CARSON WATER SUBCONSERVANCY DISTRICT
Regional Water System & Flood Committee

NOTICE OF PUBLIC MEETING

DATE: **June 9, 2021**

TIME: **10 am**

LOCATION: **CWSD Conference Room & Zoom**
777 E. William Street, Suite 110A
Carson City, NV 89701

CWSD is fully open for in-person meetings, but virtual attendance is available via ***Zoom***. If you prefer to phone in, call (669)900-9128. Meeting ID: 869 0387 7561; Passcode: 803253

AGENDA

Please Note: *The Carson Water Subconservancy District (CWSD) Board may: 1) take agenda items out of order; 2) combine two or more items for consideration; and/or 3) remove an item from the agenda or delay discussion related to an item at any time. All votes will be conducted by CWSD Board of Directors. Reasonable efforts will be made to assist and accommodate individuals with disabilities who wish to join the meeting. Please contact Catrina Schambra at (775)887-7450 (**catrina@cwsd.org**), at least two business days in advance so that arrangements can be made.*

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1. Call to Order the CWSD Regional Water System & Flood Committee
2. Roll Call
3. For Discussion Only: Public Comment - Action may not be taken on any matter brought up under public comment until scheduled on an agenda for action at a later meeting.
4. For Possible Action: Approval of Agenda
5. For Possible Action: Approval of the Regional Water System and Flood Committee March 30,2021 Meeting Minutes
6. For Possible Action: Discuss expanding the CTP Program
7. For Possible Action: Discussion the Water Marketing Study and next steps
8. For Discussion Only: Public Comment - Action may not be taken on any matter brought up under public comment until scheduled on an agenda for action at a later meeting.
9. For Possible Action: Adjournment

Supporting material for this meeting may be requested from Catrina Schambra at 775-887-7450 (catrina@cwsd.org) and is available on the CWSD website at www.cwsd.org.

In accordance with NRS 241.020, this notice and agenda has been posted at the following locations:

Dayton Utilities Complex
34 Lakes Blvd
Dayton, NV

Lyon County Administrative Building
27 S. Main St.
Yerington, NV

Carson City Hall
201 N. Carson St.
Carson City, NV

Alpine County Administrative Building -
99 Water St.
Markleeville, CA

Minden Inn Office Complex
1594 Esmeralda Avenue
Minden, NV

Churchill County Administrative Complex
155 N Taylor St.
Fallon, NV

Carson Water Subconservancy District Office
777 E. William St., #110A
Carson City, NV

CWSD website:
https://www.cwsd.org
State public meetings website:
http://notice.nv.gov

AFFIDAVIT OF POSTING

The undersigned affirms that on or before 9:00 am on January 3 ,2001, he/she posted a copy of the *Notice of Public Meeting and Agenda* for the January 9,2020 regular meeting of the CWSD Regional Water System & Flood Committee, in accordance with NRS 241.020; said agenda was posted at the following location:

____

____

SIGNATURE

Name: ____

Title: ____

Date & Time of Posting: ______________________________

CARSON WATER SUBCONSERVANCY DISTRICT

Regional Water System & Flood Committee

March 30, 2021, 10 am

***Draft* Minutes**

The CWSD Regional Water System & Flood Committee meeting was held via Zoom Videoconference and teleconference due to Governor Sisolak's statewide Emergency Directive in response to the COVID-19 Pandemic.

Committee Members Present:
Jack Jacobs
January Riddle
Lisa Schuette
Mike Workman

Absent Committee Members:
Pete Olsen
Fred Stodieck

CWSD Staff Present:
Ed James
Catrina Schambra

Director Jacobs called the video/teleconference meeting of the CWSD Regional Water System & Flood Committee to order at 10 am. Roll call determined a quorum of the committee was present.

Item #3 – Discussion Only: Public Comment - None

Item #4 - For Possible Action: Approval of Agenda

Director Workman made a motion to approve the Regional Water System and Flood Committee Agenda. The motion was seconded by Director Schuette and unanimously approved by the Regional Water System and Flood Committee.

Item #5 - For Possible Action: Approval of the Regional Water System and Flood Committee Minutes of August 12, 2020

Director Workman made a motion to approve the Regional Water System and Flood Committee Minutes from August 12, 2020. The motion was seconded by Director Jacobs and unanimously approved by the Regional Water System and Flood Committee.

Item #6 - For Possible Action: Discuss and possibly authorize CWSD to apply for a Grant from BOR for a Basin Plan Study

Mr. James gave a brief history of this Basin Study project. In 2012, CWSD staff received approval to submit for a BOR grant for this study and were awarded the $200,000 grant. At the same time, UNR received a $4 million grant which included USGS participation in their study. This would allow them to do much more than we could do with our much smaller funding grant. It was decided that CWSD would withdraw the grant request and await the conclusion of the UNR's "Water for the Seasons" study before pursuing a study in this area.

Last year the *Water for the Seasons* project was completed. Out of the study the USGS developed a detail groundwater/surface water model for the Carson Valley and a detail climate model. At the same time, the USGS completed their modeling efforts on the Middle-Carson River sections.

The UNR study did not follow the Alpine Decree and the models used need to be updated with current data. CWSD's current BOR grant for Water Marketing Study is almost complete. New models are needed. This Basin Study would update models, hire a consultant to put the plan together and ensure that there is no adverse effect to Lyon County.

With these various tools, staff would like to pursue enhancing the models and incorporate the work the USGS is doing in Douglas County to develop an overall watershed water plan. This plan will help define the water strategies in the watershed for the next 40 years.

The BOR grant requires 50% match; however, this money can be leverage with the USGS 35% matching funds. The estimated cost of the project are as follows:

Basin Plan Costs - $210,000
BOR Grant Match - $105,000
CWSD Cash Match – $50,000
CWSD In-Kind Match - $55,000

USGS modeling $160,000.
USGS matching Funds - $56,000
CWSD match funds - $104,000

The funds for this project would be used to (a) pay USGS $104,000, and (b) pay an engineering firm to prepare the plan $51,000.

Due to the timing of the application deadline (April 21, 2021) and the need to move forward to seek letters of support , Mr. James is seeking the approval of the committee to move forward with the application, with their recommendation to the full Board for approval at the April 21, 2021 Board meeting.

Discussion followed regarding following the Alpine Decree and the change in the assumptions that were used at the time of the UNR study that are no longer valid as production has totally changed. This will be a 3-year study that will update Master Plan water needs for the future to meet demands due to climate change, and to make sure there are no negative effect to Lahontan water flows. Director Jacobs asked if the focus is more on demand or availability. Mr. James responded the focus would be on the overall water system for the area due to climate change.

Director Workman made a motion to recommend approval to the Board of Directors to pursue the BOR Basin Study grant. The motion was seconded by Director Schuette and unanimously approved by the Regional Water System &

Flood Committee.

Item # 7 – For Possible Action: A review of the various projects to be submitted under FEMA MAS 12 Grant Application

Mr. James reported that the FEMA Risk Map Charter Meeting was held on March 17, 2021 with representatives from all counties and several watershed agencies to review proposed FEMA CTP MAS 12 projects and decide their priority order. He confirmed FEMA MAS 12 funding of $785,000 is earmarked for CWSD and will cover the proposed list of projects below:

- Southeast Carson Area Drainage Plan
- Buckeye Creek detention/flood control basin design.
- Virginia City– Drainage Mitigation Study and Community Outreach –
- East Carson Area Drainage Plan
- Six Mile Canyon
- Community Outreach and Mitigation Strategies - including funding request for High Water Marks

Mr. James introduced each project and its proposed costs. He asked attendees at the Charter meeting if anyone had any other projects that they would like to be considered under this funding cycle. The consensus was approval of the proposed list with no additional projects per the county representatives in attendance.

Mr. James is asking the committee to recommend approve of these projects for the FEMA MAS 12 funding application. Mr. James and Ms. Neddenriep will begin working on the application to be submitted in April.

Director Workman made a motion to recommend approval to the Board of Directors for staff to apply for FEMA MAS 12 funding based on project list presented. The motion was seconded by Director Schuette and unanimously approved by the Regional Water System & Flood Committee.

Item # 8 – For Possible Action: Discussion of MB Web Access Proposal

Included in FEMA MAS 11 funding requests was a project to develop a web access platform where engineers, developers, and county staff could utilize the data from the various flood models that have been developed in the Carson River Watershed. Michael Baker is the engineering firm selected to conduct this project. The committee reviewed the Agreement, Business Plan, Schedule, and costs. This project is being funded through a grant from FEMA in an amount not to exceed $160,000. Included in this agreement is a separate hosting and infrastructure annual fee of $7,200 for 3 years. Costs and hosting location can be re-accessed at the end of the initial 3-year period. The separate yearly cost of $7,200 for the hosting and infrastructure will be paid by CWSD from the Outside Professional Services General Fund account.

Director Schuette made a motion to recommend approval to the Board of Directors of Contract #2021-25 Michael Baker – Web Access System in an amount not to exceed $160,000 and Hosting Infrastructure for 3-years at a fee of

$7,200 per year as presented.. The motion was seconded by Director Workman and unanimously approved by the Regional Water System & Flood Committee.

<u>Item # 9 – Discussion Only: Public Comment</u> - None

There being no further business to come before the Regional Water System and Flood Committee, Director Jacobs adjourned the meeting at 10:54 am.

Respectfully submitted,

Catrina Schambra
Secretary to the Board

CARSON WATER SUBCONSERVANCY DISTRICT
Regional Water System & Flood Committee

TO: Committee Members

FROM: Edwin James

DATE: June 9, 2021

SUBJECT: Agenda Item # 6– For Possible Action: Discuss Expanding the CTP Program

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DISCUSSION: CWSD receives funding from FEMA that covers all costs of CTP projects. Counties have asked CWSD to expand projects outside of the Watershed but inside the counties to have broader access to this funding.

STAFF RECOMMENDATION: Provide direction to staff.

CARSON WATER SUBCONSERVANCY DISTRICT
Regional Water System & Flood Committee

TO: Committee Members

FROM: Edwin James

DATE: June 9, 2021

SUBJECT: Agenda Item # 7– For Possible Action: Discuss the Water Marketing Study and next steps

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DISCUSSION: Presentation and follow-up questions regarding the Water Marketing Study Report and the next steps.

STAFF RECOMMENDATION: Provide direction to staff.

Carson Water Subconservancy District

Carson River Water Marketing

May 6, 2021

Draft:
For Carson Water Subconservancy District and Stakeholder Review

Prepared For:
Carson Water Subconservancy District
777 E. William St. Suite 110A
Carson City, NV 89701

Prepared By:

LUMOS & ASSOCIATES

308 N. Curry Street, Suite 200
Carson City, NV 89703
775 / 883-7077

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Certification

The technical material and data contained in the document were prepared under the supervision and direction of the undersigned professional engineer. The opinions contained in this document reflect Lumos & Associates professional judgment in context with the scope of work and contract. The presented opinions are based on the conditions, information, and data provided to Lumos & Associates at the time the document was published and may be subject to change based on changing conditions, information, and data. Lumos & Associates did not verify independent information, conditions, and opinions supplied by others. There is no written or implied warranty or guarantee for any damages that occur from third party use of this document.

Draft:
For Carson Water Subconservancy District &
Stakeholder Review

Prepared by

Authorization

On June 19, 2019, the Carson Water Subconservancy District approved a contract with Lumos & Associates to complete a Water Marketing Study. The project is being funded through a US Bureau of Reclamation Water Marketing Strategy Grant. The contract scope of work is summarized as follows:

- Task 1.1 Project Management and Administration
- Task 1.2 Communication and Outreach
- Task 1.3 Evaluate Existing Water Supply by River Segment
- Task 1.4 Identify and Rank Storage and Infrastructure Needs and Opportunities
- Task 1.5 Water Marketing Analysis
- Task 1.6 Water Market Report

Abbreviations

AF	acre foot
AFA	acre foot annually
AF/AC	acre foot per acre
ASR	aquifer storage and recovery
CFR	Code of Federal Regulation
CFS	cubic feet per second
CWSD	Carson Water Subconservancy District
DCLTSA	Douglas County Lake Tahoe Sewer Authority
GPM	gallons per minute
GWUDI	groundwater under the direct impact of surface water
IHGID	Indian Hills General Utility District
IVGID	Incline Village General Improvement District
LCUD	Lyon County Utility District
MAR	managed aquifer recharge
MG	million gallons
MGD	million gallons per day
MGSD	Minden-Gardnerville Sanitation District
MLWS	Marlette Lake Water System
MPUD	Markleeville Public Utility District
NAC	Nevada Administrative Code
NRS	Nevada Revised Statute
PPB	part per billion
RIB	rapid Infiltration Basin
STPUD	South Tahoe Public Utility District
TCID	Truckee-Carson Irrigation District
USGS	US Geological Survey
WTP	water treatment plant
WWTP	wastewater treatment plant
σ	standard deviation

Definitions

Community Water System (CWS) – "a system that supplies water to the same population year-round" (US Environmental Protection Agency, 2017).

Conjunctive Management – jointly managing ground and surface waters together rather than exclusively.

Groundwater Under the Direct Impact of Surface Water (GWUDI) – According to 40 CFR §141.2 GWUDI is *any water beneath the surface of the ground with significant occurrence of insects or other macroorganisms, algae, or large-diameter pathogens such as Giardia lamblia or Cryptosporidium, or significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity, or pH which closely correlate to climatological or surface water conditions.*

Non Community Water System (NC) – A water system that "provides water in a place such as a gas station or campground where people do not remain for long periods of time" (US Environmental Protection Agency, 2017). These systems are also known as Transient Non-Community systems (TNC).

Non-Transient Non-Community System (NTNC) – A system that "regularly supplies water to at least 25 of the same people at least six months per year" (US Environmental Protection Agency, 2017).

Perennial Yield – "the maximum amount of groundwater that can be salvaged each year over the long term without depleting the groundwater reservoir" (King, 2018)

Riparian water right – the right to use natural flow on riparian land, or in other words the right to use the natural flow of water on land that touches a surface water. Riparian rights can only be used on land that drains back to the river, lake, or stream the water came from and only apply to naturally occurring flows (California Water Boards, 2019).

Standard Deviation – represents the deviation from the mean (or average) of a dataset. A larger standard deviation indicates that the datapoints in the dataset are more widely dispersed from the mean. A smaller standard deviation indicates the datapoints are closer to the mean.

1.0 INTRODUCTION

1.1 Water Marketing Report Background

The purpose of this report is to formally document the varied efforts, evaluations, concepts, and outreach to develop a water marketing exchange and transfer strategy for the Carson River watershed. This report generally covers two very broad topics. The first topic addresses Carson River watershed history, regulatory oversight, data, and trends. These topics are covered in Chapters 2.0 through 4.0 The second topic covers existing water marketing opportunities and future water marketing strategies. These topics are covered in Chapters 5.0 through 6.0. Future water marketing strategy(ies) will consider water supply instability, water supply shortages, legal and physical restraints, and potential water storage concepts.

1.2 Carson River Watershed Background

The Carson River originates in the Eastern Sierra Mountains of California and terminates in the Carson Sink in the Nevada desert. Although numerous streams and creeks come together to form the Carson River, the main tributaries are the East Fork and the West Fork of the Carson River. Elevations range from 11,460-feet at Sonora Peak near the headwaters of the East Fork to 3,850-feet in the Carson Sink, nearly 200 miles downstream. The Carson River allows communities to thrive in the desert. Waters that begin as High Sierra snowpack are utilized for potable consumption (through surface water treatment and groundwater recharge), agricultural uses, and recreation. The river also provides for a variety of flora and fauna that changes as the river descends the Sierra Mountains to the Nevada desert. The Carson watershed is bordered by the Truckee River watershed on the west and north and the Walker River watershed to the south. Table 1.1 summarizes some key features of the Carson Watershed and Figure 1.1 and Figure 1.2 highlight the location and topography of the watershed.

Table 1.1 – Carson Watershed Facts

Watershed Area	3,962.9 $miles^2$
Carson River Length	131.1 miles
East Fork Carson River Length	68.0 miles
West Fork Carson River Length	39.6 miles
Named Creeks, Rivers, canals, etc. in Watershed	186
Total Length of named Creeks, Rivers, Canals, etc. in Watershed	1,043.8 miles

LUMOS & ASSOCIATES

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WWW.LUMOSINC.COM

Carson City Subconservancy District

Carson Watershed Area Map

REV	DATE	DESCRIPTION	BY

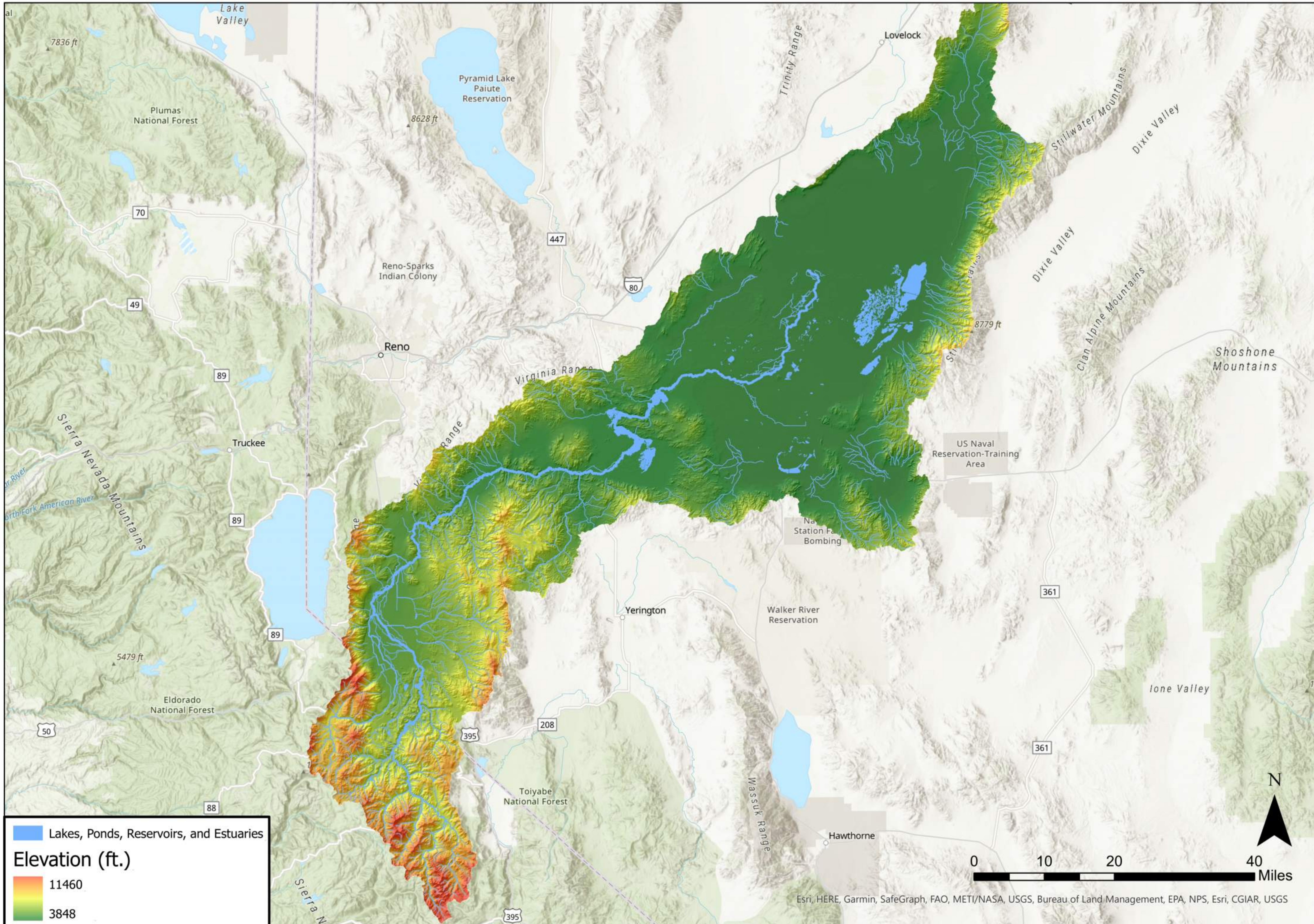
BAR IS 1 INCH ON ORIGINAL DRAWING

0" 1"

IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

FIG. 1.1

DRAWN BY:	DRB
DESIGNED BY:	NTC
CHECKED BY:	NTC
JOB NO.:	9834.000
SHEETS:	



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Carson Water Subconservancy District

Carson Watershed Shaded Relief

REV	DATE	DESCRIPTION	BY

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FIG. 1.2

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DESIGNED BY: NTC
CHECKED BY: NTC
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2.0 CARSON RIVER BACKGROUND

The Carson River and surrounding areas have a rich, but at times volatile history. Over the years there have been significant legal issues surrounding the use of water from the Carson River. The purpose of the following sections is to provide a brief summary of historical instream flows and the various rules and decrees that have tried to manage these flows.

2.1 Watershed Management

Water use along the Carson River is governed by the Alpine Decree. In 1925, the US Department of the Interior initiated the decree through *United States of America vs. Alpine Land and Reservoir Company, et al*. Fifty-five years later, in October 1980, the decree was finalized. The decree establishes surface water rights in both California and Nevada, establishes the right to reservoir storage, and defines the operation of the river on rotation. In addition the decree recognizes riparian rights in California and appropriative rights in Nevada (Nevada Division of Water Planning, 1999).

The Alpine Decree established eight (8) autonomous river segments, with segment 7 being subdivided into five (5) sub segments (see Table 2.1 and Figure 2.9). It also establishes consumptive use and duties for bottom, alluvial, and bench lands (see Table 2.2). However, the Decree does not define these lands (Nevada Division of Water Planning, 1999). The following summarizes the water distribution according to the Alpine Decree and Federal Water Master (Wathen, Larrouy, & Callahan, 2012):

1. Segment 1 – This segment consists of mostly riparian water rights and minimal regulation.
2. Segment 2 – This segment of river is regulated when flow at the Gardnerville gauge drops to 200 cfs. One-third of flows are diverted to the Allerman Canal and 2/3rds of flows remain in the river channel. Water is distributed based on priority.
3. Segment 3 – This segment consists of mostly riparian water rights and minimal regulation.
4. Segment 4 – Regulation of this segment is based on the *Anderson-Bassman Decree* and the *Price Decree*.
    a. Anderson-Bassman Decree determines that the first Monday in June or when flows reach 100 cfs, water in the West Fork will be rotated between Segment 4 and Segment 5.
    b. Price Decree controls rotation in segment 4.
5. Segment 5 – Water deliveries are based on priority. During weeks when California users receive water, any water that reaches Nevada is delivered to junior water rights.
6. Segment 6 – Diversions are by pumping. Water that reaches pumps meets the priority of the water right.
7. Segment 7 – This segment is regulated based on sub-segments a through e.
8. Segment 8 – This segment is not regulated by the Federal Water Master

Table 2.1 – Alpine Decree River Segments (Wathen, Larrouy, & Callahan, 2012)

Segment	River	Upper Boundary	Lower Boundary
1	East Fork	Headwater	CA/NV Stateline
2	East Fork	CA/NV Stateline	Confluence of East & West Forks
3	West Fork	Headwaters	USGS gauge at Woodfords
4	West Fork	USGS gauge at Woodfords	CA/NV Stateline
5	West Fork	CA/NV Stateline	Confluence of East & West Forks
6	Main	Confluence of East & West Forks	USGS gauge at Carson City

Segment	River	Upper Boundary	Lower Boundary
7	Main	USGS gauge at Carson City	Lahontan Reservoir
7(a)	Mexican Ditch and reach between Rose Ditch and Cardelli Ditch		
7(b)	Gee Ditch		
7(c)	Koch Ditch		
7(d)	Houghman and Howard Ditches		
7(e)	Buckland Ditch		
8	Main	Lahontan Reservoir	No lower boundary

Table 2.2 – Alpine Decree Duty and Consumptive Use (Nevada Division of Water Planning, 1999; Wathen, Larrouy, & Callahan, 2012)

	Newlands Project		Above Newlands Project	
	Duty	Consumptive Use	Duty[1]	Consumptive Use
Bottom Lands	3.5 AF/AC	2.99 AF/AC	4.5 AF/AC	2.5 AF/AC
Alluvial Fan Lands	NA	NA	6.0 AF/AC	2.5 AF/AC
Bench Lands	4.5 AF/AC	2.99 AF/AC	9.0 AF/AC	2.5 AF/AC

2.2 Surface Water Rights

As part of this project, an extensive summary of surface water rights in the Carson River watershed has been compiled. Over 2,000 surface water rights have been identified with associated data, including owner, priority, duty diversion location and source (see Appendix A). This dataset shows Nevada water rights dating back to 1849 to as recently as 2018.

2.3 Groundwater Management

There are seven defined groundwater basins in the Carson River watershed (see Table 2.3 and Figure 2.10). Six different groundwater basins are located in Nevada and one in California (Nevada Division of Water Resources, 2017; California Department of Water Resources, 2016). Although the Carson Valley Basin is intersected by the Nevada – California state line, it is physically the same hydrographic basin.

Table 2.3 – Carson Watershed Groundwater Basins

Groundwater Basin #	Groundwater Basin Name
CA 6-006	Carson Valley
NV105	Carson Valley
NV 104	Eagle Valley
NV 103	Dayton Valley
NV 102	Churchill Valley
NV 101A	Packard Valley
NV 101	Carson Desert

[1] In a 1980 Court Opinion regarding the upper watershed, the Court indicated that inadequate evidence existed to classify the three land types referenced in the Alpine Decree. The opinion then states that "the Water Master will exercise discretion in distributing water to meet the various demands of the various land types hereinabove noted, insofar as it is practical to do so" (The United States of America Vs. Alpine Land & Reservoir Company, a corporation, et al., 1980, pp. 27-28).

2.4 Historical Instream Flows

Annual average and peak day instream flow data was obtained from the USGS National Water Information System (US Geological Survey, 2020). The USGS has historically maintained numerous gauges along the Carson River, with numerous gauge locations no longer in service. Table 2.4 provides gauge details, historical data, and statistical analysis of four longstanding gauges located along the East Fork, West Fork, and main fork of the Carson River based on annual data[2].

Table 2.4 – Historical Flow Data and Statistics

	West Fork at Woodfords	East Fork near Gardnerville	Carson River near Carson City	Carson River near Fort Churchill
USGS Station #	10310000	10309000	10311000	10312000
Latitude	38.7697	38.8452	39.1078	39.2917
Longitude	-119.8328	-119.7061	-119.7122	-119.3111
Data Record Analyzed	1940 to 2019	1940 to 2019	1940 to 2019	1940 to 2019
Annual Average Flow, CFS	103.5	367.5	403.9	380.1
Annual Median Flow, CFS	94.2	341.0	342.7	320.2
Max Annual Average Flow, CFS	264.3	1,040.0	1,292.0	1,270.0
	2017	2017	2017	2017
Minimum Annual Average Flow, CFS	26.1	91.6	58.5	36.3
	1977	1977	1977	1977
Annual Flow Standard Deviation, CFS	49.8	181.2	255.9	257.8
Average Peak Day Flow, CFS	1,170.6	3,597.7	4,175.0	3,284.7
Median Peak Day Flow, CFS	818.5	2,430.0	2,210.0	2,020.0
Maximum Peak Day Flow, CFS	8,100.0	20,300.0	30,500.0	22,300.0
	1/1/1997	1/3/1997	1/3/1997	1/3/1997
Minimum Peak Day Flow, CFS	170.0	626.0	385.0	230.0
	5/13/1988	5/16/1988	5/16/1988	6/11/1977
Peak Day Flow Standard Deviation, CFS	1,250.7	3,556.6	5,509.3	3,677.7
Annual Average to Peak Day Average Multiplier	11.3	9.8	10.3	8.6

Figure 2.1 through Figure 2.4 show annual average and peak day instream flows at each of the gauge stations listed in Table 2.4. For each gauge location, average annual flows can vary significantly from year to year. The "average" flow does not consistently occur, it is arguably just the average of extreme high and low flows that occur from year to year. Or in other words, it is just a statistical average. Visually, these charts show an increasing frequency of higher flow rates after 1980.

[2] Due to inconsistent data in the early 1900's, each dataset was reduced to the years 1940 to 2019.

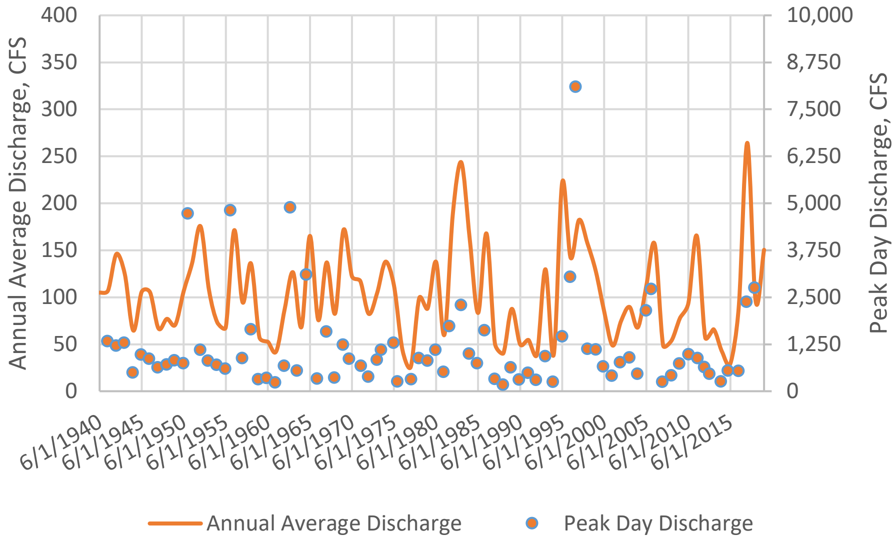


Figure 2.1 – West Fork at Woodfords Historical Data (USGS #10310000)

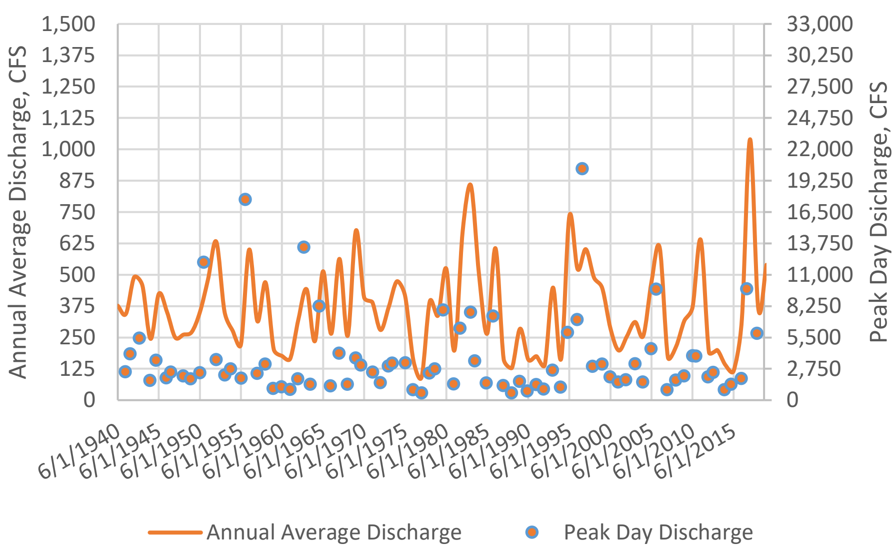


Figure 2.2 – East Fork near Gardnerville Historical Data (USGS # 1039000)

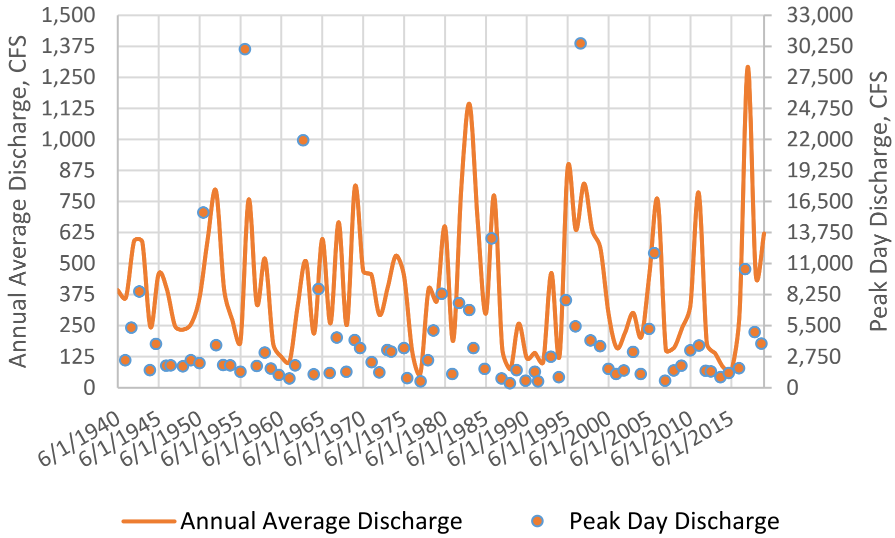


Figure 2.3 – Carson River near Carson City Historical Data (USGS #10311000)

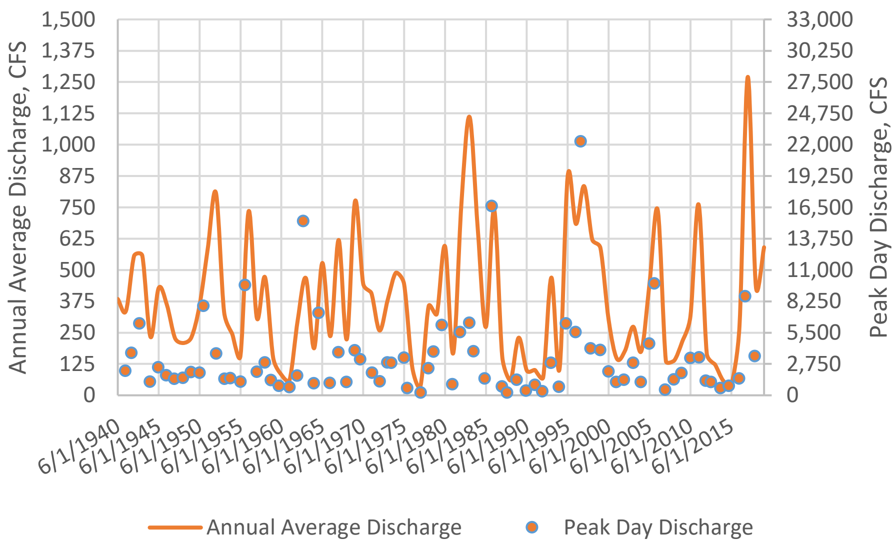


Figure 2.4 – Carson River near Fort Churchill Historical Data (USGS # 10312000)

Table 2.5 captures the increased frequency of extreme high and low flows in the Carson River. This Table summarizes the number of years between 1940 and 1979 and 1980 to 2019 that exceed the 90th percentile flow and the number of years that flows did not exceed the 10th percentile flow. Flows above the 90th or below the 10th percentile were considered extreme flow years. Categorizing the data from 1940 to 1979 and 1980 to 2019 breaks the data up into two, equal 39-year time periods. The data indicates that years with extreme high or low annual average flows have over doubled since 1979.

Table 2.5 – Trends in Instream Flow – Time Period Analysis

	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 2019	6	8	8	8
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 2019	3	2	2	1

As previously discussed, instream flow data indicates that flow trends have been changing. To evaluate these changes, linear regression models were developed for each gauge. Regression models developed for the annual data shown in Figure 2.1 through Figure 2.4 showed no statistical significance[3]; however, as previously noted, instream flows are highly variable (see the standard deviation in Table 2.4) and becoming more variable (see Table 2.5). It is believed that this high level of annual variability impacts the ability to develop statistical trends. To develop statistical significance, the 10-year running average was calculated for each gauge using monthly flows. The 10-year running average is simply the average of the previous 10-years from a given date. The 10-year running average calculation helps average out extreme highs and lows and provides better insight into trends in the dataset. Figure 2.5 to Figure 2.8 shows the 10-year running average flow and 10-year running average sample standard deviation for the gauges listed in Table 2.4 from 1940 to 2019. Each figure includes a trendline and associated regression equation through the 10-year running average calculation. The trend line for each gauge shows a trend of decreasing flows at each gauge location. Regression statistics indicate that the negative trend is statistically significant at the West Fork, East Fork, and Carson City gauges (P value of 0.00 to 0.01) but is less significant at the Fort Churchill gauge (P value of 0.11).

[3] P-values for the slope in the regression analysis ranged from 0.86 to 0.99. Assuming an alpha value (significance level) of 0.05, the regression models did not indicate a statistical change in flow based on the annual average flow dataset.

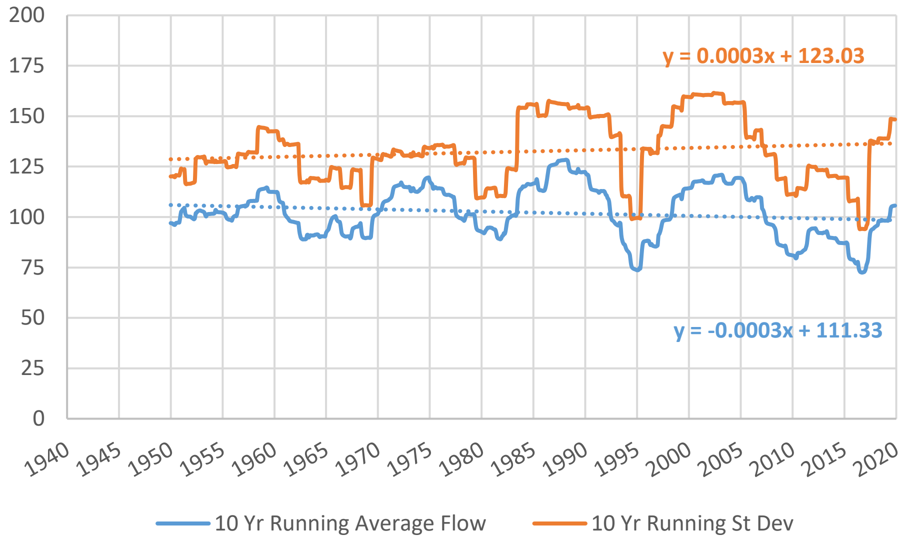


Figure 2.5 – West Fork at Woodfords 10-Year Running Average (USGS #10310000)

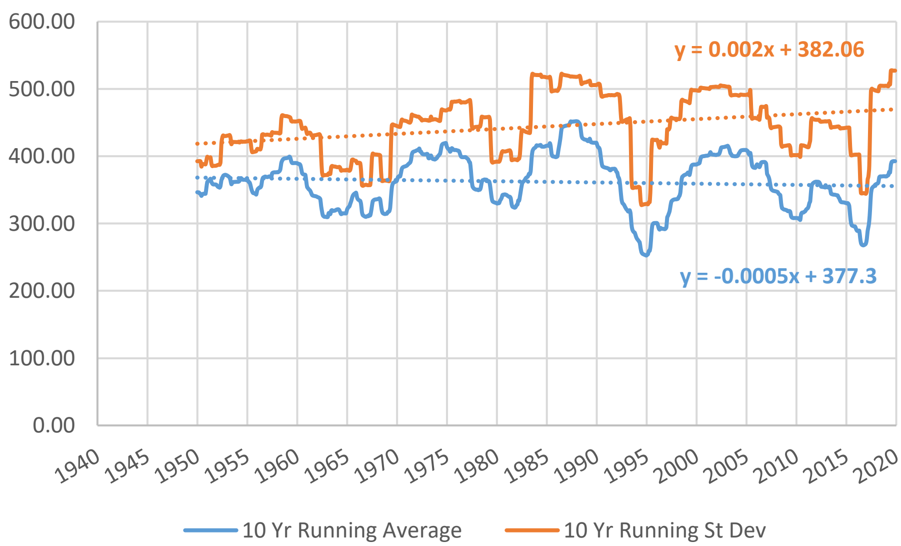


Figure 2.6 – East Fork near Gardnerville 10-Year Running Average (USGS # 1039000)

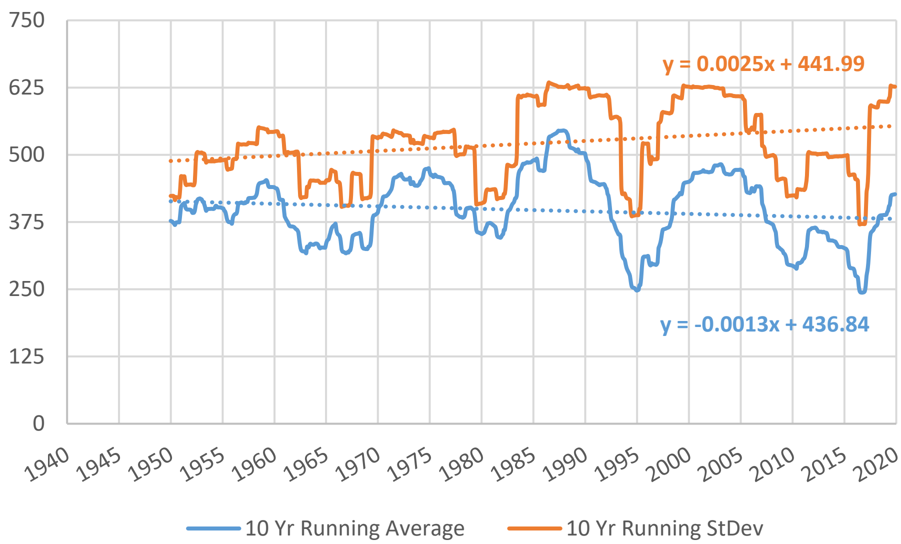


Figure 2.7 – Carson River near Carson City 10-Year Running Average (USGS #10311000)

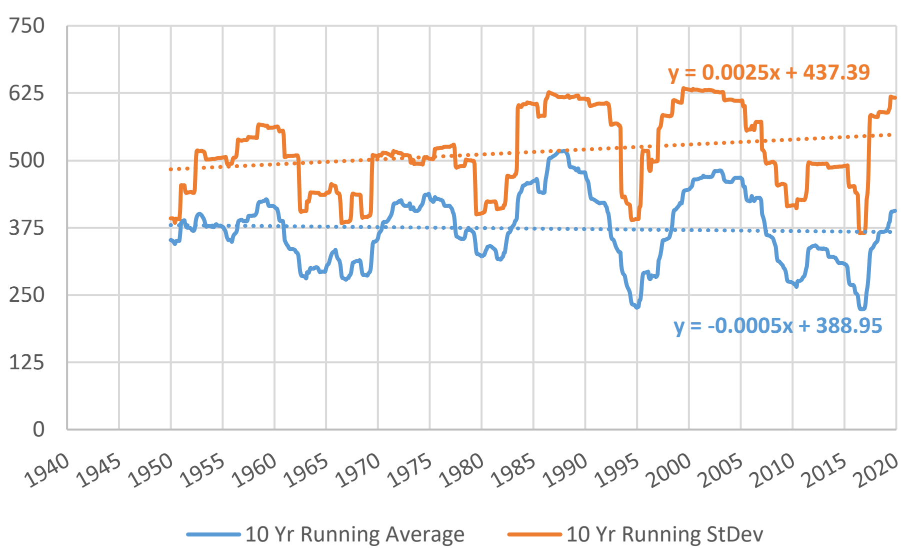


Figure 2.8 – Carson River near Fort Churchill 10-Year Running Average (USGS # 10312000)

Using the regression equation for each trendline[4], Table 2.6 provides estimates of the annual average decrease in flow and the cumulative decrease in flow from 1940 to 2019. It should be noted that these decreases in flow are long-term trends and do not indicate conditions from year

[4] The slope of the regression equation indicates the average change in flow per day in CFS. Table 2.4 presents the change in flow in CFS per year, which is calculated by multiplying the regression equation slope by 365.25 days per year.

to year. The Fort Churchill gauge showed the lowest decrease in flow as a percentage of average flow and the Carson City gauge showed the highest decrease in flow as a percentage of average flow. For comparison, Table 2.6 also includes combined flows from the East and West Fork gauges. These two gauges largely indicate the naturally occurring flow in the Carson River watershed and provide a baseline for other flows. It should be noted that regression models were also developed using the 10-year running average from annual flow data. These models were not as statistically significant, but the results were less than 5% different from the 10-year monthly running average data for all gauges except the East Fork gauge.

Table 2.6 – Trends in Instream Flow – Regression Analysis

Location		West Fork at Woodfords	East Fork near Gardnerville	West Fork + East Fork	Carson River near Carson City	Carson River near Fort Churchill
Annual Average Change in Flow	CFS	-0.11	-0.18	-0.29	-0.47	-0.18
Change in Flow between 1940 and 2019	CFS	-8.3	-14.9	-23.2	-36.5	-14.3
Average Flow between 1940 and 2019	CFS	103.5	367.5	468.3	403.9	380.1
% Average Change in Flow between 1940 and 2019		-8.20%	-3.88%	-4.83%	-9.11%	-3.80%

The trends for decreasing flows at each gauge appear to contradict the increasing occurrence of higher flows as shown in Table 2.5. It is assumed that this discrepancy between the regression and time period analysis may be attributable to the increased variation in instream flows (as indicated by the standard deviation which is discussed below). Theoretically, instream flows cannot drop below 0 CFS but theoretically there is no upper limit to flows. Not having a theoretical upper flow limit may be skewing the outputs of the time period analysis shown in Table 2.5. For example, at the Carson City Gauge (see Table 2.5) there were three years between 1940 and 1979 where the average annual flow exceeded 732 CFS (90^{th} percentile flow) but there are eight years between 1980 and 2018 that exceeded 732 CFS. Similarly, at the Carson City gauge there was only one year between 1940 and 1979 where the average flow never exceeded 76 CFS (10^{th} percentile). Between 1980 and 2018, there were 2 years where average flow never exceeded 76 CFS.

Figure 2.5 through Figure 2.8 also shows the 10-year running sample standard deviation for each of the four gauges. Standard deviation is a measure of how much variance is in a dataset or in other words how far the data varies from the average. The trendline through the 10-year running sample standard deviation has a significant positive slope, indicating that the sample standard deviation has been increasing over time. The interpretation of this trend is that instream flows have become more variable over time (as discussed in the previous paragraph). This trend is consistent with the time period analysis shown in Table 2.5.

The conclusion of this analysis is that instream river flows are becoming more inconsistent with higher highs, more frequent lows (can never go below 0 CFS), and a decreasing trend in instream flows. This trend is true for each gauge listed in Table 2.4. For water users along the Carson River, these trends are troubling. The result is an amplification of the "feast or famine" condition that already exists for the Carson River with the average flow slowly decreasing. If this trend continues, flows will continue to become more extreme, less reliable, and continue to decline. The lack of significant storage in the upper watershed prevents any stabilization or mitigation of these extremes.

2.5 Water Storage

2.5.1 Existing Water Storage

Outside of Lahontan Reservoir (storage capacity of 294,000 AF), there is very limited surface water storage within the Carson River watershed. Table 2.7 provides a summary of existing reservoirs above Lahontan Reservoir providing a combined storage capacity of approximately 11,766 AF. This storage volume is a mere 4% of the storage available in Lahontan Reservoir. With Lahontan included, the Carson River watershed contains 305,766 AF of storage. By comparison, the Truckee River watershed contains 1,089,210 AF of storage[5] (Wathen, Larrouy, & Callahan, 2012), nearly 3.6 times more storage than the Carson River watershed.

Table 2.7 – Carson River Reservoirs above Lahontan (Wathen, Larrouy, & Callahan, 2012)

Reservoir	Fork	Decreed Storage (AF)	Ownership	Priority
Scott Lake	West	508	Dressler, Neddenrip	1895, 1918
Red Lake	West	1,103	California Fish and Game	1895 & 1922
Crater Lake	West	167	Dressler	1895
East Lost Lake	West	92	Carson Subconservancy District	1924
West Lost Lake	West	127	Carson Subconservancy District	1924
Mud Lake	West	3,172	Benlty Agrodynamics	1879 & 1909
Tamarack Lake	East	404	Alpine Land and Reservoir Company	1895
Kinney Meadows	East	435	Alpine Land and Reservoir Company	1895
Upper Kinney Meadows	East	328	Alpine Land and Reservoir Company	1895
Lower Kinney Meadows	East	495	Alpine Land and Reservoir Company	1895
Wet Meadows	East	207	Alpine Land and Reservoir Company	1895
Lower Sunset	East	250	Alpine Land and Reservoir Company	1895
Upper Sunset	East	68	Alpine Land and Reservoir Company	1895
Summit Lake	East	31	Alpine Land and Reservoir Company	1901
Raymond Lake	East	50	Alpine Land and Reservoir Company	1895
Heenan Lake	East	2,948	Bently Agrodynamics and California Fish and Game	1923
Burnside Lake	East	100	Bently Agrodynamics	1892
Allerman No.'s 1, 2, & 4	East	1,081	Park Cattle & Bently Agrodynamics	1877 & 1905
Ambrosetti	East	200	Carson City	1882

[5] Lake Tahoe = 744,600 AF, Independence = 17,500 AF, Donner = 9,500 AF, Boca = 40,870 AF, Prosser = 29,840 AF, Stampede = 226,500, and Martis = 20,400 AF. It should be noted that Martis Reservoir is used primarily for flood control and usually operates at minimum pool.

Reservoir	Fork	Decreed Storage (AF)	Ownership	Priority
Total West Fork		**5,169**		
Total East Fork		**6,597**		
Total Reservoir Storage		**11,766**		

2.5.2 Historically Proposed Water Storage Projects

There is a long history of investigations and proposals for additional surface water storage in the Carson River watershed. As far back as 1888, legislation identified and withdrew certain lands for construction of reservoirs. In the 1888 legislation, lands for the following reservoirs were identified (Pumphrey, 1955):

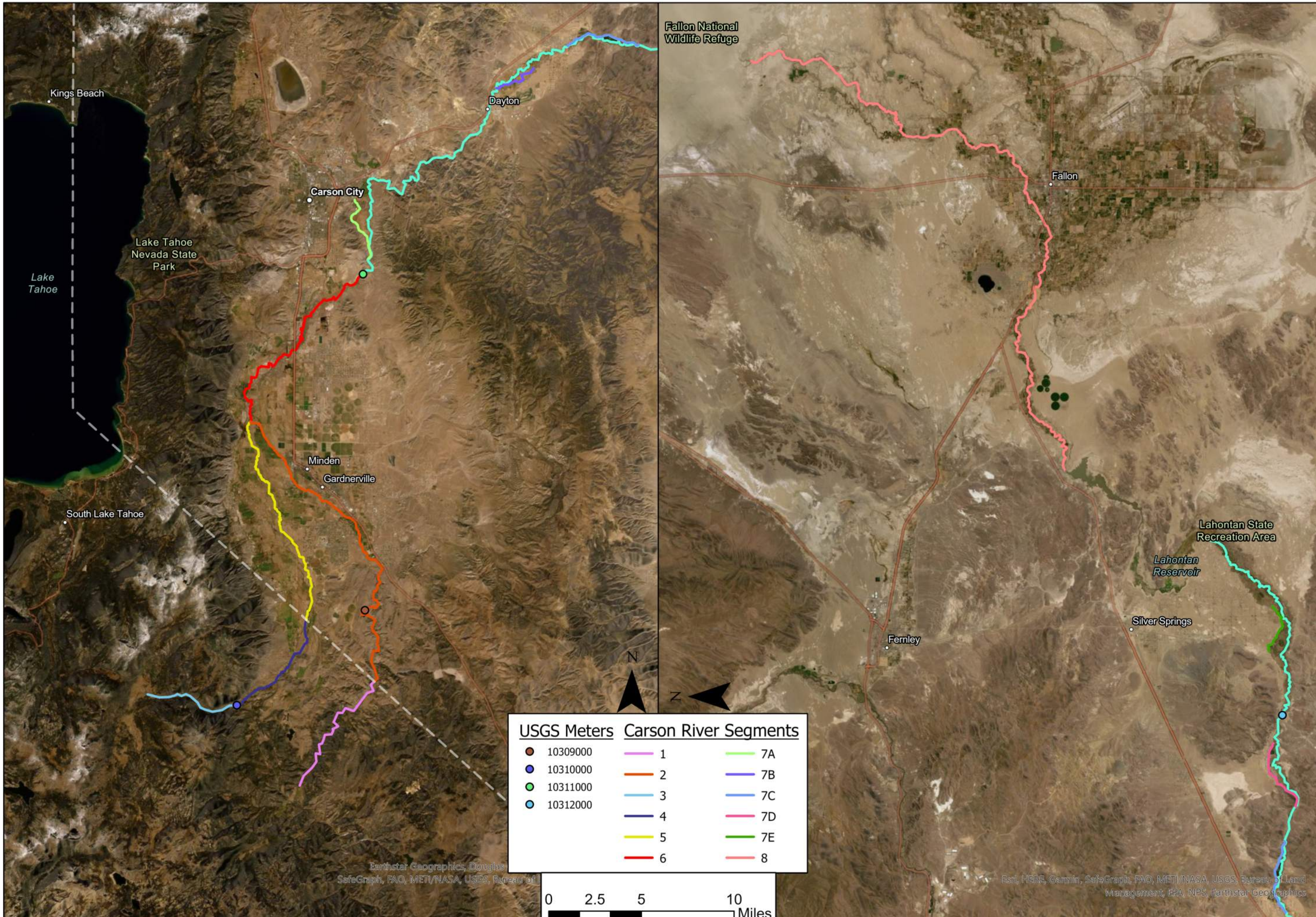
- Pleasant Valley
- Mt. Bullion
- Indian Pool
- Heenan Lake
- Silver King
- Wolf Creek
- Dumonts Meadow
- Hope Valley
- Harveys Meadow

In 1955, the USGS published a report evaluating potential surface water storage and power generation sites in the Upper Carson River basin. The report identified the following potential reservoirs (Pumphrey, 1955):

- Hope Valley, West Fork
    - Base elevation – 7,000 feet
    - Pool elevation – 7,120 feet
    - Area at pool elevation – 1,180 acres
    - Capacity at pool elevation – 30,100 AF
    - Notes: Regulation dam or out of basin water imports would be required to satisfy water rights
- Horseshow Bend, East Fork
    - Base elevation – 4,960 feet
    - Pool elevation – 5,200 feet
    - Area at pool elevation – 1,190 acres
    - Capacity at pool elevation – 103,000 AF
    - Notes: An auxiliary dam would be required to develop this site to full capacity. It was noted that a ~2 mile tunnel could connect this site to the West Fork to reduce the impacts from construction of the Hope Valley reservoir.
- Watasheamu, East Fork
    - Base elevation – 5,020 feet
    - Pool elevation – 5,300 feet
    - Area at pool elevation – 1,780 acres
    - Capacity at pool elevation – 175,000 AF

- Pinyon, East Fork
  - Base elevation – 5,080 feet
  - Pool elevation – 5,400 feet
  - Area at pool elevation – 2,340 acres
  - Capacity at pool elevation – 284,000 AF
- Markleeville, East Fork
  - 97,000 AF of storage with 230 foot dam
  - 244,000 AF of storage with 330 foot dam
- Silver King, East Fork
  - Base elevation – 6,370 feet
  - Pool elevation – 6,500 feet
  - Area at pool elevation – 777 acres
  - Capacity at pool elevation – 44,200 AF
- Dumonts Meadow, East Fork
  - Base elevation – 6,670 feet
  - Pool elevation – 6,800 feet
  - Area at pool elevation – 552 acres
  - Capacity at pool elevation – 35,000 AF
- Pleasant Valley, Pleasant Valley Creek
  - Base elevation – 5,790 feet
  - Pool elevation – 6,000 feet
  - Area at pool elevation – 790 acres
  - Capacity at pool elevation – 59,900 AF
- Wolf Creek, Wolf Creek
  - Base elevation – 6,360 feet
  - Pool elevation – 6,500 feet
  - Area at pool elevation – 394 acres
  - Capacity at pool elevation – 26,100 AF

It should be noted that of the 1888 and 1955 sites listed above, only Heenan Lake was constructed. However, investigative and planning efforts for several reservoirs, especially the proposed Watasheamu reservoir, have been ongoing for many years.



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Carson City Subconservancy District

Alpine Decree River Segments Map

NV

Carson City

Carson City

REV	DATE	DESCRIPTION	BY

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Carson Water Subconservancy District

Hydrographic Basins

Nevada

Carson City

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3.0 WATER USE

3.1 Groundwater Basin Usage

As previously discussed, with the exception of Carson City, Douglas County, and Lyon County, all municipal water systems rely solely on groundwater as their water source. However, there are numerous other interests and users that rely on groundwater. These other uses include irrigation, commercial, recreation, environmental, domestic, livestock, etc. Groundwater users most commonly rely on a well to pump water out of the groundwater aquifer for use. As a result, there is a vast network of water wells located throughout the Carson River watershed allowing water to be extracted from the aquifer.

As discussed in Section 2.3, the Carson River watershed is divided into seven distinct hydrographic basins, one in California and the remaining basins in Nevada. Groundwater withdrawal data from the hydrographic basins was obtained from the Nevada Division of Water Resources (State of Nevada Division of Water Resources, 2020). California Basin 6-006 and Nevada Basin 105 are physically the same hydrographic basin that is divided by the California-Nevada state line. On the California side of the Carson Valley Basin the primary users are a limited number of domestic wells. Since there are a limited number of users in the California portion of the Carson Valley Basin, it is assumed that data from the Nevada side of the basin is generally representative of the entire basin. Of the other basins, no groundwater withdrawal data is available from Nevada Basin 101A (Packard Valley) and only limited data is available from Basin 101 (Carson Desert). Data has been categorized as irrigation (agricultural), domestic (private wells), municipal / quasi-municipal, and other. The "other" category includes various mining, industrial, recreation, environmental, etc. uses.

Table 3.1 shows the average annual withdrawals by hydrographic basin from 2013 to 2017, the perennial yield (and system yield when available), and the percent of the perennial yield that is being withdrawn from each basin. Reported perennial and system yields are taken from the Nevada Department of Water Resources Hydrographic Basin Summaries (2020). Perennial yield refers to naturally occurring recharge, generally through precipitation. System yield includes the perennial yield plus other sources of groundwater recharge such as irrigation and engineered recharge. Active recharge sites include Carson City's aquifer storage and recovery (ASR) system in Vicee Canyon (primarily from the Marlette Lake Water System), recharge from bypassing Kings and Ash Creek around the Quill WTP, and wastewater rapid infiltration basins located at several locations in the watershed. System yield is generally considered a more accurate representation of aquifer capacity. It should be noted that estimates of the perennial and system yields are not exact and there are other entities that have indicated different basins yields. However, for this project, the Nevada Division of Water Resources is considered the authoritative source. From Table 3.1, Churchill Valley and the Carson Desert hydrographic basins are withdrawing more water than the perennial yield. However, over the entire watershed, between 81% and 96% of available aquifer capacity is currently being used. There is between 2,700 to 14,700 AFA of additional groundwater available in the Carson River watershed. If system yield is considered, the available aquifer capacity would be even greater.

Table 3.1 – Nevada Groundwater Usage by Hydrographic Basin (Nevada Division of Water Resources, 2020)

Groundwater Basin #	Groundwater Basin Name	2013 to 2017 Average Annual Withdrawals (AFA)	Perennial Yield (System Yield) (AFA)	Average Withdrawals as a % of Perennial Yield (System Yield)
CA 6-006	Carson Valley	31,460	49,000	64%
NV105	Carson Valley			
NV 104	Eagle Valley (Carson City)	4,607	4,900 (9,000)	94% (51%)
NV 103	Dayton Valley (Dayton)	8,723	8,000 to 20,000[6]	109% to 44%
NV 102	Churchill Valley (Silver Springs)	2,267	1,600	142%
NV 101	Carson Desert (Fallon)[7]	16,235	2,500	650%[8]
NV 101A	Packard Valley	Unknown	710	Unknown
Total		63,291	66,000 to 78,000	96% to 81%

Based on available data and perennial yield estimates, there is some additional groundwater capacity in the Carson River watershed. It does not appear that groundwater quantity is a limitation for the watershed as a whole. However, local limitations such as groundwater quality, hydrogeologic limitations of the aquifer, and transmission of available water do pose serious challenges in some areas of the watershed. For example, the Carson Valley has aquifer capacity well in excess of the current demand. But, arsenic, low pH, manganese, fluoride, total dissolved solids (TDS), and nitrate are all documented water quality issues present in the Carson Valley that reduce the usability of groundwater for potable purposes. Treatment is required to correct these water quality issues before groundwater can be used for potable use in a community water system. Other issues include sub-hydrographic basins with inadequate capacity to meet demand, such as the Ruhenstroth area of the Carson Valley or documented contamination of groundwater from septic systems (Naranjo, Welborn, & Rosen, 2013). Although Ruhenstroth, Fish Springs, and Johnson Lane are all located in the Carson Valley, these areas do not experience the same aquifer capacity that other areas of the Carson Valley do. Much of this has to do with recharge capacity (these areas on are on the east, or Pinenut side of the Carson Valley) and hydrogeologic conditions.

Figure 3.1 summarizes the average groundwater withdrawals as a function of withdrawal type and hydrographic basin. This figure shows the magnitude of the water used in the Carson Valley compared to other downstream basins. Between 2013 and 2017, groundwater withdrawals from the Carson Valley Basin accounted for nearly 50% of all groundwater withdrawals in the Carson River watershed. Eagle Valley, Dayton Valley, Churchill Valley and the Carson Desert accounted

[6] Although this range is reported by the Nevada Division of Water Resources as the perennial yield, it may be more representative of the system yield.
[7] Comprehensive data for the Carson Desert Basin is not widely available. Presented data is based on 2013 and 2015 statewide pumpage reports available through the Nevada Division of Water Resource.
[8] Although accurate, this number is somewhat misleading. Although the perennial yield in the Carson Desert is relatively small, the system yield is likely significantly higher. The Carson Desert hydrographic basin is heavily influenced by irrigation and transfers from the Truckee River.

for 7%, 14%, 4%, and 26% of total groundwater withdrawals in the Carson River watershed, respectively. It should be noted that data for withdrawals from domestic wells is estimated by the Nevada Division of Water Resources assuming each 1 AFA is withdrawn from each domestic well per annum. Domestic well owners are not required to monitor use, so the reported values for domestic wells should only be considered an estimate.

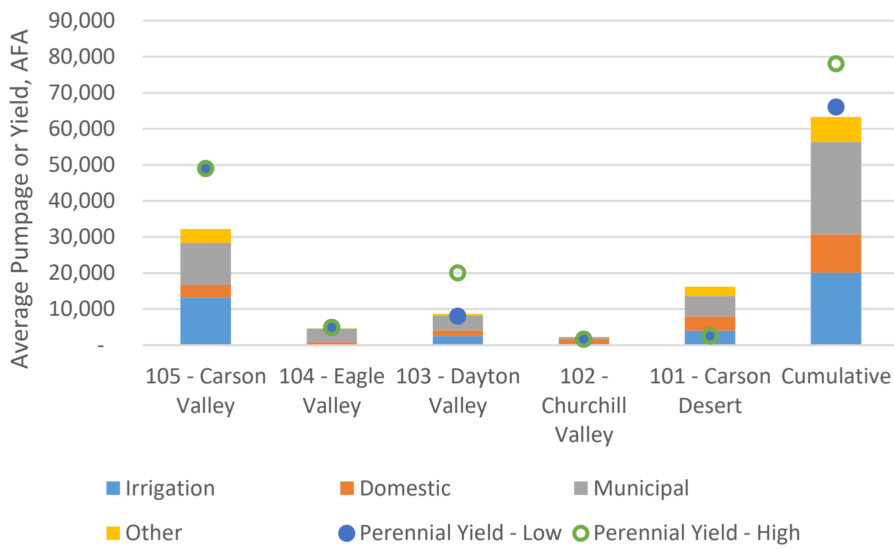


Figure 3.1 – Groundwater Usage by Hydrographic Basin

Table 3.2 illustrates the issued water rights as a percentage of the perennial yield. This Figure indicates that every hydrographic basin is over allocated based on currently issued water rights and estimated perennial yield. This is a potentially serious issue; however, it is not likely that all of the issued water rights will be exercised such that actual pumping will increase to the issued water rights volume (see Table 3.1). This water deficit could be partially mitigated by determining the system yield for each basin rather than using just the perennial yield. As previously discussed, system yield considers other recharges such as irrigation and engineered recharge systems.

Table 3.2 highlights the discrepancy between "paper water" and "wet water". "Paper water" refers to a water right that allows an entity to withdraw water from the aquifer. Whereas "wet water" refers to the physical water in the aquifer. In many situations "paper water" exists where "wet water" does not exist or where it is not of sufficient quantity or quality for the intended use. In some areas, such as Silver Springs, there is an excess of "paper water" but insufficient "wet water" making some water rights essentially unusable. At times, the volume of "wet water" can vary. For example, a 2011 USGS report documented long-term declines in static groundwater levels of more than 40-feet on the northwest side of Carson City and water level declines of 10-feet have been documented in the Carson Plains and Stagecoach sub-hydrographic basins (Maurer, 2011). However, more recent data suggests that some of this long-term static groundwater level decline has recovered, partially as a result of recharge activities in Carson City.

Table 3.2 – Groundwater Water Rights by Hydrographic Basin as a Percent of Basin Perennial Yield

	Irrigation	Domestic	Municipal	Other	Total
105 – Carson Valley	105%	3%	71%	17%	195%
104 – Eagle Valley	8%	0%	145%	6%	160%
103 – Dayton Valley	90% / 36%	6% / 2%	187% / 75%	24% / 9%	306% / 123%
102 – Churchill Valley	224%	0%	332%	28%	585%
101 – Carson Desert	161%	1%	427%	365%	793%
Cumulative	101%	3%	110%	30%	238%

In Nevada, groundwater use is based on the concepts of prior appropriation and beneficial use. With the exception of domestic wells, a water user must have a water right which allocates the diversion rate, duty, place of use, etc. of the withdrawal. In California, groundwater use is loosely regulated. In 2014, the California Sustainable Groundwater Management Act was enacted, requiring medium and high priority basins to balance pumping and recharge. At the time of this report, the only hydrographic basin located in the California portion of the Carson River watershed is not impacted by this law.

It should be noted, that the data and discussion presented in this section does not consider the concept of conjunctive use and conjunctive management. In other words, this analysis does not account for the interaction and connection between surface water and groundwater. However, the authors acknowledge the interaction and connection between surface water and groundwater, but it was beyond the scope of this project to consider this interaction.

3.2 Municipal Water Usage

3.2.1 Current Use

Within the Carson River watershed there are 84 regulated potable water systems stretching from Alpine County to Churchill County (for a complete list, see Appendix D). Of these systems, there are 32 "community" water systems[9] that provide water to approximately 44,000 residential, commercial, industrial, and landscape irrigation water services connections in the watershed. The remaining 52 regulated systems are classified as non-community water systems which include businesses not connected to a municipal water system, parks, campgrounds, etc. Non-community water systems were not analyzed as part of this project (California State Water Resources Board, n.d.; Nevada Division of Environmental Protection, n.d.).

Of the 32 community water systems in the watershed, water usage data was collected from 18 systems, representing 97.5% of the water system service connections[10]. Table 3.3 contains summary data from these water systems. Data presented in this table is taken primarily from pumpage records from 2015 to 2019 and is ordered from highest usage per connection to the smallest usage per connection. The average total annual usage for these water utilities is 25,796 AFA. Assuming that all other community water systems usage is consistent with those systems shown in Table 3.3, total community water system demand in the Carson River watershed (for all 32 community water systems) would be approximately 26,460 AFA, or 8,620 million gallons of

[9] A community water system is defined as a system that supplies water to the same population year-round.
[10] Douglas County operates 6 different permitted community water systems in the Carson Valley. For simplicity these systems collectively referred to as Douglas County.

water per year. Figure 3.2 depicts the volume of water usage per entity compared to other water systems. For illustration, Figure 3.3 shows the seasonal changes in demand per connection for Douglas County water systems (on average, the highest user per connection). For Douglas County the average to monthly demand multiplier varies from a low of 0.27 in February to a high of 2.06 in August (average day demand to average month demand). This data highlights the seasonal changes in water demand in the Carson River Watershed. Other water systems are expected to have similar demand curves but the average to monthly multipliers will likely vary from water system to water system.

Table 3.3 – Water Usage Data from Select Community Water Systems

	Connections	% of Connections	Average Annual Usage (AFA)[E]	% of Average Usage	AFA per Connection[F]	% of Avg AFA per Connection
Douglas County[A]	2,378	6.4%	2,088	8.1%	0.76	126.9%
Gardnerville Ranchos GID[A]	3,992	9.3%	2,881	11.2%	0.72	120.0%
Town of Minden[B]	1,799	4.2%	1,252	4.9%	0.70	115.8%
City of Fallon[B]	3,215	7.5%	2,220	8.6%	0.69	114.9%
Carson City[A]	16,883	39.3%	11,078	42.9%	0.66	109.1%
Churchill County[C]	271	0.6%	147	0.6%	0.54	90.5%
Gardnerville Water Co [A]	2,376	5.5%	1,279	5.0%	0.54	89.5%
Indian Hills GID[A]	1,950	4.5%	995	3.9%	0.51	84.8%
Stagecoach GID[B]	564	1.3%	256	1.0%	0.45	75.5%
Silver Springs GID[B]	1,088	2.5%	484	1.9%	0.44	74.0%
Lyon County Utility District[A]	6,849	16.0%	2,772	10.7%	0.40	67.3%
Storey County[D]	635	1.5%	231	0.9%	0.36	60.6%
NAS Fallon[B]	550	1.3%	113	0.4%	0.21	34.2%
Total or Weighted Average	42,910		25,796		0.60	

[A] Data was provided directly from the utility to Lumos & Associates. Douglas County operates 6 community water systems in the Carson Valley.
[B] Data was provided to Lumos & Associates by CWSD staff
[C] Data extracted from *Churchill County Water and Wastewater Utilities Master Plan* (Shaw Engineering, 2019).
[D] Data provided to Lumos & Associates by the Marlette-Hobart Water System
[E] One-acre foot of water is equal to 325,851 gallons of water. The largest water user, Carson City, uses on average 3,609.6 million gallons of water per year, or 9.9 million gallons per day. The smallest user, NAS Fallon, uses 36.8 million gallons of water per year, or 0.2 million gallons per day.
[F] 1.12 AFA per equivalent dwelling unit (EDU) is commonly used for estimates of water use. 1.12 AFA is equal to nearly 1,000 gallons per day. In most cases, a water system will have more EDU's than water connections. The largest user on a per connection basis, Douglas County, uses on average 680 gallons per day per connection. The smallest user on a per connection basis, NAS Fallon, uses on average 183 gallons per day per connection. The weighted average usage is 544 gallons per day per connection.

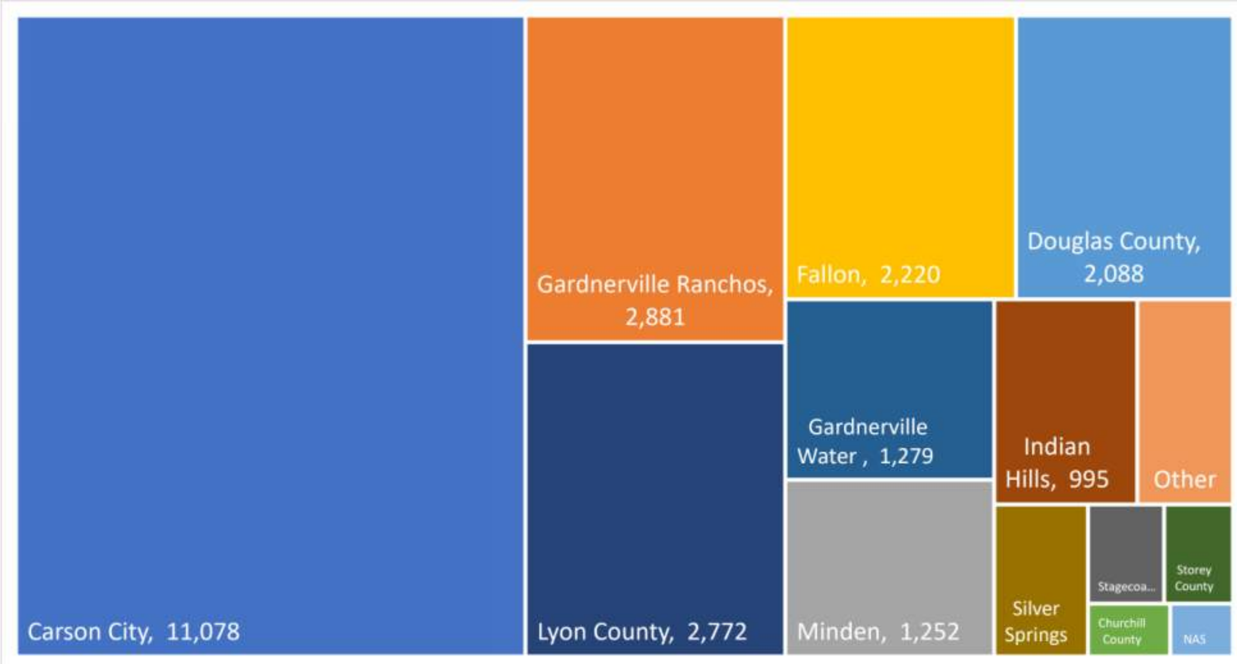


Figure 3.2 – Water Usage Comparison in AFA

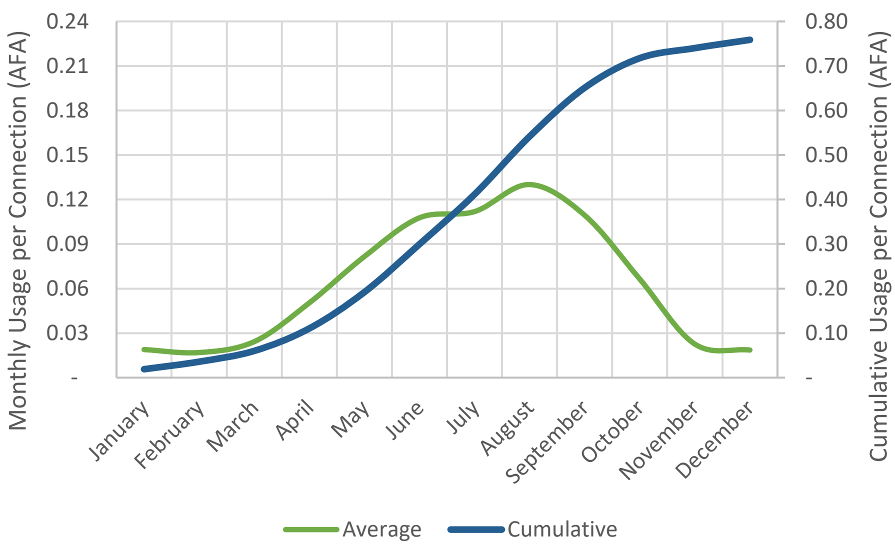


Figure 3.3 – 2015 to 2019 Douglas County Monthly Water Usage

All of these water systems use groundwater to meet system demand. However, Carson City, Douglas County, and Lyon County Utilities also utilize surface water for potable use. Carson City utilizes induction wells and diverts water from Kings Creek, Ash Creek, and the Marlette Lake Water System (MLWS) for treatment at the Quill water treatment plant. The MLWS transfers water from the Tahoe Basin / Truckee River watershed to Carson City. On average, 17%, of Carson City's public water supply comes from Kings Creek, Ash Creek, and the MLWS and 11%, comes from induction wells (Carson City Public Works Department, 2018). Douglas County utilizes one induction well off of Jack's Valley Road which accounts for approximately 2% of their water usage. Lyon County utilizes an induction well in the vicinity of the Rolling A wastewater treatment plant. In 2019, this induction well accounted for approximately 25% of water usage in the Lyon County Utility District water system[11].

It is important to note that many of these community water systems change the way that they use their water sources as a result of seasonal demand changes, growth, and changing water quality regulations. For example, in 2001 the EPA adopted a new standard for arsenic that dropped the maximum contaminant level potable water systems from 50 parts per billion (ppb) to 10 ppb. This rule significantly impacted numerous wells in the Carson River Watershed and was a motivating factor that led to the construction of the regional water system connecting Minden, Douglas County, Carson City, and Indian Hills. As another example, Carson City's ability to fully utilize surface water from Ash Creek and the MLWS has been significantly reduced due to implications of the Disinfection Byproducts Rule and the Long Term 2 Enhanced Surface Water Treatment Rule (LT2). These issues highlight the challenges with providing potable water. Community water systems have to meet seasonally variable water demands, increasing demands due to growth, and increasingly more stringent water quality requirements.

3.2.2 Estimated Future Municipal Water Usage

Based on the 2015 to 2019 water usage data, future municipal water usage estimates were generated for each community water system shown in Table 3.3. Twenty-year water usage and connection counts were estimated using population growth projections from the Nevada State Demographer[12] (Hardcastle, 2019). Estimates indicate that population growth is expected to vary greatly from County to County. But growth rates for all counties are expected to decrease over time. Table 3.4 and Figure 3.4 summarizes expected water usage and water system customer counts between 2020 and 2040.

It should be noted that the Nevada State Demographers population growth estimates are used primarily for tax forecasting and other similar uses. As a result, the State Demographer's estimates may potentially underestimate actual growth. However, underestimating population growth may be offset by decreasing trends in water usage. Many community water systems are experiencing reductions in water usage per connection. Changes in water usage can be the result of water rate structures (increased cost can lead to reductions in usage), water efficient appliances, a trend towards smaller lots, and water efficient landscaping.

[11] Lyon County's induction well (Well 20) usage varies from year to year. In the past, pumpage from this well has been impacted by system hydraulics, construction projects, and instream flows.
[12] The State Demographer projections end in 2038. The average growth rate from 2020 to 2038 were used to estimate growth in 2039 and 2040. Average estimated growth rates from Nevada were used to estimate usage and connections for water systems in California.

Table 3.4 – Water Usage and Connection Estimates

		2020	2025	2030	2035	2040	2020 to 2040 % Increase
Douglas County	Connections	2,754	2,796	2,807	2,799	2,781	0.9%
	Usage (AFA)	2,101	2,132	2,141	2,135	2,121	
Gardnerville Ranchos GID	Connections	4,016	4,077	4,093	4,081	4,054	0.9%
	Usage (AFA)	2,898	2,942	2,953	2,944	2,925	
Town of Minden	Connections	1,810	1,837	1,844	1,839	1,827	0.9%
	Usage (AFA)	1,260	1,279	1,284	1,280	1,272	
City of Fallon	Connections	3,225	3,257	3,319	3,369	3,401	5.5%
	Usage (AFA)	2,227	2,249	2,292	2,327	2,349	
Carson City	Connections	16,951	17,223	17,344	17,327	17,279	1.9%
	Usage (AFA)	11,122	11,301	11,380	11,369	11,337	
Churchill County	Connections	272	275	280	284	287	5.5%
	Usage (AFA)	148	149	152	155	156	
Gardnerville Water Co	Connections	2,390	2,426	2,436	2,429	2,413	0.9%
	Usage (AFA)	1,287	1,306	1,311	1,307	1,299	
Indian Hills GID	Connections	1,962	1,991	1,999	1,993	1,980	0.9%
	Usage (AFA)	1,001	1,016	1,020	1,017	1,010	
Stagecoach GID	Connections	575	623	653	670	687	19.5%
	Usage (AFA)	261	283	296	304	312	
Silver Springs GID	Connections	1,110	1,203	1,259	1,292	1,326	19.5%
	Usage (AFA)	494	535	560	575	590	
Lyon County Utility District	Connections	6,986	7,570	7,925	8,133	8,346	19.5%
	Usage (AFA)	2,828	3,064	3,208	3,292	3,378	
Storey County[13]	Connections	652	744	841	922	1,000	53.4%
	Usage (AFA)	237	271	306	336	364	
NAS Fallon	Connections	552	557	568	576	582	5.5%
	Usage (AFA)	113	114	117	118	120	
Other	Connections	1,122	1,181	1,229	1,261	1,289	14.8%
	Usage (AFA)	675	710	739	758	775	
Total or Weighted Average	Connections	44,376	45,761	46,597	46,975	47,251	6.5%
	Usage (AFA)	26,650	27,352	27,759	27,916	28,007	5.1%
	Demand / Connection	0.60	0.60	0.60	0.59	0.59	

[13] Much of the projected growth in Storey County is likely to occur outside of the Carson River Watershed.

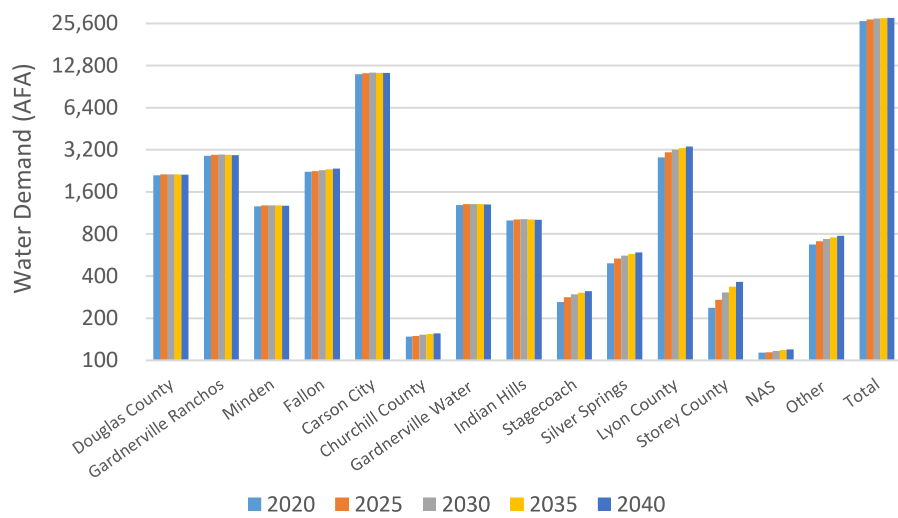


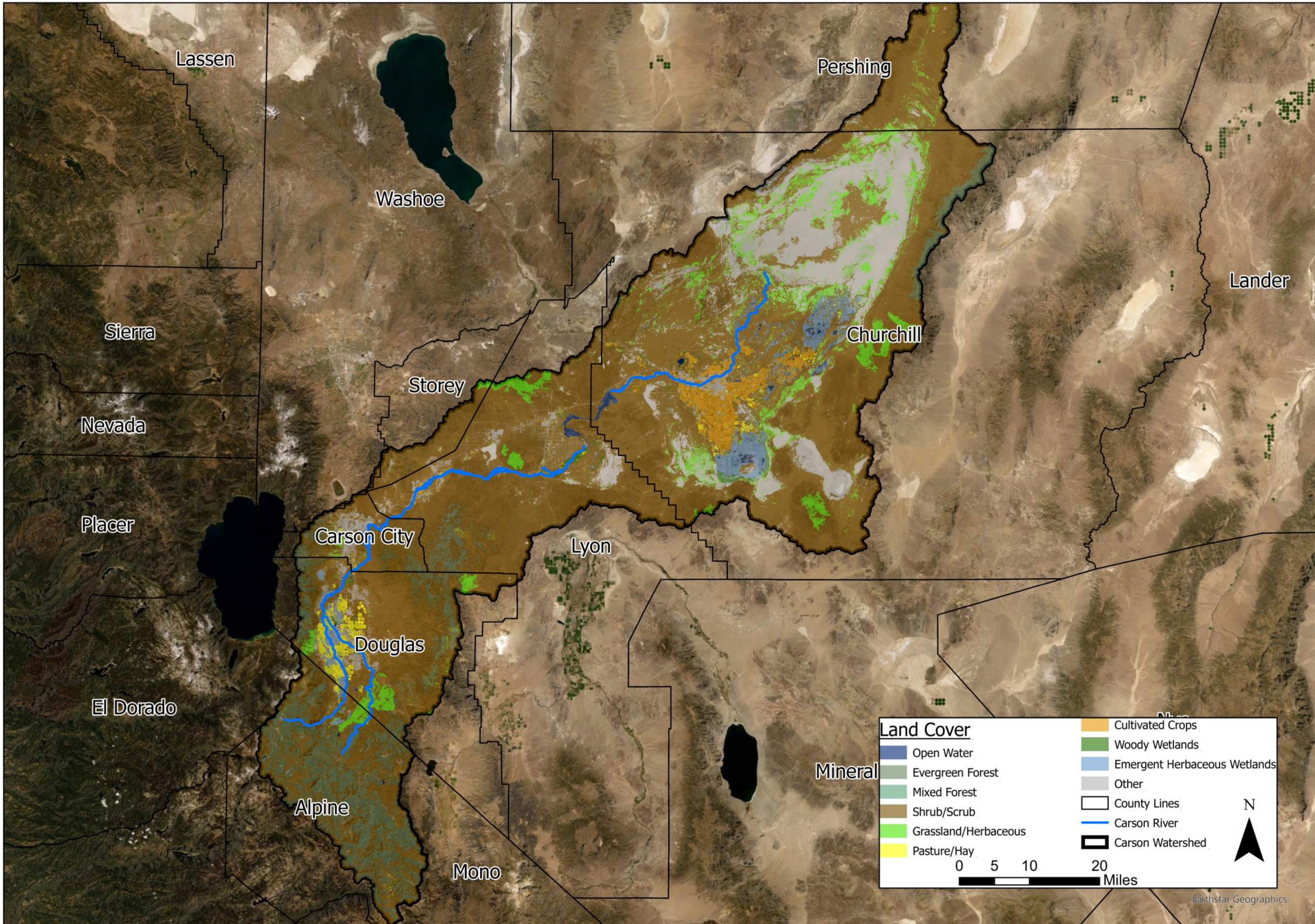
Figure 3.4 – Estimated Water Usage by Water System

3.3 Agricultural Usage

The Carson River watershed encompasses many livestock-raising properties, especially in Douglas, Lyon, and Churchill counties. However, the U.S. Department of the Interior and U.S. Geological Survey both concluded that livestock in Nevada receive an inconsequential amount of water from surface water sources. A majority of livestock receive water from wells or on-farm water sources such as precipitation-filled ponds and troughs (US Department of the Interior, US Geological Survey, 2014). In their report, the US Department of the Interior indicates that it is unlikely that significant surface water resources will be diverted for livestock in the near future.

Throughout Nevada there are 6.1 Million Acres of total farmland and the majority of crops include alfalfa and hay as well as some small corn and wheat farms (U.S. Department of Agriculture, 2019). Utilizing data from the Department of Agriculture, estimates of how much of this land is in the Carson watershed were made. Using this it was possible to estimate how much surface water was used by each county from the Carson River. The Carson River travels through Douglas, Carson City, Lyon, and Churchill counties, but not all of the counties receive all of their surface water from The Carson River watershed. For example, Yerington, a large population and agricultural area in Lyon County, receives no water from the Carson River. The National Landcover Database was used estimate how much of the irrigated land in each county was in the watershed. Using the National Land Cover Database, agricultural land was classified into the type of vegetation and how the land has been developed either by nature or by human-intervention.

Utilizing this process, the total area of irrigated farmland in Douglas, Carson City, Lyon and Churchill counties was estimated to be 136,000 acres (see Figure 3.5). Based on data in the 2017 Census of Agriculture, it was determined that the average water application rate in Nevada is 2.8 Acre-feet of water per acre of irrigated land (2019). Using this value, the estimated water demand for agriculture in the Carson watershed is 380,800 Acre-feet.



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Carson City Subconservancy District

Carson River Watershed
Land Cover

STATE
COUNTY
CITY

BY	DESCRIPTION	REV DATE

BAR IS 1 INCH ON ORIGINAL DRAWING

0" 1"

IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

FIG 3.5

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4.0 CLIMATIC CONDITIONS

As discussed in Section 2.4, flows in the Carson River can be described as highly variable with flows trending downward over time. The purpose of this Section is to evaluate these trends in context with historical climatic conditions. To distinguish weather conditions from climatic conditions, annual temperature and precipitation data was used rather than daily weather data. Since the purpose of this report is not a detailed climatic evaluation of the watershed, the analysis presented in this chapter focuses on climatic conditions in Carson City and how these conditions correlate with flows at the Carson City gauge from 1940 to 2019.

Table 4.1 and Figure 4.1 shows annual precipitation and average annual temperature data for Carson City from 1940 to 2019 (Prism Climate Group, 2020). Similar to instream river flows, precipitation at Carson City can be highly variable from year to year as evidenced by the high standard deviation. Annual average temperature exhibits much less variability. Figure 4.1 shows trendlines for precipitation and average annual temperature. The trends indicate that the average temperature is trending up (at 0.0263 °F on average per year) and that precipitation is trending down (at -0.0364 inches on average per year)[14]. These trends are consistent with and highlight the previously presented finding that instream flows in the Carson River are trending down (based on the assumption that there is a correlation between instream flows and precipitation).

Table 4.1 – Carson City Climatic Summary, 1940 to 2019

	Annual Precipitation (inches)	Annual Average Temperature (°F)
Max	22.4	53.7
Average	10.2	50.4
Minimum	2.4	48.3
Standard Deviation	4.4	1.2

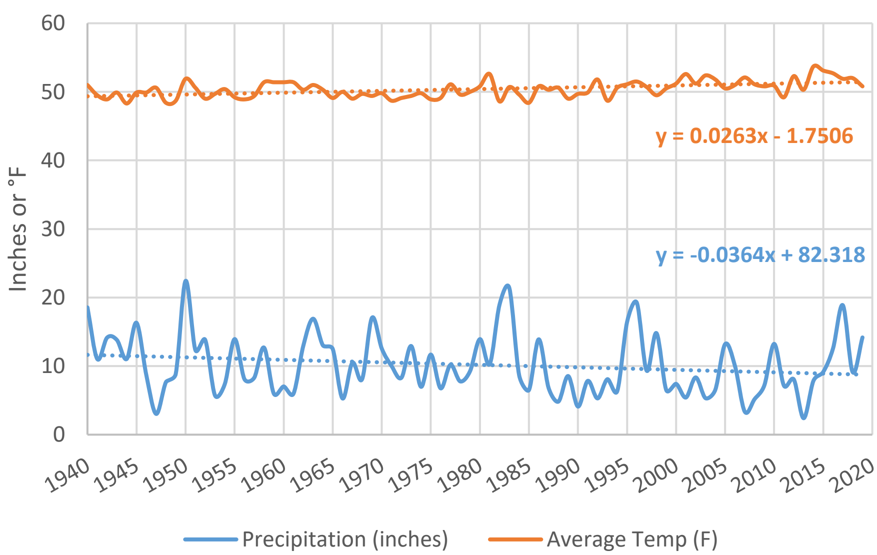


Figure 4.1 – Carson City Climatic Summary, 1940 to 2019

[14] Both of these trends are statistically significant.

Multiple variable regression models were evaluated to determine the relationship between precipitation, temperature, and flows. The regression models indicated that precipitation and temperature both impacted flows in the Carson River. However, the regression models also indicated that other factors contributed to flow, and potentially more importantly, variability in flow. Other factors that may impact variability in flows include soil moisture, snowpack, precipitation type (snow or rain), spring runoff, upstream diversions, etc. Given the trends shown in Figure 4.1, and the relationship between temperature and precipitation, it can be concluded that increasing temperature and decreasing precipitation will result in a decrease in the average flows in the Carson River.

5.0 WATER MARKETING STRATEGIES

Sections 2.0 through 4.0 present and discuss numerous different topics related to the Carson River watershed. In summary, these sections highlight several important trends and topics, including:

- Flows in the Carson River are becoming more variable with higher highs and lower lows,
- Trends indicate that average instream flows have been declining over time,
- Climatic conditions are trending towards increasing temperatures and decreasing precipitation in Carson City,
- There is a lack of storage in the watershed, especially the upper watershed; and
- Population growth will likely increase future demand for water resources in the watershed.

Given these conditions, implementation of existing and new water management and marketing strategies will be needed to balance decreasing and more variable water supplies with increasing demand. Chapter 5.0 and 6.0 discuss existing and potential water marketing strategies, concepts, and alternatives that are or could be implemented to help address the likely future imbalance between water supply and demand.

5.1 Current Institutional and Water Marketing Practices

In the Carson River watershed, there are several existing programs, statutes, and decrees that govern the use of water, and by extension, the marketing of water. Regarding water marketing, the Alpine Decree and existing State water laws are of particular interest. As discussed in Chapter 2.0, the Alpine decree establishes surface water duties on the Carson River in both California and Nevada, establishes the right to reservoir storage, and defines the operation of the river on rotation. Additionally, the decree recognizes riparian rights in California and appropriative rights in Nevada (Nevada Division of Water Planning, 1999).

In addition to the Alpine Decree, state water laws also govern how water is used. In Nevada, water law is based on the concept of prior appropriation and beneficial use. In other words, water rights grant priority to water users ("first in time, first in right") for designated beneficial uses (State of Nevada Division of Water Resources, 2020). Regarding surface water, California water law is a system of riparian rights and prior appropriation. However, groundwater laws in California are limited and relatively new. The 2014 Sustainable Groundwater Management Act (SGMA) requires Groundwater Sustainability Plans and groundwater restrictions on high and medium priority basins. The Carson Valley hydrographic basin is not classified as a priority basin and as a result there are few laws, statutes, or codes that regulate the use of groundwater on the California side of the watershed. (California Department of Water Resources, 2020).

The Alpine Decree and prior appropriation determine rotation of surface water from the Carson River. However, the Alpine Decree does allow for the rotation and exchanging of water among ditches and users to improve water economy as long as the exchanges do not cause injury to other users. Through rotation, junior water rights are served as long as possible. In addition, the Alpine Decree allows for changes in the point of diversion, place of use, and manner of use. It should be noted that the process to change a point of diversion, place of use, and/or manner of use is an extensive and time consuming process.

Similar to the Alpine Decree, Nevada state water law allows for changes in the point of diversion, place of use, and manner of use for groundwater. Although there are numerous restrictions and limitations, Nevada groundwater rights in the Carson River watershed can be bought, sold, exchanged, and moved. However, these changes can require an extensive and time consuming process, but ultimately do provide some level of flexibility in how water can be used. Arguably, existing laws and the Alpine Decree allow for several methods of water marketing within the watershed to increase the efficiency of water used.

Within the context of the Alpine Decree and state water laws, entities within the Carson River have effectively used existing water marketing mechanisms to maximize the use of water in the watershed. The following is a summary of some of these efforts:

- Farm Unit – Nevada Revised Statute (NRS) 533.040 §4 states that a surface water right in a federal reclamation project is appurtenant to the "entire farm" and that the place of use can be the "entire farm" rather than an "identifiable" place within the farm. Water usage on the farm cannot exceed what has been allotted through decrees. This statute allows agricultural surface water users in the Newlands Project flexibility to use water where it may be most beneficial rather than a specific location within the farm unit. Within the Carson River Watershed, the concept of the Farm Unit only applies within the Newlands project through the Truckee-Carson Irrigation District (TCID).
- Regionalization – Significant action has been taken in recent years to interconnect community water systems to maximize water availability and to utilize the most efficient sources of water. These activities include construction of regional water infrastructure and the completion of multi-agency, collaborative studies. Regional infrastructure project includes:
  - Douglas County regional water system – Through this system, water from the Town of Minden is distributed to Douglas County (specifically the East Valley, North County, and West Valley water systems), Indian Hills GID, and Carson City. This system is supported by miles of transmission mains, numerous water tanks, two booster stations, and interagency coordination.
  - Other system interties include:
    - Gardnerville Water Company – Town of Minden
    - Douglas County – Sierra Estates GID
    - Douglas County – Carson City
    - Carson City – Lyon County Utilities
    - Various interties between Douglas County's different community water systems (i.e. the Foothill water system is connected to the Sheridan Acres system).
- Water Rights Dedications – Many community water systems require either a dedication or purchase of existing water rights for new water system connections or developments. Historically, 1.12 AFA of water per residential connection has been required to either be dedicated to the water utility or purchased from the water utility[15]. This dedication rate exceeds average water usage (see Table 3.3) providing each entity a theoretical buffer between their "paper water" and "wet water." In addition, several water purveyors have indicated that they have acquired various surface water rights over time.
- Water Reuse – Numerous entities use reclaimed water in the Carson River watershed. There are numerous wastewater treatment plants (WWTP) that eventually dispose of

[15] In recent years some utilities have decreased this water right requirement per residential dwelling unit. In addition, there is inconsistency between community water systems on how the transfer or purchase of water rights is administratively managed.

treated effluent to the Carson River watershed. WWTPs range from outdated facilities to modern membrane systems that are able to meet stringent effluent requirements. The following is a summary of different municipal treated wastewater that is discharged to the Carson River watershed.

- South Lake Tahoe PUD – STPUD pumps treated wastewater over Luther Pass (CA Highway 89) to Harvey Place reservoir in Diamond Valley (Indian Creek drainage, a tributary of the East Fork of the Carson River). Water is used for irrigation of agricultural crops in Diamond Valley. This system imports water from the Tahoe Basin / Truckee River watershed to the Carson River watershed.
- Douglas County Lake Tahoe Sewer Authority – DCLTSA pumps treated wastewater over Kingsbury Grade (NV Highway 207) to a storage reservoir in Carson Valley. Water is used for irrigation of agricultural crops in Carson Valley. This system imports water from the Tahoe Basin / Truckee River watershed to the Carson River watershed.
- Incline Village GID – IVGID pumps treated wastewater over Spooner Summit (US Highway 50) to the Carson Valley. Treated effluent is used for golf course irrigation, irrigation of agricultural crops, and wetlands disposal. This system imports water from the Tahoe Basin / Truckee River watershed to the Carson River watershed.
- Markleeville Public Utility District – MPUD disposes of treated effluent in infiltration/evaporation basins adjacent to Markleeville Creek.
- Minden Gardnerville Sewer District – MGSD stores treated effluent in the Carson Valley for irrigation of agricultural crops. MGSD can store effluent in a storage reservoir adjacent to the WWTP or in a privately-owned reservoir.
- Indian Hills General Improvement District – IHGID disposes treated wastewater effluent through golf course irrigation. Storage is primarily in golf course water features.
- Douglas County – Douglas County disposes of treated wastewater effluent through irrigation of agricultural crops. Douglas County is also permitted to use a rapid infiltration basin (RIB) for disposal. During winter months Douglas County stores treated effluent in a lined storage reservoir adjacent to the North Valley WWTP.
- Carson City – Treated wastewater from the Carson City WWTP is used for golf course irrigation and irrigation of agricultural crops at the Prison farm. During winter months Carson City stores effluent in Brunswick Canyon Reservoir.
- Lyon County – Lyon County operates two wastewater treatment plants (Rolling A and South Plant). Treated effluent is disposed on through golf course irrigation and groundwater infiltration via rapid infiltration basins.
- Silver Springs – The Silver Springs WWTP is operated by Lyon County and primarily discharges treated effluent to the Silver Springs Airport for infiltration and evaporation.
- Churchill County – Treated effluent from the Moody Lane WWTP is primarily disposed of through evaporation / infiltration basins. However, the facility is permitted to discharge to the Wade Drain. It should be noted that the Moody Lane WWTP is a membrane bioreactor treatment process which is capable of producing extremely high quality effluent.
- City of Fallon – The City of Fallon is permitted to discharge treated effluent to the New River Drain.

- NAS Fallon – The Naval Air Station is permitted to discharge treated effluent to the Lower Diagonal Drain.

In many ways, water users within the Carson River watershed are utilizing existing water marketing tools to maximize the benefits of the Carson River within the framework of the Alpine Decree and existing water laws. Numerous collaborative programs and projects are in place that have improved the use of Carson River water. Future projects and interagency efforts should attempt to maximize the availability of water for the benefit of the watershed.

5.2 Future Water Marketing Concepts

The purpose of this section is to provide an overview of concepts that may be used for or as a component of future water marketing strategies. The following discussion focuses on very general concepts regarding how water from the Carson River can be removed, conveyed, stored, and how it can be later used. It is important to emphasize that this report assumes that any new water management strategy must satisfy the requirements of the Alpine Decree, state water law(s), and not negatively impact water users in the Carson River watershed. A more detailed discussion on how these concepts could be implemented is found in Chapter 6.0.

5.2.1 Surface Water Extraction

Induction Wells

Induction wells are typically shallow wells constructed in close proximity to a surface water (lake, river, stream, etc.). From a water rights standpoint, the water pumped from an induction well is treated as surface water. As a result, surface water rights are assigned to induction wells. However, from a potable water standpoint, the definition and assumption that an induction well is surface water has significantly different implications. According to 40 CFR §141.2 groundwater under the direct impact of surface water (GWUDI) is defined as *any water beneath the surface of the ground with significant occurrence of insects or other macroorganisms, algae, or large-diameter pathogens such as Giardia lamblia or Cryptosporidium, or significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity, or pH which closely correlate to climatological or surface water conditions*. If water from an underground source is classified as GWUDI it must be filtered and disinfected according to the Surface Water Treatment Rule (SWTR) before it can be considered potable. If the water is not classified at GWUDI, it can be treated as groundwater and may not require any treatment prior to use. As a result, water from an induction well that exhibits the characteristics of the surface water must be treated prior to potable use, resulting in significantly higher cost for construction and operation of infrastructure.

Induction wells may be used to extract surface water from the Carson River for storage and water use or potentially for direct use. From a water marketing infrastructure standpoint induction wells could be used to pump water to a storage system (see Section 5.2.3 below) so that water can be stored for later use or for direct use where needed. Induction wells are fairly common in the Carson River watershed. As discussed in Section 3.2, Douglas County, Carson City, and Lyon County currently utilize induction wells to supply potable water. It should be noted that these induction wells are not classified as GWUDI.

Pumped Diversions

Pumped diversion requires infrastructure to pump surface water directly from a surface water source. A surface water right is required to pump water from a surface water source. Pumped water can be discharged into a gravity conveyance system or into a piped pressure system for deliver to the point of use (see Section 5.2.2). There are several different approaches to pumped diversions that can be used depending on various design factors, including quality of water and capital cost. Options include installing suction piping directly into the surface water with only a coarse screen on the suction line to screen large debris, plant, animals, etc. from being pumped into the system. Another option is to install the pump suction in a well screen constructed in the riverbed. The screen is placed in gravel pack and/or clean aggregate which can provide an effective screen to not only debris, plants, and animals, but can provide some removal of sediment and fine debris.

Surface Diversions

Surface diversions often consist of diversion structures that redirect a portion of flow into another flow channel. Surface water rights are required to use a surface water diversion. Surface diversions are common in agricultural irrigation systems where water can be diverted to different locations through diversion dams, headgates, check dams, etc. In most cases various diversion structures are connected through surface and gravity pipe conveyance systems.

5.2.2 Water Conveyance

Surface Conveyance

Surface conveyance systems typically consist of a series of diversion structures, canals, and/or ditches used to move surface water by gravity to where it is used. The Carson River watershed already utilizes a large network of diversion structures, canals, and ditches for irrigation purposes. The Newlands project constructed a large surface distribution network that the Tahoe Carson Irrigation District operates and maintains.

In relation to potential water marketing concepts, existing or new diversions/canal/ditches/ could transport surface water from the Carson River to a storage system (see Section 5.2.3 below) for water to be stored and used at a later time.

Piped Conveyance

Like a surface conveyance system, a piped conveyance system transports water from its source to where it is used. Unlike a surface conveyance system, piped conveyance can de designed and operated as gravity or pressure systems. Gravity systems operate similar to a surface conveyance system, pipes are installed at grades that allow water to flow from one point to another by gravity. In a gravity pipe system, water levels in the pipe are often less than the diameter of the pipe[16]. Gravity systems operate like canals or ditches, with the primary difference being that a piped gravity system is enclosed, allowing the system to be buried but less accessible. Municipal sewer systems rely on gravity pipe systems extensively to collect raw wastewater from system users. Piped gravity systems can decrease water losses (through evaporation and leakage) and reduce

[16] The relationship between the depths of flow to the diameter of the pipe is often referred to as the d/D ratio, where d is the depth of flow and D is the diameter of the pipe. Acceptable d/D ratios typically range from 0.5 to 0.75, meaning that the depth of the flow never reaches the diameter of the pipe.

the risk of contamination but may have a higher capital cost when compared to surface conveyance systems.

Unlike gravity systems, pressure pipe systems are designed and operated so that the depth of flow in the pipe is the same as the diameter, resulting in the water pressure in the pipe exceeding atmospheric pressure. The energy to pressurize the water in the pipe is typically provided by pumps or when the water source is at a higher elevation than the pipe, resulting in water pressure. A pressure pipe conveyance system is generally required when water must be delivered to higher elevations (via pumping) or when pressure is required at the delivery point. Potable water systems use pressure pipe systems to deliver pressurized water to system connections at varying elevations.

5.2.3 Water Storage

Aquifer Storage

Aquifer Storage (which is also known as managed aquifer recharge (MAR)) is a manmade, managed process used to replenish groundwater aquifers. Aquifer storage and recovery (ASR) is the process of replenishing an aquifer with ability to use the stored water later. Aquifer storage is normally achieved through supplementing natural aquifer recharge through water spreading, infiltration basins, or injection wells. Water can later be recovered through extraction wells, or in some cases return flows to a surface body (US Environmental Protection Agency, 2018). To implement an aquifer storage system there are both administrative / permitting requirements and physical infrastructure requirements. In Nevada, administrative requirements include permitting requirements through the Nevada Division of Water Resources and potentially the Nevada Division of Environmental Protection Bureau of Safe Drinking Water (if stored water will be used for potable purposes). Physical infrastructure can vary greatly based on the method of recharge and extraction. Surface water injection requires construction of injection wells. Surface water infiltration requires construction of infiltration basins or water spreading basins. Water is typically recovered through wells but there is some evidence that proper hydrogeological conditions and proximity to surface waters can lead to natural return flows to a surface water body (Niswonger, Morway, Triana, & Huntington, 2017).

New Reservoir Storage

As discussed in Section 2.5.2 there have been numerous historical proposals to construct new reservoirs in the Carson River watershed. Most of these historical proposals were to construct reservoirs in existing stream or river channels (onstream reservoirs). Given the environmental impacts and cost of these projects, it is assumed that constructing an onstream dam and reservoir is not a feasible option. As a result, only offstream reservoir storage alternatives are considered in this report. Offstream reservoirs may have a smaller environmental impact than onstream reservoirs. In addition, there is likely a larger variety of suitable locations and construction options to develop new offstream reservoirs.

Depending on various factors, including storage capacity and topography, an offline reservoir can be constructed using dams, levees, embankments, and/or excavations. The new reservoir can be lined to reduce water loss to seepage or can be unlined to allow (or even encourage) seepage. The reservoir can be filled through various extraction and conveyance methods (see Sections 5.2.1 and 5.2.2) via gravity through canals, ditches, and pipes, or water can be pumped to the new reservoir.

Offstream reservoirs are somewhat common in the Carson River watershed. Existing offstream reservoirs are largely used for agricultural uses and storage of treated wastewater effluent.

Expand Existing Reservoir Storage

As shown in Table 2.7 and discussed in Section 2.5.1, outside of Lahontan Reservoir existing surface water storage in the Carson River watershed is limited to numerous small reservoirs. In some cases, it may be possible to expand existing dams to increase the storage capacity of some of these existing reservoirs. Expanding existing reservoirs may pose numerous challenges including environmental impacts. In addition, many of the smaller reservoirs are privately owned which could lead to complex contractual requirements.

5.2.4 Water Banking

Water banking is a concept where water right owners can voluntarily and temporarily transfer the use of their water rights to another owner. Water banks allow regional water users flexibility to exchange water, to mitigate the short-term effects of drought (Sanchari Ghosh, 2014). Additionally, water banking can better sustain water users and maintain a strong level of local involvement in water resource strategies. It is a particularly attractive concept to private water rights owners, who can generate income from these transactions and have their water rights protected through relationships with public entities. In return, public entities are benefitted by the ability to ensure that public water is being put to the most beneficial uses. As a result, water banking may provide the greatest benefit to municipal water users in the Carson River watershed. Lastly, adopting a water banking system allows for a more transparent way for willing water rights holders to advertise their water rights in an equal opportunity environment and allows for multiple beneficiaries (Lewis, 2021).

Especially in drought prone areas of the western United States, water banking presents a real water marketing solution to meet increased social, environmental, and economic demands. In 2020, the Utah State Legislature approved a pilot program to begin studying how water banking can add flexibility to rigid water rights, provide additional water to meet increased municipal and industrial demand, and promote greater collaboration amongst the water user community (Lewis, 2021).

There are also challenges to be considered with using a water banking concept. Due to high transaction costs, owners and consumers have been slow to evolve the water market in response to increasing water scarcity (Sanchari Ghosh, 2014). The persistence of historical institutions that control water allocation create strong barriers to the expansion of new water marketing connections. Therefore, strong governmental support of a water banking program would be beneficial to ease the creation of a fluidly moving program.

In the Carson valley, for example, water banking could be used as an application of managed aquifer recharge. Due to the nature of the semi-arid region, using water banking in conjunction with MAR can minimize evaporation losses and promote better regional water storage. A credit system could be developed where users can deposit water storage in years where immediate demand is low and withdraw from the system later. Subsurface storage is insulated from significant evaporation losses, which makes it possible for water to be accounted for more accurately (Gonzales, Dillon, Page, & Vanderzalm, 2020).

Developing a contract or statutory water bank would require the identification of a service area, legally enforceable agreements to protect water rights owners and public interest, and a structure of governing members to agree on how water transactions may take place. This structure could take place in many forms but would require regulatory time and effort to organize a system that makes sense for the Carson River watershed. One way to simplify transactions is to create term-limited agreements, so that ownership does not change for banked water rights. If MAR is used in a banking system, groundwater transactions should be distinguished from surface water transactions. The Utah Water Bank has utilized a combination of these strategies to create a pilot water bank that could be a potential source of information for watershed stakeholders to begin establishing a water banking structure. It is important to note that implementation of a water banking system in the Carson River watershed would need to conform to the requirements and limitations of the Alpine Decree.

Small scale, restricted types of water banking are currently used in the Carson River watershed. For example, water right owners may dedicate water rights to a municipal entity for use with an agreement that the private entity can use that water right in the future for land development. These agreements differ significantly from regional or statewide water banking structures that offer more opportunities for water rights owners and water users.

6.0 CONCEPTUAL ALTERNATIVES

Section 5.2 presented general concepts that could be used to enhance and add to existing water marketing strategies in the Carson River watershed. The following sections provide examples of how these general concepts could be implemented in the Carson River watershed. It should be noted that the following conceptual alternatives are not an exhaustive list of water marketing alternatives. Presented alternatives simply provide an outline of conceptual water infrastructure improvements that could be used to improve and enhance water marketing in the watershed. In addition, due to the cost and regulatory complexity of each of these alternatives, it is not likely that any alternative will be implemented in the near future. These alternatives should be viewed as long-term planning concepts that can be used to help guide current planning and policy discussions.

6.1 Conceptual Alternative 1 – Managed Aquifer Recharge Site 1

As discussed in Section 5.2.3, MAR and ASR are water storage methods that can be used to either replenish groundwater aquifers, or store water in more shallow parts of the aquifer, for later use. For conceptual purpose, a potential location where this method could be implemented near Stagecoach is shown in Figure 6.2. This site, located north of the Carson River (in Segment 7C as delineated by the Alpine Decree), is made up of Asolde-Patna complex soil (USDA-NRCS, 2020). This area was identified as a potential infiltration site because of the potential high transmissivity (infiltration) rate of the soil per the soil survey. The extended length of the site (2.5 miles) allows for variation and flexibility in constructing multiple infiltration basins where water can be spread, as the spreading location will affect the potential for aquifer storage or potential delayed return flows to the Carson River. Depending on the geologic conditions and gradient of the aquifer, two scenarios are possible. The first is that infiltrated water primarily returns as surface water flow to the Carson River downstream, later in the season. This scenario could be beneficial for when river flows naturally decrease late-season. The second scenario is that the water infiltrates into the groundwater aquifer, augmenting natural aquifer recharge.

A general assumption is that the closer in horizontal distance to the river that water is infiltrated, the more likely that it is to return as river flow downstream, and the further away the water is infiltrated from the river, the more likely it is that groundwater recharge will occur. However, extensive percolation and infiltration testing would be required to confirm the soils transmissivity. Testing and modeling would also be necessary to understand the boundary conditions of the underground aquifer, including the direction of gradient that will ultimately decide where infiltrated water flows.

To capture surface water from the River, an induction well(s) would need to be installed along the river. Water right(s) would need to be acquired to allow for pumping surface water from the inductions well(s). A potential location for the induction well is shown in Figure 6.2. A pipeline (approx. 3.4 miles in length) would need to be constructed to transfer the water pumped from the induction well to the infiltration site. The infiltration site would consist of a series of constructed, earthen infiltration basins. At this potential location, it is assumed that the groundwater gradient flows downward from the infiltration site to the northeast. In this case, excess water would flow towards the Stagecoach area, in the Dayton Valley Hydrographic Unit. Based on this assumption, groundwater wells could be constructed (or existing wells could be used) near Stagecoach, to extract the water stored in the aquifer.

Although the constructed components represent a significant capital cost, this alternative could provide a more stable water source for the Stagecoach area and could become a water source for Silver Springs in the future, a water-deficit area (via a proposed "Highway 50" regional pipeline).

MAR has been successfully used in semi-arid regions globally as a solution to overcome water scarcity. However, there are still also potential issues associated with MAR, such as clogging infiltration basins. High rates of sedimentation during infiltration periods can reduce the infiltration basin capacity over time. As a consequence, the recharge rate in areas of MAR can decrease over time, which can lead to the abandonment of an aquifer recharge project. Proper maintenance, including routinely scraping top layers of the infiltration site, can extend the useful life of the infiltration basins (Mohammed Zaidi, 2020).

To implement this alternative an existing entity or new entity would need to be established to manage the new infrastructure, distribute stored water to participating entities, and manage the legal contracts and regulatory hurdles to distribute water potential across jurisdictional boundaries. This alternative could operate under a water banking framework to provide the broadest range of water marketing opportunities.

6.2 Conceptual Alternative 2 – Managed Aquifer Recharge Site 2

The Douglas County-Lake Tahoe Sewer Authority (DCLTSA) owns bentonite lined storage reservoirs northeast of Gardnerville near Johnson Lane, (in Segment 2 as delineated by the Alpine Decree). This is a potential managed aquifer recharge location using infiltration basins. In this alternative, some of the existing infrastructure at the DCLTSA reservoirs may be repurposed. Specifically, the DCLTSA reservoirs and part of the existing pipeline that currently runs from the DCLTSA treatment plant near Lake Tahoe to the DCLTSA reservoirs. The existing pipeline transfers treated effluent from the east side of the Lake Tahoe basin, over Kingsbury grade, and across Muller Lane, to discharge the treated effluent to various irrigation canals, and specifically, to the Bently reservoir, located near the unused DCLTSA reservoirs. In order not to mix treated effluent with excess canal or river water, a new pipeline would be constructed from nearby canals to the unused portion of the DCLTSA sewer line near the Bently Reservoir. Figure 6.3 shows a conceptual layout for this alternative.

There are numerous factors to be considered with an infiltration option at this location. It is important to note that these basins were historically used for treated wastewater disposal and storage and were constructed with a bentonite clay liner. Although this bentonite lining is old and likely desiccated, it would likely result in poor transmissivity for infiltration basins. In addition, there is potentially soil contaminants remaining from the wastewater disposal operation that may present hurdles to this alternative. To transform the reservoirs into infiltration basins, the remaining clay liner would need to be removed. Removal and disposal of the clay liner is not an extensive process, however, removal of more than the clay liner may be required to address potential contamination. In addition to rehabilitating and remediating the existing ponds, it would be necessary to construct a second pipeline that would extend from a canal or nearby water source (likely the Allerman Canal) to the discharge at the infiltration basins (piped conveyance as discussed in Section 5.2.2). For this alternative, an intake and pumping system would be constructed on the canal at the point of diversion to pump water into the infiltration basins. As the infiltration basins are at an elevation higher than the river, long -term pumping could incur significant energy costs. Similar to Alternative 1 (MAR Site 1), infiltration testing and other site testing would be required to better understand the site specific hydrogeologic conditions.

However, it is important to note that this is not likely to be an annual operation, but rather an intermittent diversion of water when flows are higher than normal. Extraction well(s) would be required to pump stored water from the aquifer. Depending on water quality and intended use, extracted water could be diverted into a community water system in the Carson Valley or could be pumped back into a canal for use downstream.

Due to numerous septic tanks in the area and a historical lack of a nitrogen removal process at DCLTSA, high groundwater nitrate concentrations are documented in the immediate area around the infiltration basins and in the nearby Johnson Lane area. Implementing a managed aquifer recharge system may result in further distribution of the nitrate contamination, potentially contaminating a larger portion of the aquifer. However, as the infiltration process continues over time, the finite amount of nitrate may become diluted, possibly creating a long-term benefit for the east side of the Carson Valley. Another potential solution to mitigate the presence of nitrate in the immediate vicinity of the DCLTSA ponds would be to remove the adjacent contaminated soil before allowing infiltration to begin. However, due to the significant area of soil that would require removal, this may be a less feasible and more costly option. Overall, the main beneficiary to this alternative is Douglas County, who would see potentially increased groundwater capacity and improved groundwater quality over time.

Another method of utilizing these existing ponds would be to refurbish the existing liner and use the basins as surface-water storage. Since the existing clay liners have been dry for several years, it is assumed that the existing clay liner should be removed. Additionally, it is important to note the potential for contaminants from the sites previous use as a treated wastewater storage facility. Pollutants and chemicals in the existing bentonite liner and soils may lead to the contamination of the water stored in the existing ponds. However, the benefit of this method would be an increase in surface storage and a more direct return of the water to the Carson River in times of low flow, when compared to recharging the aquifer. In order to utilize these basins as surface-water storage, a pump would need to be installed at the basin itself in order to move the water from the basins back into the Allerman Canal. It would be determined the most economically feasible course of action is to utilize the same pipe that brought water to the basins to return the water back to the canal. A downside of the method of utilizing the basins to store surface-water is that it will increase water loss due to evaporation, when compared to Managed Aquifer Recharge. Additionally, this method will involve the relining of the basins and installation of another pump which may bring the cost of this sub-alternative to an amount that makes this approach undesirable.

Using the existing DCLTSA ponds for infiltration or surface water storage would require surface water rights to pump water to the ponds. An existing entity or new entity would need to be established to manage the new infrastructure, distribute stored water to participating entities, and manage the legal contracts and regulatory hurdles to distribute water potential across jurisdictional boundaries. This alternative could operate under a water banking framework to provide the broadest range of water marketing opportunities. This alternative could potentially be used to provide water to community water systems but given the potential for contamination may be more suitable to provide stored water for agricultural uses.

6.3 Conceptual Alternative 3 – Expanding Existing Reservoir Storage

Another potential concept is to expand existing reservoirs. Expanding existing reservoir storage has the potential to simplify means of reusing excess water, as there is already existing infrastructure that supports beneficial use of the stored water. Due to the limited storage in the

Carson River watershed, expansion of Lahontan Reservoir or Mud Lake are the two existing reservoirs considered for this alternative. Operation of expanded reservoirs may likely be able to operate under the same regulatory framework as current operations with additional water available for storage to potentially a larger base of water right owners. The following paragraphs discuss the feasibility and implications of expanding either reservoir.

Mud Lake: Mud Lake is a privately owned reservoir in the upper Carson Valley with a surface area of approximately 290 acres. The reservoir is filled with water from the West Carson River and Indian Creek. Water from the West Carson River is diverted to the Indian Creek drainage through a series of ditches and diversion structures. Discharge from Mud Lake flows back into the West Carson River. Figure 6.4 shows potential lake level contours that would result from increasing the height of the Mud Lake dam. Increasing the height of the dam would require construction of a second dam or embankment on the east side of the reservoir. Without a second dam in this location, increasing the water level would result in water spilling on the east side of the reservoir into Indian Creek and eventually draining into the East Carson River. Therefore, this option would not only require the expansion of the existing dam but would also require construction of a secondary dam to prevent overspill, incurring a significant construction cost. However, the upstream location of Mud Lake allows for many beneficiaries, as it would essentially act as increased water storage for all downstream users. Therefore, in high demand periods, the water could be used at lower points in the Carson River watershed.

Lahontan Reservoir: Lahontan Dam was constructed in 1905 as part of the Newlands Project. The dam is constructed on the Carson River creating a reservoir area of approximately 14,200 acres at full pool. In addition to damming the Carson River, the Truckee-Carson canal flows into Lahontan Reservoir near the dam. The Truckee-Carson Canal originates at Derby Dam on the Truckee River and transfers water from the Truckee watershed to the lower Carson River watershed.

Expansion of Lahontan Reservoir would require expansion of the existing dam but would also require construction of a secondary dam or embankment immediately to the east of the current dam (see Figure 6.4). In addition, reservoir expansion would also require modifications to US Highway 50 along the north shore of Lahontan Reservoir. The proximity of US Highway 50 to the proposed dam area creates challenges of pooled water approaching or extending beyond the current road grade. Expansion of Lahontan reservoir primarily benefits Churchill County residents, as the additional water storage would remain at the end of the watershed, for downstream users only.

Based on a preliminary review of historical data from the National Water Information System (US Geological Survey, 2020), between 1960 and 2019, Lahontan Reservoir has only filled to 295,500 AF (the spillway level) 808 days during the period (see Figure 6.1). In other words, Lahontan Reservoir fills to capacity only 4% of the time. There are several factors that influence this, including operational strategies and downstream water demands. But it may also indicate that the watershed does not have the capacity to routinely fill an enlarged Lahontan Reservoir.

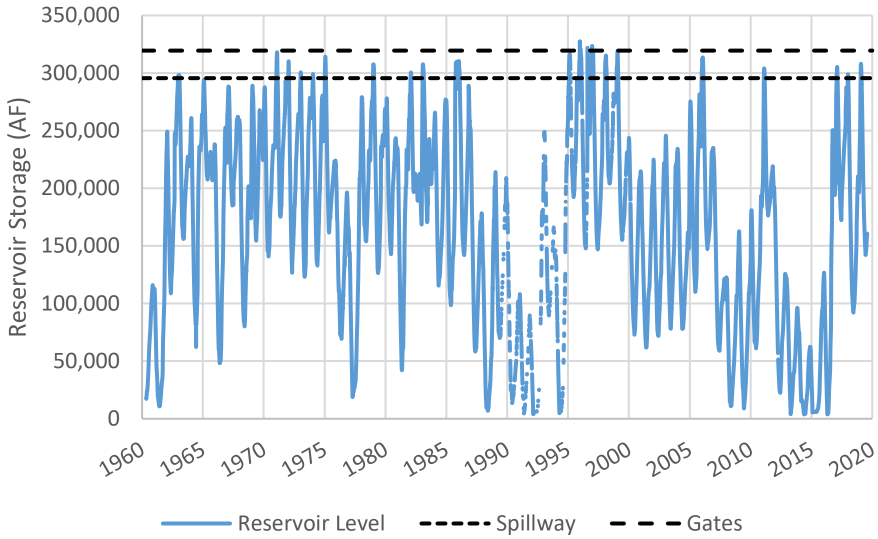


Figure 6.1 – Historical Lahontan Reservoir Storage

6.4 Conceptual Alternative 4 – Regional Potable Water Managed Aquifer Recharge

A proposed regional pipeline along Highway 50, currently in planning stages, will hydraulically connect public water systems from Dayton to Stagecoach (and eventually Silver Springs). This alternative would construct a well or series of wells adjacent to this regional pipeline. During periods low demand and excess potable water availability, water from the regional pipeline could be injected into the constructed well(s) near Stagecoach. Then, during periods of high demand, and limited excess water, stored water could be pumped from these wells into the regional pipeline, for use in the regional water system. This would allow water purveyors, including Lyon County Utility District, flexibility in being able to allocate the additional resources to where it is most needed. For example, stored water could be used in Silver Springs (if the proposed pipeline is extended to Silver Springs), an area that is commonly affected by water deficit and drought. Figure 6.6 shows a conceptual layout of this alternative.

The capital cost of this alternative is likely significantly less than other alternatives due to the already proposed pipeline infrastructure that can be utilized. The remainder of capital cost would be for drilling and construction of groundwater injection/extraction wells in Stagecoach, and a possible extension of the regional pipeline to Silver Springs. Depending on the in-line pressure of the new pipeline, a combination of gravity flow and pumping may be utilized to move water throughout the system, potentially decreasing overall operation and pumping costs.

This alternative would inject potable water, potentially from multiple sources, into the aquifer in the Stagecoach area. There is a risk that this approach could contaminate potable water. Contamination could occur through various mechanisms. If the aquifer has existing water quality problems (ie. arsenic, nitrate, etc.), injecting potable water in the aquifer may result in contamination of the potable water. Another potential water quality issue is mixing water with different water chemistry with the existing aquifer. Mixing these water could lead to changes in pH, or leaching of minerals that were stable prior to introducing different water chemistry. These issues can be complex and must be evaluated prior to implementation of this (or a similar) alternative.

Conceptually, there are multiple beneficiary stakeholders to this alternative. Residents of Dayton, Stagecoach, and potentially Silver Springs would benefit from potentially more robust water supplies. In addition, water suppliers could experience decreased source water demand during peak periods since downstream users may be able to rely on water that was stored locally during low demand periods.

This alternative may be able to utilize existing water rights held by community water systems or transferred to community water systems providing water to the regional water system. To implement this alternative an existing entity or new entity would need to be established to manage the new infrastructure, distribute stored water to participating entities, and manage the legal contracts and regulatory hurdles to distribute water potential across jurisdictional boundaries. This alternative could operate under a water banking framework to provide the broadest range of water marketing opportunities.

6.5 Conceptual Alternative 5 – Combined Flood Control and Groundwater Recharge

The Ruhenstroth subdivision in Douglas County occasionally experiences flooding on Smelter Creek, an ephemeral stream which flows through the subdivision. The stream is typically dry, with seasonal runoff and storm runoff occurring during thunderstorms. Although the stream rarely has sustained flows, when it does, short-duration, high-flow conditions can occur. Currently, the subdivision lacks a conveyance system to subdue flow and stabilize a path for flow, so significant storms can bring damage to homes, drainage structures, and roads within the floodplain. In addition to flooding risks, the local aquifer in Ruhenstroth has been experiencing declining static groundwater levels and nitrate contamination due to the concentration of septic tanks in the area.

An evaluation completed by RO Anderson, considered flood control alternatives and proposed a flood control detention basin just east of the Ruhenstroth subdivision. RO Anderson's evaluation proposed a flood control facility basin sized for a 100-year storm event that would equalize outflow so that it is contained within the existing channel (R.O. Anderson, 2016). The proposed infrastructure would include a dam control structure, consisting of an embankment, a low-level primary outlet, and an emergency spillway.

By significantly limiting discharge to the subdivision, a flood control structure or facility would protect downstream homes, and effectively remove the entire subdivision from the floodplain (R.O. Anderson, 2016). Conceptually, the excess flow captured in the reservoir structure could also be infiltrated within constructed basins or downstream in Smelter Creek to provide groundwater recharge and flushing to the overall groundwater aquifer. These same basins could also be used as infiltration basins. Excess surface water flows from nearby canals or the Carson River could be pumped into the stormwater detention basins in times of low surface water demand and during periods of low flood risk. For this alternative, it is assumed that induction wells would be constructed near the Carson River. When the infiltration/stormwater basins could not be used for infiltration (during flooding or seasonal runoff), the induction well(s) could potentially be used as a water source for nearby water systems, including the Gardnerville Ranchos GID. Use of infiltrated water would likely be limited to the domestic wells located in the Ruhenstroth area. It is important to note that storage availability for flood mitigation should always be maintained to ensure that the primary use of the control facility is to protect nearby homes from flood damage. Figure 6.7 shows the conceptual layout of the dam, induction well, and waterline.

The direct beneficiaries of this conceptual alternative include the residents of Ruhenstroth and Douglas County, by reducing the potential damage to public infrastructure, and providing overall environmental improvements to the condition and storage levels of the groundwater aquifer. However, there is limited regional benefit to downstream users. Douglas County has attempted to partially fund these improvements in the past through FEMA's Hazard Mitigation Grant Program. However, funding efforts were unsuccessful, in part due to the low benefit cost ratio for the project. In addition, constructing dams on Federally owned property is difficult and time consuming, likely leading to multiple years to obtain permits and easements.

It should be noted that this alternative has been developed primarily with the intent of providing flood mitigation to the Ruhenstroth area. This community faces a significant flood threat during severe storms and their community would benefit greatly from the proposed flood control structures. This Alternative does not provide significant water storage to the Carson River watershed water-users and it does not help capture significant excess flow in the water system. However, if the construction of this Alternative could be covered under largely through FEMA the Ruhenstroth community would benefit significantly from this flood mitigation. But Carson River consumers would not experience a great increase in water storage or in the capturing of excess river flow.

6.6 Conceptual Alternative 6 – New Reservoir Storage

The Bing Pit, situated at the corner of Bing Road and Kimmerling Road in Douglas County, is an active gravel pit that is being utilized by Bing Materials for construction material and fill extraction. The pit is nearing the end of its useable life and it is unknown what remediation is planned for the pit. With the expansive area and an already excavated pit, a potential solution would be to fill the pit with surface water from the West Fork of the Carson River.

This alternative would require constructing a pumped diversion on the West Fork of Carson River and a transmission pipeline to the existing gravel pit. It is anticipated that groundwater recharge would occur through infiltration. However, depending on the depth of the stored water in the pit, return flows to the West Fork of the Carson River could be via the constructed transmission pipeline either through gravity or pumping.

Reservoirs have the potential to increase surrounding property value to homes and can add aesthetic and recreational resources for nearby residents (Sarah Nicholls, 2018). Recreationally, the reservoir could potentially serve as a new neighborhood location for boating, fishing, swimming, walking, and attract other regional park-goers to the area. The Sparks Marina in nearby Washoe County came about in a similar way to the proposed reservoir, as it was originally a deep gravel pit that became filled during the 1997 Truckee River flood. Over time, the marina has become a community staple, providing a place for youth sports, community events, university clubs, and general day use. Set in a geographically similar area as the Sparks Marina, a recreational reservoir in the Gardnerville Ranchos could be a significant addition to the public parks and green spaces in Douglas County. However, as the surface area of the pit is approximately 100 acres, and water depth of the reservoir would be approximately 40 feet, almost one billion gallons of water will be required to maintain the potential new reservoir as a recreational area. In a region prone to drought and water deficit, it is possible that this excessive amount of water could be allocated more usefully elsewhere in the region.

A significant challenge associated with this alternative is that water to fill the proposed reservoir could potentially be better utilized elsewhere in the watershed and excess flows do not occur on an annual basis, meaning there will be periods of time that no flow is available to direct to the reservoir. This will require increased effort by Douglas County to allocate enough resources to keep the reservoir full enough for recreational benefits. Alternatively, the reservoir could potentially be operated only in years of excess flow, but this would likely result in stagnant water that attracts vectors and becomes an unsightly area. Water stagnation is not a desirable outcome and could present serious problems with this alternative.

The possible layout of a waterline and pumping facility is shown in Figure 6.8. If a new reservoir is constructed for water storage, multiple communities downstream could benefit from increased regional water capacity through groundwater infiltration and return flows from the reservoir to the West Fork of the Carson River. However, the recreational benefits of the reservoir will likely be more beneficial to Carson Valley.

To implement this alternative an existing entity or new entity would need to be established to manage the new infrastructure, distribute stored water to participating entities, and manage the legal contracts and regulatory hurdles to distribute water potential across jurisdictional boundaries. This alternative could operate under a water banking framework to provide the broadest range of water marketing opportunities.

6.7 Summary Table

The overall advantages and disadvantages to each conceptual alternative are shown in Table 6.1. It is important to note that each of these alternatives have been explored for conceptual purpose only, and will require significant investigation, study, design, funding, construction, operations, and maintenance to successfully implement and operate. Similarly, no single concept will be implemented on all years, and negate other water strategies currently in use. These strategies are intended to be used intermittently, during high flow, low demand years, as complementary resources in the Carson River watershed. Ideally, an appropriate water strategy will result in benefits to multiple communities in the region and lessen overall water stress on the region in drought years.

Table 6.1 – Summary of the presented conceptual alternatives

	Conceptual Alternative	Advantage	Disadvantages
1	Managed Aquifer Recharge Site 1	Increased regional water storage, increased groundwater storage, simple operation	Potential clogging of infiltration basins, potential water contamination, limited nearby water users, pumping costs
2	Managed Aquifer Recharge Site 2	Increased regional water storage, Potential use of existing infrastructure, Potential groundwater quality improvements	Not near water-deficit area, pumping costs, Known site contamination, Potential site remediation
3a	Expand Existing Reservoir Storage – Mud Lake	Increased regional water storage, Use of existing infrastructure, No pumping costs, Simple operation	Existing facilities privately owned, Extensive improvements required, High capital cost and design requirements

3b	Expand Existing Reservoir Storage – Lahontan Reservoir	Increased local water storage	Limited beneficiaries, Extensive improvements required, Extremely high capital cost and design requirements, Limited ability to fill reservoir
4	Potable Water Managed Aquifer Recharge	Increased regional water storage, Increased groundwater storage, Simple operation, Potential use of proposed infrastructure, Low capital cost, Close proximity to water-deficit area	Potential water contamination
5	Combined Flood Control and Groundwater Recharge	Flood mitigation, Increased local groundwater storage, Potential for FEMA grants, Potential groundwater quality improvements, Potential for regional potable use	Limited groundwater storage beneficiaries
6	New Reservoir Storage	Increased surface water storage, Increased groundwater storage, Potential for recreational opportunities	Pumping costs, High operational requirements, High capital cost, Potential for water stagnation

6.8 Opinion of Probable Cost

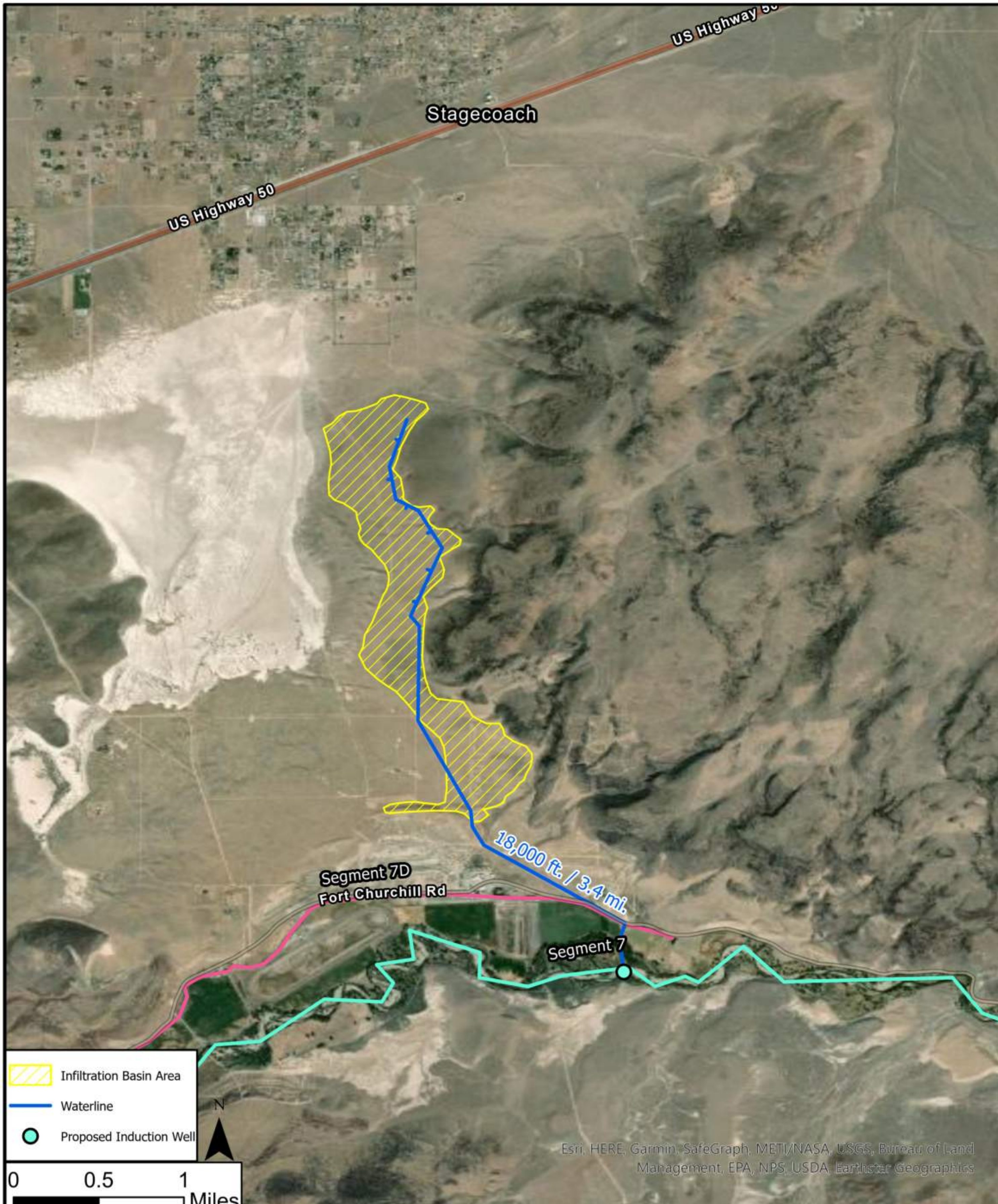
Table 6.2 provides a summary Class 5 engineer's opinion of project cost for each alternative. It is assumed that presented costs will be a one-time capital cost for the CWSD or other entities that may consider implementing these alternatives. Presented costs do not include costs for further project planning, pre-design site investigations, design, permitting, easements, and ongoing maintenance and operations.

Engineer's opinions of probable costs are presented for each alternative. It should be noted that the presented opinions of probable costs are strictly conceptual in nature and may differ significantly from actual construction costs. These costs reflect the engineer's impression of material, equipment, labor, etc. at the time of the estimate based on experience and judgement in applying presently available data. The engineer has no control over cost of labor, materials, equipment, competitive bidding practices, market conditions, tariffs, costs associated with funding packages, inflation, etc. Thus, the engineer cannot warrant that the actual project construction costs will not vary from the engineer's opinion of probable cost. Generally, engineer's concept/study level opinion of cost (Class 5 estimate) is -30% to +50% of actual costs.

Table 6.2 – Opinion of Probable Cost

Conceptual Alternative	Total Cost
Managed Aquifer Recharge Site 1	$12,000,000
Managed Aquifer Recharge Site 2	$12,900,000
Expand Existing Reservoir Storage – Mud Lake	$11,600,000
Expand Existing Reservoir Storage – Lahontan Reservoir	$59,000,000
Potable Water Managed Aquifer Recharge	$6,800,000
Combined Flood Control and Groundwater Recharge	$16,200,000
New Reservoir Storage	$18,600,000

Each of the conceptual alternatives presented in this report require significant permitting, regulatory review, and have very high capital costs. Because of these issues, it is not likely that any of these alternatives will realistically be implemented in the near future. However, policy makers, water managers, etc. should consider these alternatives and other long-term planning concepts in their routine planning efforts to help adapt to changing conditions in the Carson River watershed.



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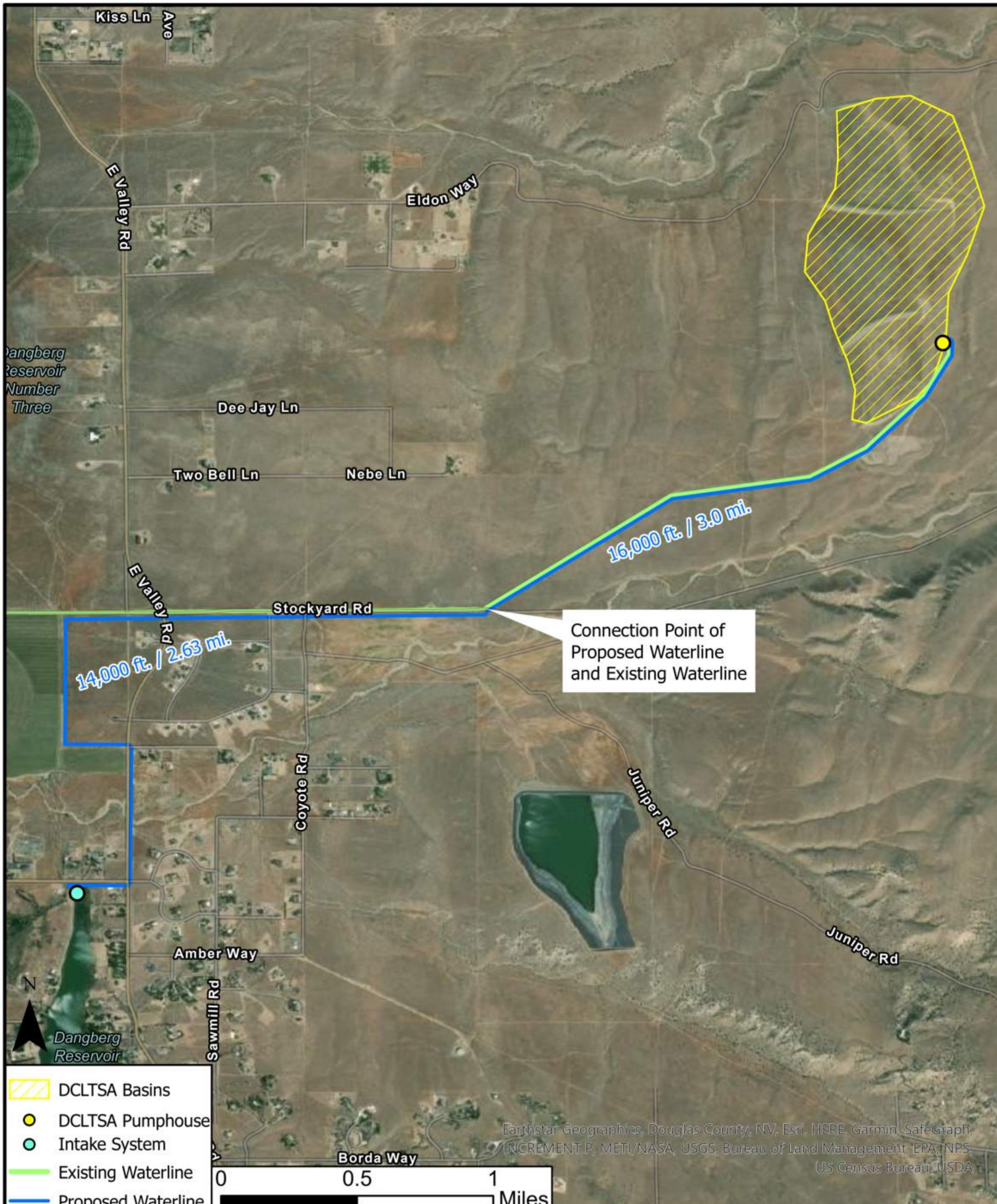
Carson Water Subconservancy District

Conceptual Alternative 1
Managed Aquifer Recharge near Stagecoach

Stagecoach | Lyon | NV

Date:	2/17/2021
Scale:	1 : 48,000
Job No:	9834.000
Figure:	6.2



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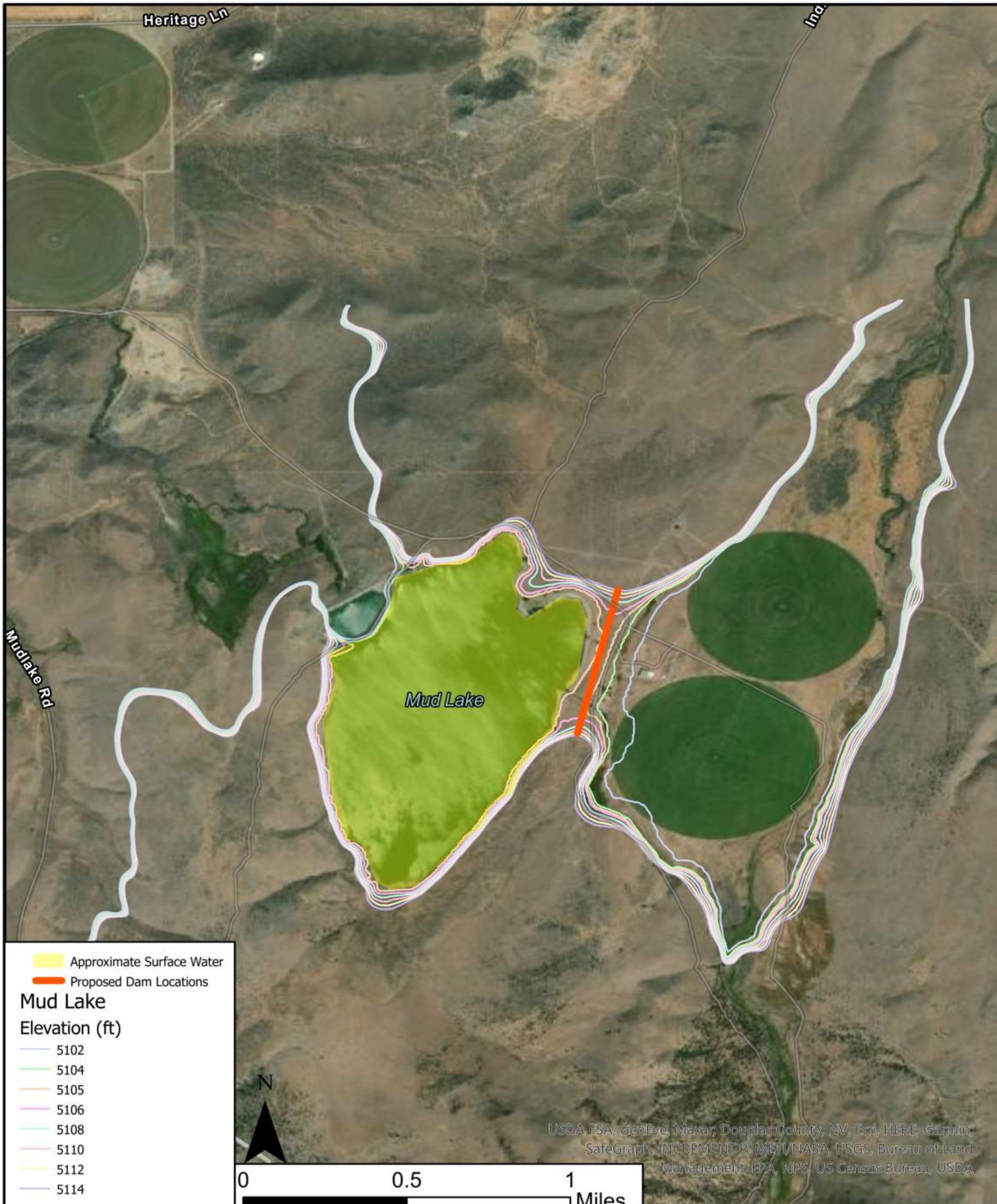
Conceptual Alternative 2
Managed Aquifer Recharge near Johnson Lane

Gardnerville | Douglas | NV

Date:	2/17/2021
Scale:	1 : 30,000
Job No:	9834.000
Figure:	6.3



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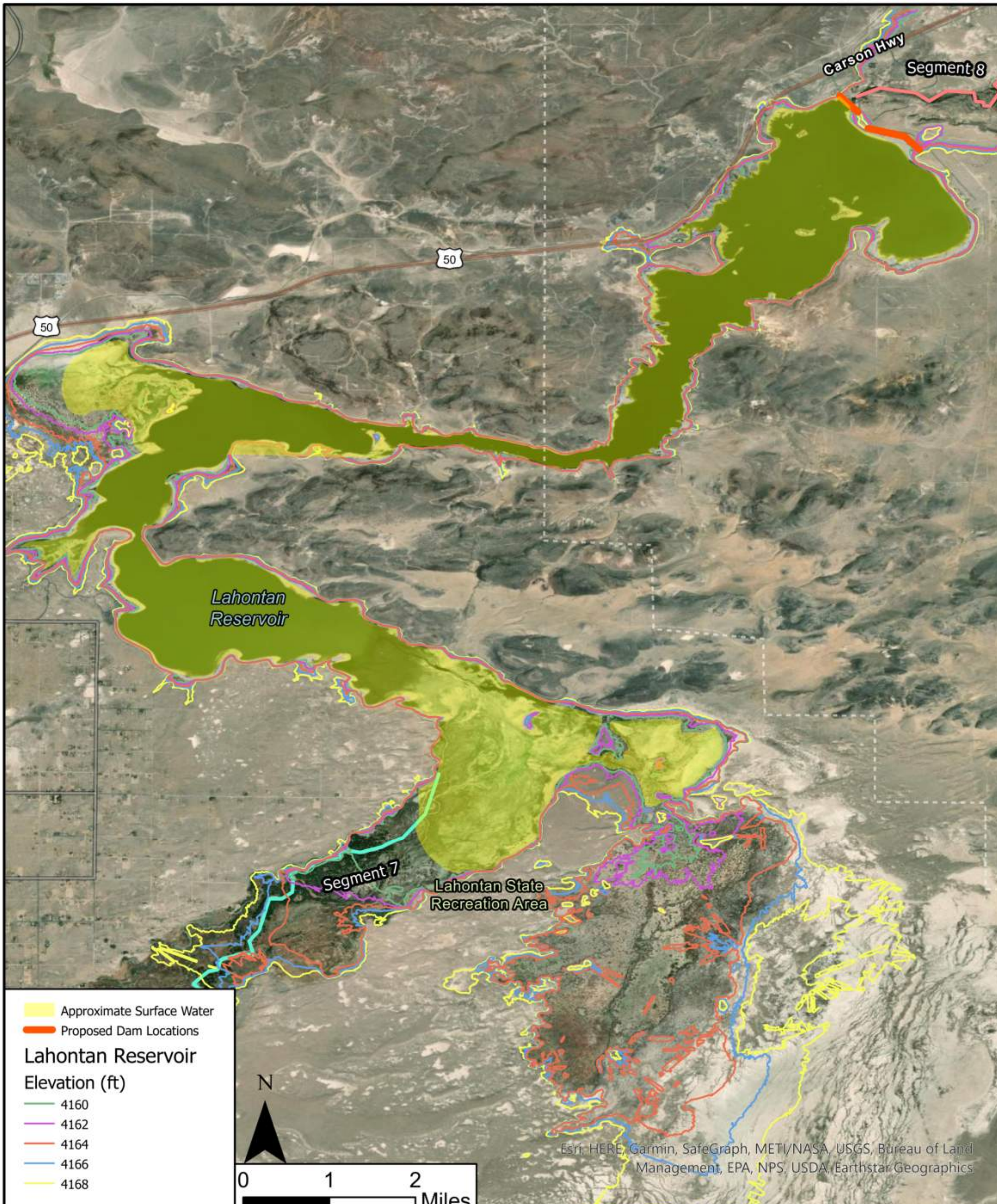
Carson Water Subconservancy District

Conceptual Alternative 3A
Expanding Existing Reservoir Storage

Gardnerville | Douglas | NV

Date:	2/17/2021
Scale:	1 : 25,000
Job No:	9834.000
Figure:	6.4



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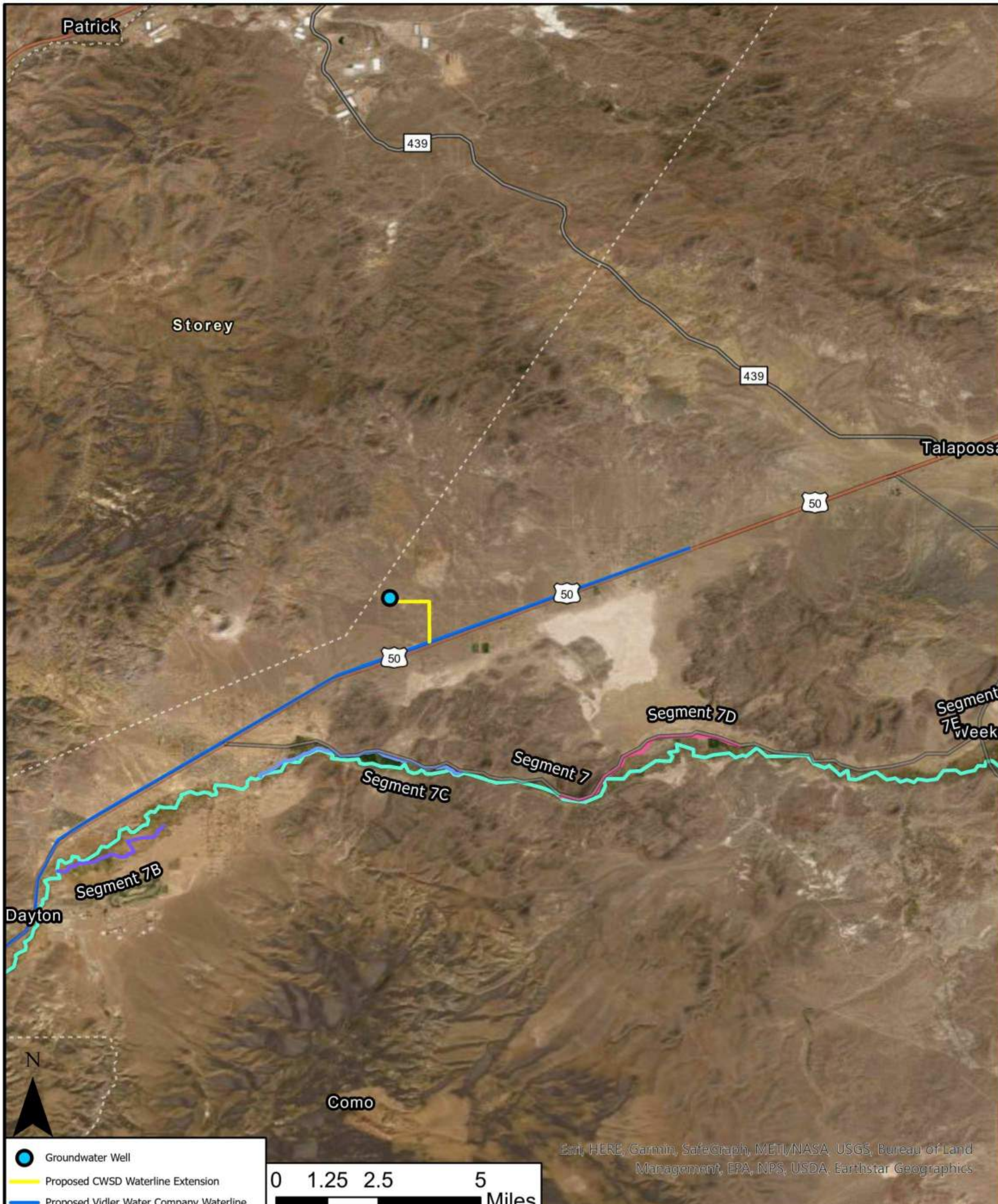
Carson Water Subconservancy District

Conceptual Alternative 3B
Expanding Existing Reservoir Storage

Silver Springs | Lyon | NV

Date:	2/17/2021
Scale:	1 : 95,000
Job No:	9834.000
Figure:	6.5



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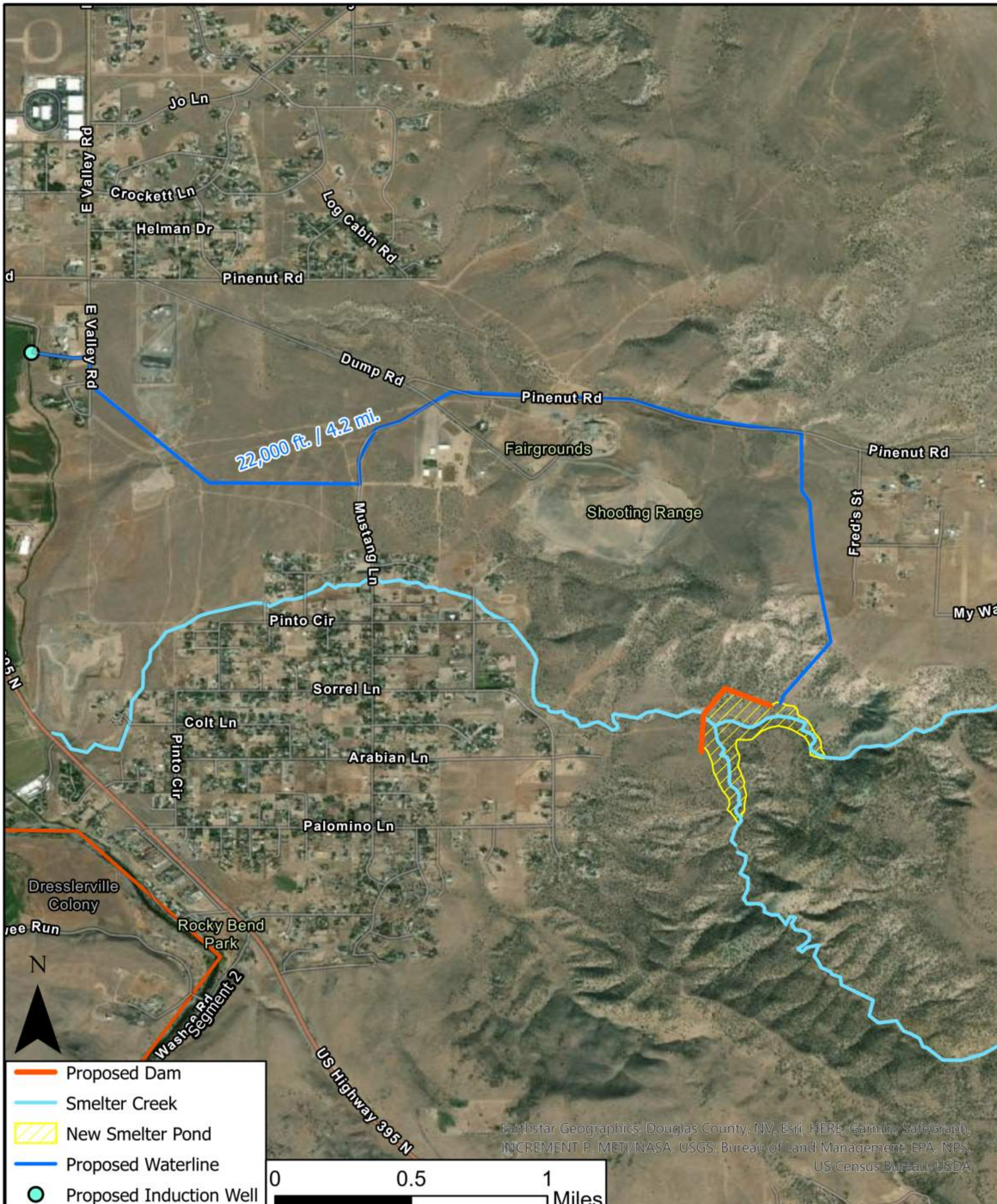
Carson Water Subconservancy District

Conceptual Alternative 4
Regional Piped Water Access near Seneca Road

Stagecoach | Lyon | NV

Date:	2/17/2021
Scale:	1 : 200,000
Job No:	9834.000
Figure:	6.6



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Carson Water Subconservancy District

Conceptual Alternative 5
Combined Flood Control and Groundwater Recharge

Gardnerville Douglas NV

Date:	2/17/2021
Scale:	1 : 48,000
Job No:	9834.000
Figure:	6.7

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Carson Water Subconservancy District

Conceptual Alternative 6
New Reservoir Storage

Gardnerville | Douglas | NV

Date:	2/17/2021
Scale:	1 : 30,000
Job No:	9834.000
Figure:	6.8

7.0 CONCLUSIONS

Through preparation of this report various data was collected, evaluated, and analyzed that provides insight into historical, current, and future water conditions and trends that the Carson River watershed has or may experience. Data indicates that the Carson River watershed is changing. Instream flows, precipitation, and temperatures are changing and becoming more variable over time. These changes are likely going to result in more water instability in the Carson River watershed. Along with increased water instability, population growth is anticipated, increasing the demand for water, putting more pressure on water resources, including the Carson River.

As a result of increasing climatic variability, water instability, and increasing water demand, existing and new water marketing strategies will become critical to maximize the use of limited water resources. Current water marketing strategies provide some flexibility to use water resources more efficiently. However, implementing new water marketing strategies will likely be required to balance increasingly unstable water supplies with increasing demands. Increasing water rights flexibility (ie. through water banking) and increased water storage will likely be essential tools to find the appropriate balance.

The purpose of this report is to formally document the varied efforts, evaluations, concepts, and outreach to develop a water marketing exchange and transfer strategy for the Carson River watershed. The report presented numerous infrastructure concepts intended to extract, convey, and store water. These concepts were applied through the development of six different conceptual alternatives that could be used to store water for use during periods of increased demand. In addition, water banking, a largely administrative concept, was discussed. These water marketing alternatives were presented as concepts to illustrate the application of infrastructure used for water marketing. Implementation of any of these alternatives or concepts will require additional evaluation, study, permitting, etc. before specific water marketing improvements can advance beyond the planning phase of a project.

Given the imbalance between variable water supplies and increasing demand, Lumos & Associates recommends that additional modeling, study, and evaluations be pursued. Existing water models should be reevaluated and updated for the Carson River watershed so that MAR/ASR and surface water storage alternatives can be evaluated against current conditions. Based on modeling, hydrological/hydrogeological evaluations, and pedestrian surveys, in-field site investigations should be considered to determine that feasibility of improved water marketing infrastructure. Although the presented alternatives will likely not be implemented in the near future, further study and site investigations will help prepare water users for implementation of future infrastructure required to adapt to changing conditions in the Carson River watershed.

Administrative and political solutions should be pursued in parallel with evaluating physical water marketing infrastructure improvements. These administrative and political activities should evaluate the funding, operation, maintenance, and oversight of potential infrastructure improvements. In addition, water banking concepts should be investigated to ensure that the proper legal framework exists to implement and support new water marketing infrastructure.

Water users could implement components of the proposed alternatives in the near future that could be adapted to water marketing concepts in the future. For example, induction wells that are constructed in the near term could potentially be used with a future managed aquifer recharge project. In addition, regional pipelines could provide more efficient water use. Water users should consider the long-term applications of near term improvements during project planning.

It is important to note that implementation of any significant administrative program and/or infrastructure project will be a significant undertaking. As such, it is important to identify and engage with interested parties and stakeholders. Stakeholder support and buy-in to any proposed changes or improvements will be necessary for the successful implementation of any water marketing strategy.

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