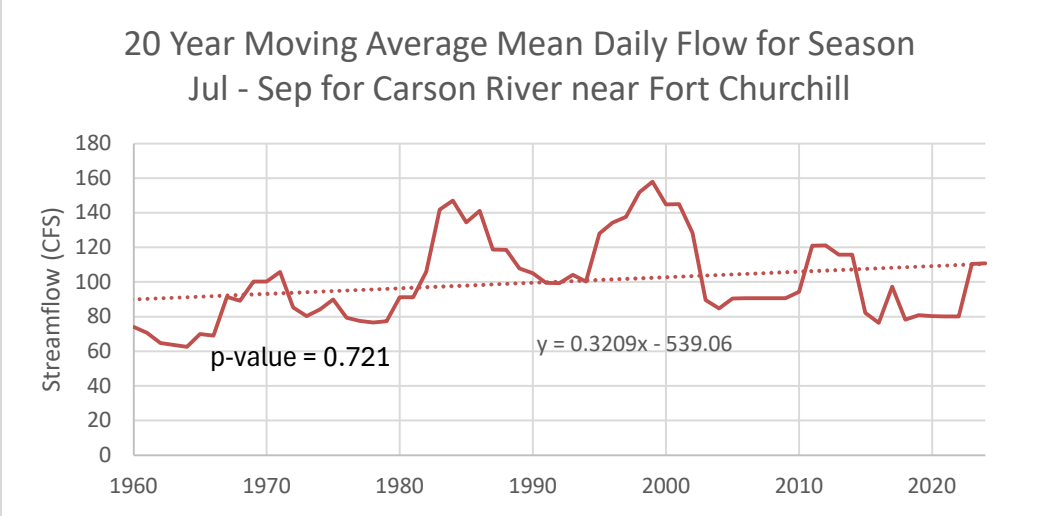

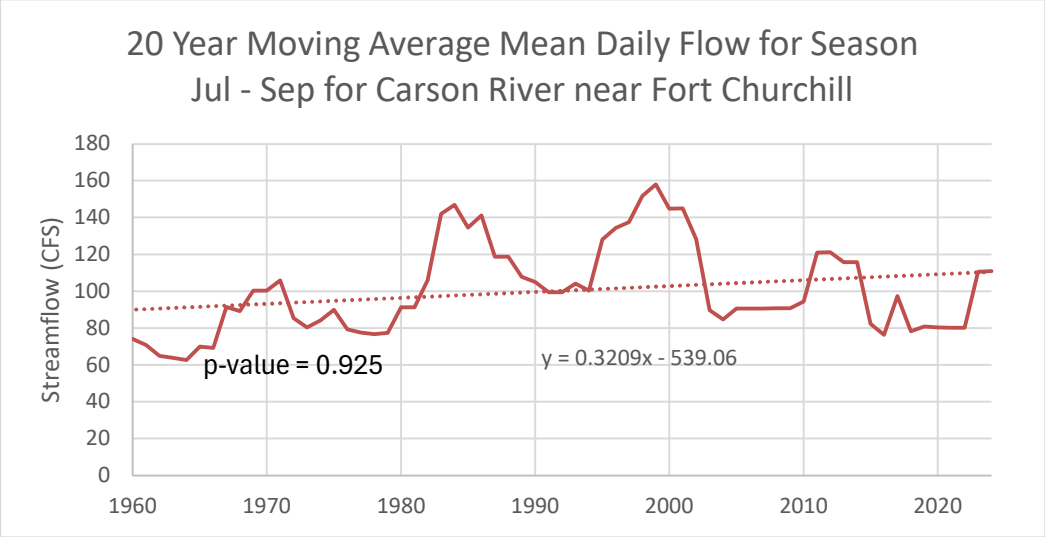

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