Gavin Newsom
Governor

Yana Garcia
Secretary for Environmental Protection

Lahontan Regional Water Quality Control Board

# West Fork Carson River Vision Plan

A water quality improvement plan to address multiple pollutants in the West Fork Carson River in Alpine County, California

July 2023 Draft

# Executive Summary

The West Fork Carson River Vison Plan (Vision Plan) describes present and future actions that will be taken to restore and protect water quality in the West Fork Carson River (WFCR). The WFCR flows from its headwaters through Alpine County to the Nevada state line. The WFCR's watershed is a rural area, mostly consisting of forestland and alpine meadows, with minimal development and land use dominated by recreation and open space. Additional land uses include active rangelands and residences. As a result of historic logging, mining, grazing, and hydromodification, as well as current grazing, road maintenance, recreational activities, septic tanks and water management, the WFCR has multiple water quality impairments. Water quality data show that the WFCR exceeds standards for nutrients, turbidity, salts, and bacteria. Stakeholders, stakeholder groups, nongovernmental organizations, and government agencies active in the watershed of the WFCR, and the greater Carson River Watershed as a whole, are implementing several projects to restore water quality, habitat, and recreational beneficial uses in the river.

Existing plans for the Carson River include Carson Water Subconservancy District's Carson River Watershed Active Stewardship Plan (CWSD 2007, 2017) and the Nevada Division of Environmental Protection's (NDEP's) Alternative Restoration Plan for Improving Water Quality in Segments of the Carson River System in Carson Valley, Nevada (NDEP, 2022). This Vision Plan provides additional detail about activities in the WFCR watershed, and contains, for the WFCR, the 9 key elements recommended by USEPA for Watershed-Based plans (USEPA, 2002), which are a perquisite for receiving Clean Water Act section 319 grant funding for projects to reduce nonpoint source water pollution.

This Vision Plan was developed as an advance restoration plan for attaining water quality standards, consistent with USEPA's 2022-2032 Vision for the Clean Water Act Section 303(d) Program (EPA Vision) (USEPA, 2022). Under Clean Water Act requirements, States must develop Total Maximum Daily Loads (TMDLs) to address impairments where water quality standards are not being met. The EPA Vision recognizes that, in addition to TMDLs, other types of plans may be more immediately beneficial or practicable for restoring water quality, encourages the most effective approaches for restoring water quality and acknowledges how vital creativity and collaboration are for successful restoration. If advance restoration plans are successful, and standards are attained, then TMDLs may not be needed.

The West Fork Carson River was selected by the staff of the Lahontan Water Board for development of an advance restoration plan because there are significant ongoing and historical water quality monitoring activities, and significant efforts by stakeholders to restore and protect water quality in the WFCR. This Vision Plan does not establish or change any existing regulations but rather it references existing regulatory and non-regulatory actions that are expected to result in attainment of Water Quality Standards in the West Fork Carson River. Development and implementation of this Vision Plan does not remove the waterbody from the 303(d) list and does not remove the requirement to develop a TMDL for the impairments. Development and implementation of the Vision Plan does provide a reason for the state to lower the priority for developing TMDLs for the 303(d) listings. If Vision Plan implementation is successful in achieving water quality standards, then the Water Board will recommend removal of the waterbody from the 303(d) list. This Vision Plan also describes planned monitoring and assessment activities to track progress in implementation of the actions described in the plan and improvements in water quality.

This Vision Plan was developed with the assistance and collaboration of stakeholder groups and agencies in the Carson River Watershed, including the Alpine Watershed Group, the Carson River Subconservancy District, Nevada Division of Environmental Protection, and the US Forest Service.

# Table of Contents

## Contents

# List of Acronyms and Abbreviations

AMMM – annual mean of monthly means

AWG – Alpine Watershed Group

CDFW - California Department of Fish and Wildlife

CDWR – California Department of Water Resources

Cl - chloride

CRASP - Carson River Watershed Adaptive Stewardship Plan

CWSD – Carson Water Subconservancy District

FIB – fecal indicator bacteria

HTNF – Humboldt-Toiyabe National Forest

LWB – Lahontan Water Board

mg/L – milligrams per liter

NDEP – Nevada Division of Environmental Protection

NO2 – nitrite

NO3 – nitrate

NH3 – ammonia

LAMP – Local Agency Management Plan

NRCS – Natural Resource Conservation Service

OWTS – onsite wastewater treatment systems

P - phosphorous

STV – statistical threshold value

S.V. – single value

SWRCB – State Water Resources Control Board

SO4 – sulfate

TDS – total dissolved solids

TKN – total Kjeldahl nitrogen

USEPA – United States Environmental Protection Agency

USFS – United States Forest Service

QAPP – Quality Assurance Project Plan

WDR – Waste Discharge Requirements

WFCR – West Fork Carson River

WQO – water quality objective

# 1. Introduction

The West Fork Carson River Vision Project Plan (Vision Plan) documents a process to address multiple pollutants affecting water quality in the West Fork Carson River (WFCR) in Alpine County, California. The WFCR is listed on the State of California's Clean Water Act Section 303(d) list (SWRCB, 2018) as exceeding water quality standards for multiple pollutants. Under Clean Water Act Requirements, the listing of these pollutants on the 303(d) list requires development of Total Maximum Daily Loads, or TMDLs. USEPA's 2022-2032 Vision for the Clean Water Act Section 303(d) Program (EPA Vision) (USEPA, 2022) recognizes that, in addition to TMDLs, other types of plans may be more immediately beneficial or practicable for restoring water quality. The EPA Vision encourages the most effective approaches for restoring water quality and acknowledges how vital creativity and collaboration are for successful restoration.

The Vision Plan is an advance restoration plan to address water quality impairments and help protect against future impairments in the WFCR. The Vision Plan does not establish any new regulatory requirements but discusses existing California Regional Water Quality Control Board, Lahontan (Lahontan Water Board) programs and ongoing and expected future actions which are reasonably expected to result in attainment of water quality standards in the WFCR. When data demonstrates these pollutants are no longer exceeding standards, these waterbodies will be recommended for removal, or delisting, from the Clean Water Act Section 303(d) List. If delisted, TMDLs will no longer be required under the Clean Water Act.

The WFCR was selected by the staff of the Lahontan Water Board for development of an advance restoration plan because there are significant ongoing and historical water quality monitoring, and significant efforts by stakeholders to restore and protect water quality in the WFCR, as well as the greater Carson River system through the implementation of the Carson River Watershed Adaptive Stewardship Plan (CRASP) (CWSD, 2006, CWSD 2017).



## 1.1. Vision Plan Goals and Objectives

The overall goal of the Vision Plan is the attainment of all water quality standards in the WFCR in a reasonably expeditious manner. The Vision Plan sets out a 10-year timetable for implementation, with a goal of attainment of water quality objectives by October 2033.

Objectives related to attaining that goal are:

A. To meet the overall goal in the most efficient manner possible, by utilizing a less resource-intensive advance restoration plan which could result in the attainment of water quality objectives before proceeding with full TMDL development, and

B. To include the 9 key elements for watershed-based plans recommended by the USEPA Nonpoint Source (Clean Water Act Section 319) Program. This is an important objective because it maps out a process recommended for ensuring standards attainment, and because inclusion of these 9 key elements will make projects addressing nonpoint source pollution in the WFCR watershed eligible for Clean Water Act section 319 grant funding. The 9 key watershed-based plan elements are:
   1) An identification of the causes and sources that need to be controlled.
   2) An estimate of the load reductions expected.
   3) A description of management measures that will need to be implemented to achieve the load reductions.
   4) An estimate of the technical and financial assistance needed.
   5) An information and education component
   6) A schedule for implementation
   7) A description of measurable milestones for implementation
   8) Criteria to measure progress towards attaining standards.
   9) A monitoring program to evaluate effectiveness

## 1.2. Document Organization

This Vision Plan is organized as follows:

- Section 1 Introduces the West Fork Carson River Vision Plan need, goal and objectives.
- Section 2 Provides the background information about the West Fork Carson Watershed.
- Section 3 Provides information on water quality standards.
- Section 4 Contains a summary of the relevant quality monitoring data, and load reductions needed to attain standards.
- Section 5 Describes the causes and sources of the relevant water quality issues (addressing watershed-based plan key element #1).
- Section 6 Details the implementation plan to address the impairment by source, an estimate of the technical and financial assistance needed, and information and education component and a schedule (addressing watershed-based plan key elements #2, 3, 4, 5 and 6).
- Section 7 Provides details of stakeholder communications undertaken in development of this Vision Plan.
- Section 8 Provides details of the monitoring and reporting required to achieve Vision Plan goals. (Addressing watershed-based plan key element #9).
- Section 9 Includes information for Vision Plan evaluation and adaptive management strategies over the life of the Vision Plan (addressing watershed-based plan key element #7 and 8).

## 2. Background: Watershed and Hydrology

The West Fork Carson River (WFCR) flows northeast from its headwaters high in the Sierra, through Alpine County to the Nevada State line as shown in Figure 2-1. The WFCR combines with the East Fork Carson River near Genoa, Nevada to form the Carson River which flows northeast into its eventual terminus at the Carson Sink, as shown in Figure 2. This Vision Plan focuses on the WFCR and its watershed in California, which is all located in Alpine County (hereafter referred to as the WFCR watershed). A description of the entire Carson River Watershed is available through the Carson River Adaptive Stewardship Plan (CWSD, 2006, CWSD 2017).

The WFCR begins at over 8,000 feet along the crest of the Sierra Nevada near Carson Pass at Lost Lakes, then flows north through Faith Valley. After Faith Valley, the WFCR flows north and then east through Hope Valley. After Hope Valley, starting near Pickett's Junction, the WFCR flows northeast through a steep canyon, until it enters the southern part of the Carson Valley near the community of Woodfords and continues north to the Nevada state line. The WFCR then roughly parallels Highway 88 from Hope Valley until the state line, crossing under the highway multiple times. The WFCR is fed by several smaller tributaries along its route, including, from upstream to downstream, Forestdale Creek, Red Lake Creek, Hawkins Creek, Willow Creek, and Horsethief Creek.

The WFCR's watershed is located in a rural area, mostly consisting of forestland and alpine meadows, with minimal development and land use dominated by recreation and open space. Most of the WFCR watershed is located in the Humboldt-Toiyabe National Forest (HTNF). There is dispersed camping on the HTNF land, especially near Scotts Lake, Red Lakes, and Paradise Valley. There is one active grazing allotment on HTNF land in Hope Valley and areas upstream of the Valley. In addition, there are dispersed residences, two minor residential areas (Woodfords and Mesa Vista), one vacation resort and a few campgrounds in the watershed downstream of Hope Valley. Most of these land uses occur along the river. Downstream of Woodfords, there are rangelands used for cattle grazing in the watershed, many of which are adjacent to the river.

Flows in the WFCR consist mostly of snowmelt, baseflow from groundwater and, to a much lesser extent, releases from reservoirs in its headwaters: East and West Lost Lakes, Red Lake, Crater Lake and Scotts Lake. Collectively, these reservoirs which are all upstream from Woodfords, can store about 2,000 acre-feet of water (Hess, 1996). Water from the WFCR is diverted by pumping, as well a system of multiple ditches which divert water from the WFCR in its lower reaches, starting just upstream of Woodfords. This water is used to irrigate pasturelands along the river. Some of the water may return to the river as tailwater via surface runoff or where the ditches drain to the river on their downstream end.

A US Geological Survey flow gauge at on the WFCR Woodfords provides a long running record of flows in the WFCR, from 1901 through the present. Data from this gauge is available at https://waterdata.usgs.gov/ca/nwis/uv/?site_no=10310000

Based on data from this gauge from 1901 through 2021, WFCR flows typically peak in May with snowmelt. The median of the annual maximum daily average flow is around 600 cubic feet per second (cfs). The flow in the WFCR then rapidly decreases after its peak in May through September. The median of the annual minimum daily average flow is around 14 cfs. After the minimum flow in September, the flow in the WFCR rises and falls, with a gradual overall rise resulting from storm runoff events from October until March, when snowmelt causes a rapid rise in flows until peaking again around May. Maximum flows in the period of record are caused by rain-on snow events, the highest daily average flow of 5,500 cfs was recorded on January 2, 1997. The highest instantaneous streamflow of 8,100 cfs was measured on January 1, 1997. Annual average flows range from 30 to over 263 cfs, with a median annual average flow of 86 cfs which is equivalent to about 62,000 acre-feet per year. A detailed description of flows, geology, and channel conditions in the WFCR is available in the Upper Carson River Watershed Stream Corridor Assessment (MACTEC Engineering and Consulting, et al., 2004).

Reservoir releases and water withdrawals in the WFCR are regulated according to the Alpine Decree. The Alpine Decree is administered by a Federal Water Master who is appointed by the Federal District Court. The Federal Water Master employs a staff that maintains the records of each claim contained in the Alpine Decree and several ditch riders that monitor and administer the diversion of water from the Carson River.

Recycled water from the Tahoe Basin is used to irrigate rangelands in the WFCR watershed. Advanced secondary treated effluent from the STPUD wastewater treatment plant in South Lake Tahoe is pumped out of the Tahoe Basin over Luther Pass and into Harvey Place Reservoir in Diamond Valley, which is adjacent to the WFCR basin. This recycled water from Harvey place reservoir is then delivered via Diamond Valley Ditch to irrigate surrounding pastures, including rangelands along the WFCR.

In addition to government agencies, there are multiple groups active in the stewardship of the WFCR watershed. Ongoing coordination and collaboration with these groups will be critical to the success of this Vision Plan.

The Carson Water Subconservancy District (CWSD) is a unique bi-state non-regulatory agency which is funded by ad valorem taxes. CWSD develops watershed-wide planning documents, such as the Carson River Watershed Adaptive Stewardship Plan (CRASP) (CWSD, 2006, 2015), which help to coordinate regional efforts and are essential for obtaining federal grant monies. The CRASP serves as a 9 - Element Watershed-Based Plan for the Carson River Watershed in Nevada. A goal of this Vision Plan is to function as a 9-Element Watershed Based Plan for the WFCR portion of the Carson River Watershed in California. CWSD also provides grant funding to local entities for project implementation and implements watershed monitoring, education and restoration activities. Finally, CWSD serves as the coordinating agency for the Carson River Coalition (CRC), a large stakeholder group of federal, state, county, and tribal agencies, non-governmental entities, private citizens and landowners.

The Alpine Watershed Group (AWG) is a local nonprofit watershed group in Alpine County, CA. As a watershed group they are a locally organized, voluntary, non-regulatory group established to assess the condition of the watershed. They implement monitoring restoration and education programs in to protect, conserve and restore the watersheds of Alpine County, which includes headwaters of the Carson, Truckee, Stanislaus, Mokelumne, and American Rivers. They are a key partner to the CWSD in implementing the CRASP in Alpine County.

CWSD and AWG work with numerous other government agencies and stakeholders in their stewardship activities in the WFCR watershed, including Alpine County, the Carson Ranger District of the Humboldt-Toiyabe Nation Forest, California Department of Fish and Wildlife (CDFW), Friends of Hope Valley, the Washoe Tribe of Nevada and California, the National Fish and Wildlife Foundation, and the Sierra Nevada Conservancy. There are several past and ongoing restoration projects in the WFCR watershed which are expected to improve long-term water quality in the WFCR. Many of these projects are described at https://www.alpinewatershedgroup.org/restoration.

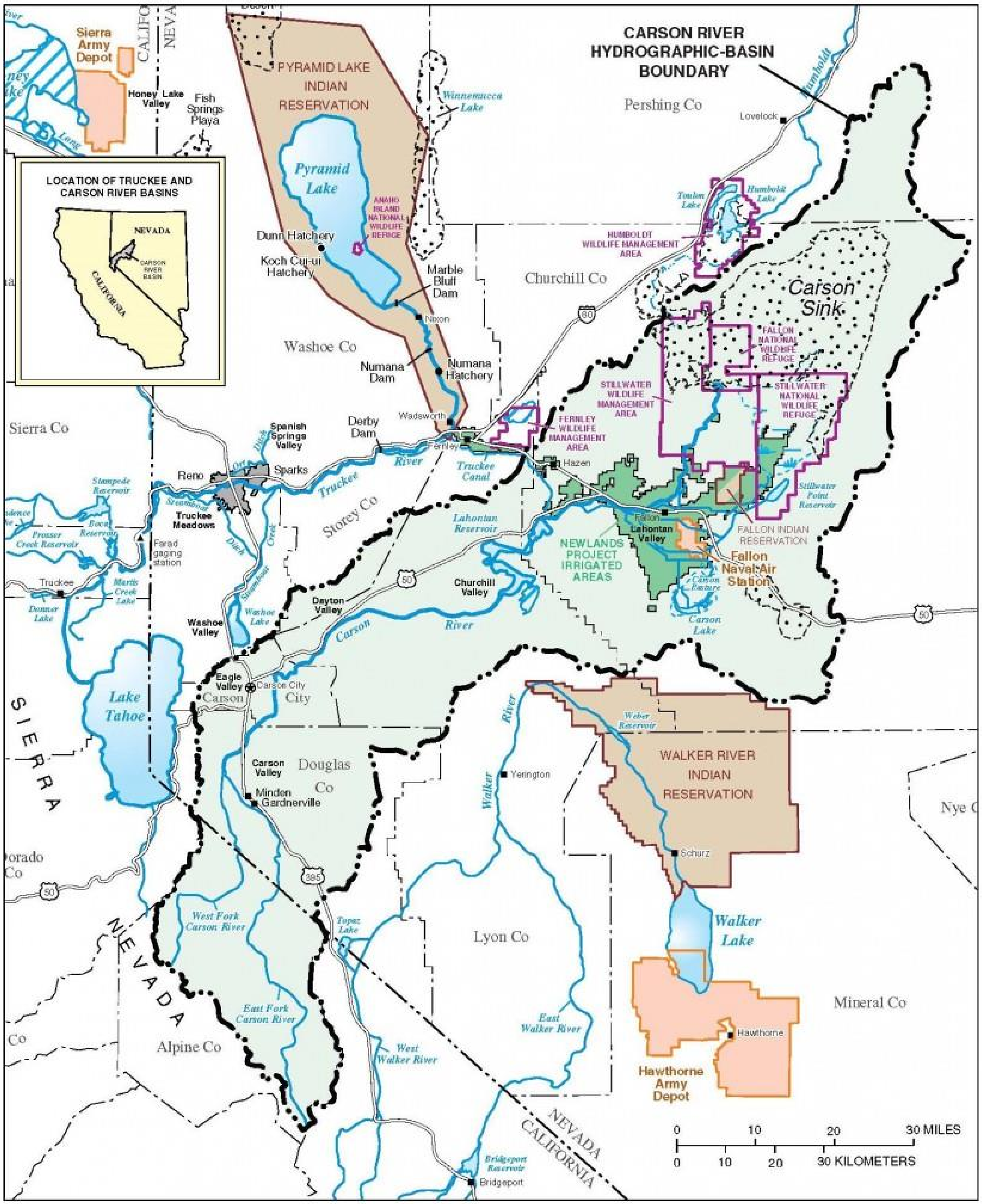


***Figure 2-1. the Carson River Watershed (map provided by USGS)***

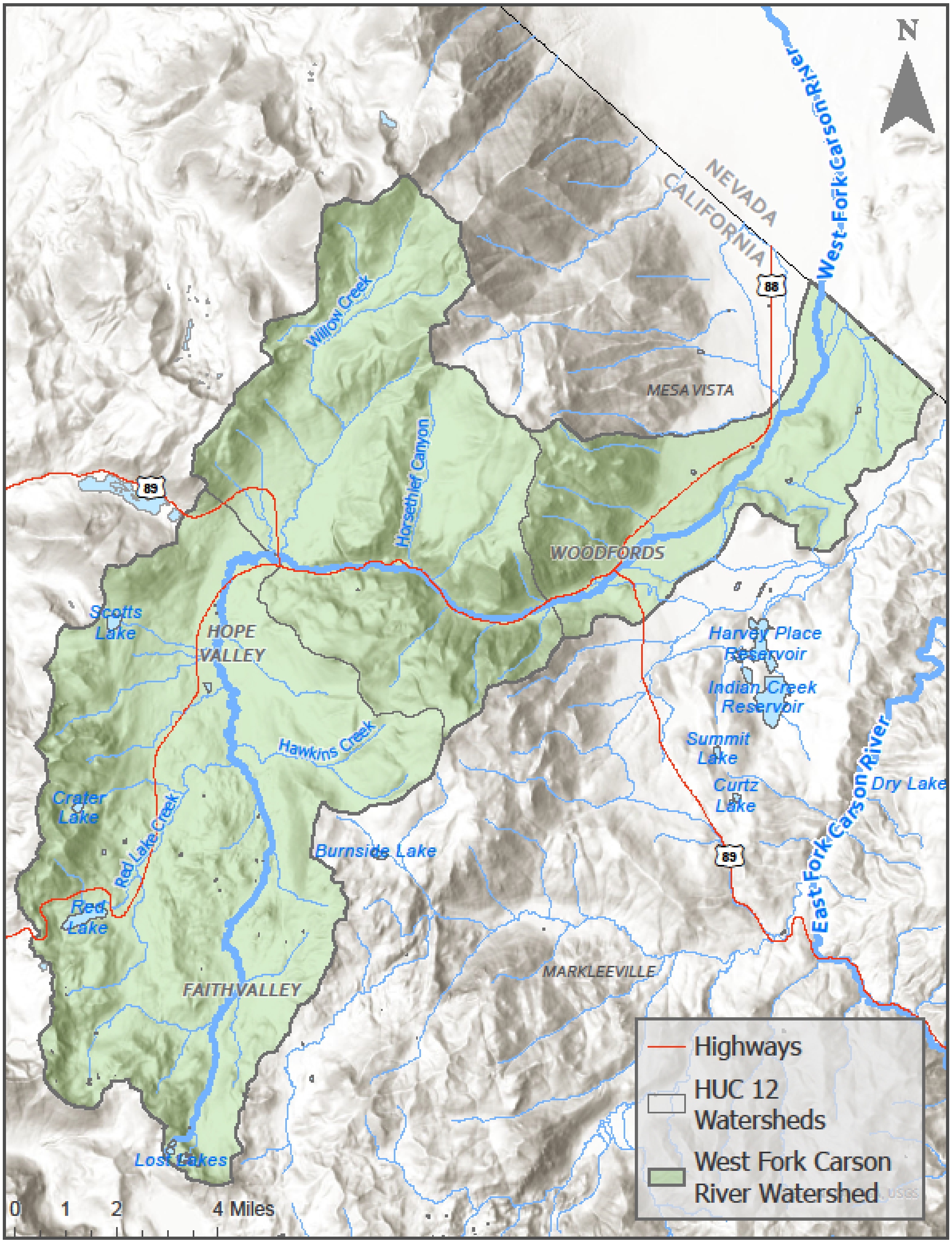


*Figure 2-2. West Fork Carson River Watershed*

# 3. Water Quality Standards

Water quality standards for the West Fork Carson River are principally established in the Lahontan Water Board's Water Quality Control Plan for the Lahontan Region (Basin Plan) (CRWQCB-LR, 2021). Additional water quality standards applicable in the Lahontan Region are established by the State Water Resources Control Board in the Water Quality Control Plan for Inland Surface Waters, Enclosed Bays, and Estuaries of California and in the California Toxics Rule promulgated by the United States Environmental Protection agency (USEPA, 2001).

Water quality standards include beneficial uses of a waterbody (such as uses for drinking water, aquatic habitat, recreation and agriculture), water quality objectives (WQOs), which are numeric and/or narrative water quality conditions protective of those uses (such as maximum concentrations of pollutants), along with antidegradation provisions that limit degradation of high-quality waters.

The West Fork Carson River is designated with fourteen (14) beneficial uses; information about which can be found in Table 2-1 op Page 2-17 in Chapter Two of the Basin Plan. These designated beneficial uses include municipal and domestic drinking water supply, agriculture, water contact recreation and cold freshwater habitat.

WQOs for the WFCR in the Basin Plan include the following:

- General WQOs that apply to all Lahontan Region surface waters including the WFCR, on pages 3-3 through 3-6,
- WQOs for the WFCR on page 3-9, and
- Site specific WQOs for two sites on the WFCR in Table 3-14 on page 3-40.

Additionally, the State Water Resources Control Board has established fecal indicator bacteria (FIB) WQOs applicable to the WFCR in the Bacteria Provisions of the Water Quality Control Plan for Inland Surface Waters, Enclosed Bays, and Estuaries of California – Bacteria Provisions (SWRCB, 2018).

A Basin Plan Amendment that proposes to remove the fecal coliform WQOs from the Basin Plan was adopted by the Lahontan Water Board in June 2023, and is expected to be considered for approval by the State Water Resources Control Board, Office of Administrative Law and finally USEPA in 2024. More information on this Basin Plan Amendment can be found at the Water Board's Basin Planning webpage.

Tables 3-1, 3-2, and 3-3 summarize the WQOs associated with the 303(d) impairment listings for WFCR. It should be noted that there are other WQOs applicable to the WFCR.

***Table 3-1 WFCR Water Quality Objectives from Basin Plan Pages 3-4 and 3-9 that are Associated with the Impairment***

| Constituent | Water Quality Objective |
|---|---|
| Iron | 0.3 mg/L (drinking water maximum contaminant limit incorporated by reference on Basin Plan page 3-4)) |
| Fecal coliform | The fecal coliform concentration during any 30-day period shall not exceed a log mean of 20/100 ml, nor shall more than 10 percent of all samples collected during any 30-day period exceed 40/100 ml. |
| Turbidity | 2 NTU, mean of monthly means |

***Table 3-2. WFCR Water Quality Objectives from Basin Plan Table 3-14 that are Associated with the Impairment (All values shown are mean of monthly means for the period of record)***

| Surface Waters | TDS (mg/L) | Cl (mg/L) | $SO_4$ (mg/L) | Total P (mg/L) | Total N (mg/L) | TKN (mg/L) | $NO_3$-N (mg/L) |
|---|---|---|---|---|---|---|---|
| West Fork Carson River at Woodfords | 55 | 1.0 | 2.0 | 0.02 | 0.15 | 0.13 | 0.02 |
| West Fork Carson River at Stateline | 70 | 2.5 | 2.0 | 0.03 | 0.25 | 0.22 | 0.03 |

Cl = Chloride
N = Nitrogen, Total
$SO_4$ = Sulfate
TDS = Total Dissolved Solids
$NO_3$-N = Nitrate as Nitrogen
TKN = Total Kjeldahl Nitrogen
P = Phosphorus, Total

***Table 3-3. WFCR WQOs Established by State Board that are Associated with the Impairment***

| Constituent | Water Quality Objective |
|---|---|
| E. Coli | ≤100 colony forming units (CFU) /100 mL six-week geometric mean, calculated weekly<br><br>Single threshold value - No more than 10% of samples >320 CFU/100 mL in any calendar month |

In addition to the standards applicable to the WFCR in California, the water quality standards shown in Table 3-4 are established by NDEP for these constituents are applicable to the WFCR at the state line where it flows into Nevada. Note this list is not exhaustive but focused on the parameters addressed in the Plan. The NDEP standards can be found at https://www.leg.state.nv.us/nac/nac-445a.html#NAC445ASec1796 and https://www.leg.state.nv.us/nac/nac-445a.html#NAC445ASec1236

***Table 3-4. Selected State of Nevada Water Quality Standards applicable to the WFCR at the State Line (Nevada Administrative Code, 445A.1796)***

| Constituent | Water Quality Criteria |
|---|---|
| Iron, dissolved (mg/L) | 96-hour average < 1 |
| Fecal Coliform (no/100 ml) | S.V.≤ 1,000 |
| Turbidity (NTU) | Single Value (S.V.) ≤ 10 |
| TDS (mg/L) | Annual average. ≤ 500 |
| Cl (mg/L) | S.V.≤ 250 |
| $SO_4$ (mg/L) | S.V. ≤ 250 |
| Total P | Annual average ≤ 0.10 |
| $NO_3$-N | S.V.≤ 10 |
| E. Coli | Geometric mean. ≤ 126<br>S.V. ≤ 410 |

The State of Nevada has different 303(d) listings for the WFCR at the state line, due to the different water quality standards in Nevada. None of parameters which are 303(d) listed in California for the WFCR are 303(d) listed in Nevada. The State of Nevada's 303(d) listings for the WFCR at state line, and applicable Water Quality Criteria established for in Nevada these constituents are shown in Table 3-5. It should be noted that these impairments are considered low priority by the State of Nevada, as discussed in section 4.1 below.

***Table 3-5. State of Nevada 303(d) Listings for the WRFC at the State Line (NDEP and Associated State of Nevada Quality Criteria (Nevada Administrative Code, 445A.1796)***

| Constituent | Water Quality Criteria |
|---|---|
| Temperature (degrees C) | Single Value (S.V.) Nov-May ≤ 13<br>S.V. Jun ≤ 17<br>S.V. Jul ≤ 21<br>S.V. Aug-Oct ≤ 22<br>ΔT ≤ 2 |
| Cadmium | 1 hour average and 96-hour average concentration as defined by USEPA Aquatic Life Ambient Water Quality Criteria for Cadmium. 2016 |
| Silver | 1-hour average as defined in U.S. Environmental Protection Agency, National Recommended Water Quality Criteria, May 2009. |
| Beryllium | 0 mg/L |

# 4. WFCR Water Quality

This section summarizes the water quality for the WFCR with a focus on constituents causing the water quality impairments which are addressed in this Vision Plan. Available data are summarized and compared to the applicable WQOs described above, and estimations of pollutant reductions needed to attain standards are calculated.

As discussed in Section 4.1, there are multiple water quality impairments in the WFCR. However, as shown in the sections below, the magnitude and frequency of WQO exceedances causing the impairments in the WFCR are not extreme in magnitude or very frequent. Additionally, data show that WQOs related to multiple other constituents (such as dissolved oxygen, toxicity, pesticides and other organic pollutants) are attained in the WFCR (SWRCB, 2021). It also be noted that the watershed is recovering from the impacts of the historical activities discussed in Section 5.1, which were much greater than the impacts of any current activities (MACTEC et al., 2004).

Generally, pollutant concentrations in the Carson River system increase in the downstream direction as discussed in this section for the WFCR, and in Glancy and Katzer, (1975) and Alvarez and Seiler (2004). Therefore, water quality improvements in the WFCR can help address downstream impairments and protect against potential future water quality impairments.

## 4.1. Water Quality Impairments in the WFCR

Water quality data for the Lahontan Region is assessed in comparison to water quality standards during the development of the Clean Water Act section 303(d) list, which is prepared under the State's Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List (Listing Policy), (SWRCB, 2015). The 303 (d) list is part of the State of California's Integrated Report for Clean Water Act Sections 305(b) and 303(d) (Integrated Report), (SWRCB, 2020).

In the current (2018) Integrated Report, the WFCR is assessed in three segments. These three segments, and the primary monitoring stations used to assess their water quality are shown in figure 4-1. Constituents listed as exceeding WQOs, or "impairments" for these segments are listed in Table 4-1. The first WFCR segment begins at the headwaters and extends to the downstream end of Hope Valley. The second segment begins at the downstream end of Hope Valley and extends to Woodfords. The third segment extends from Woodfords to the Nevada state line. The WFCR was segmented this way for assessment because of the distinct land uses and hydrogeology of each segment.

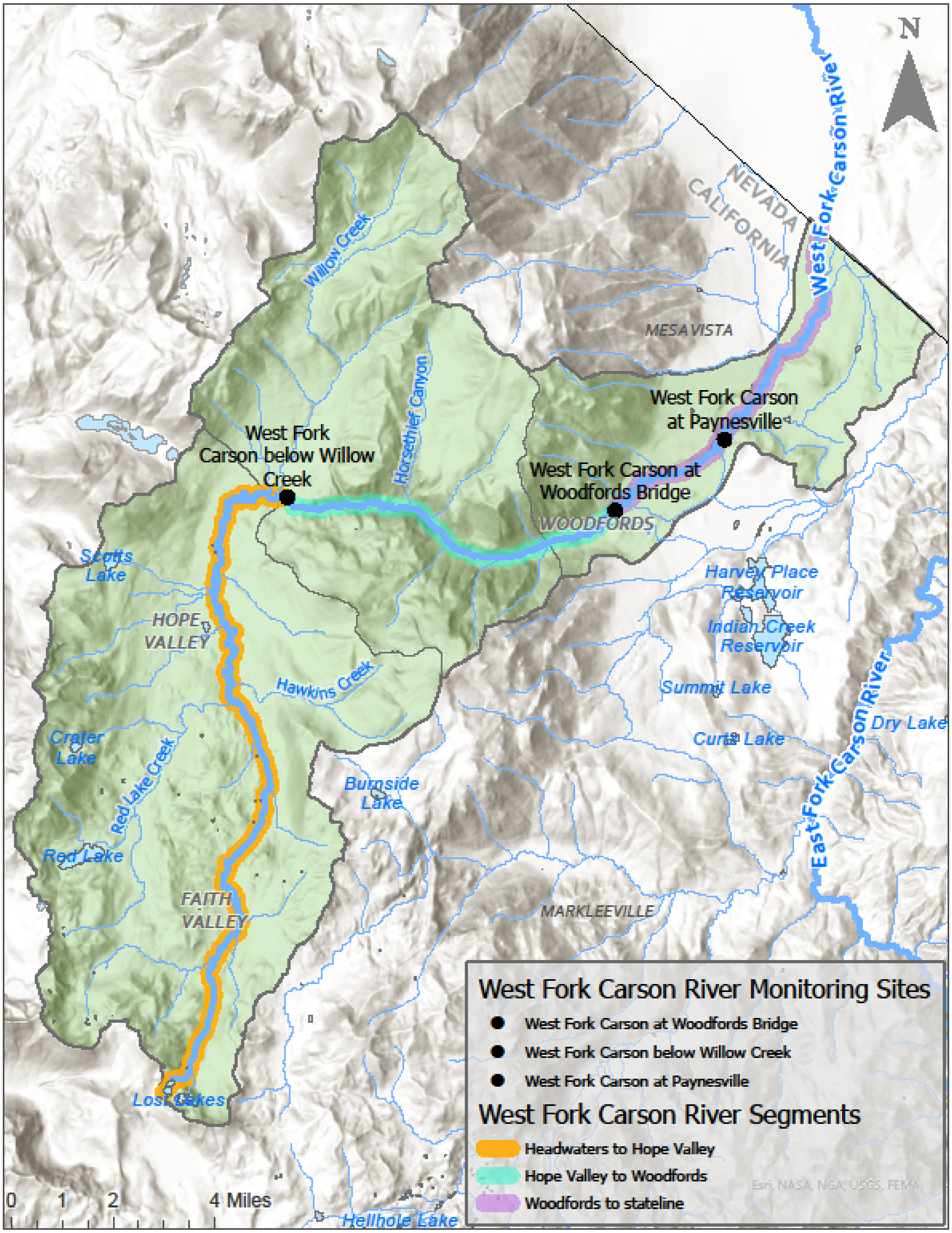


***Figure 4-1. West Fork Carson River Segments and Primary Monitoring Stations***

*Table 4-1 WFCR Segments and 303(d)-Listed Impairments*

| WFCR Segment | Water Quality Impairments |
|---|---|
| Headwaters to Hope Valley | Nitrogen (Nitrate, TKN), Phosphorous, Sulfates |
| Hope Valley to Woodfords | Chloride, Nitrogen (N, Nitrate, TKN), Phosphorous, Sulfates, Total Dissolved Solids, Turbidity |
| Woodfords to State Line | Fecal Indicator Bacteria, Iron, Nitrogen (N, Nitrate, TKN), Sulfates, Total Dissolved Solids, Turbidity |

The impairments of the WFCR shown in Table 4-1 are all associated with potential impacts to aquatic life beneficial uses of the WFCR, except for the fecal indicator bacteria impairment, and the iron impairment, which is associated with the municipal and domestic supply beneficial use. Additionally, the Nevada Division of Environmental Protection's most recent Integrated Report has multiple listed impairments for the WFCR at the state line, as shown in table 4-2.

***Table 4-2. NDEP 303(d)-listed impairments for the WFCR at State Line (from NDEP, 2022b, Attachment 2B).***

| Standard | Impaired Use | TMDL Priority | NDEP Priority Reason |
|---|---|---|---|
| Cadmium 1-hour | Aquatic Life | Low | Natural background |
| Cadmium 96-hour | Aquatic Life | Low | Natural background |
| Silver 1-hour | Aquatic Life | Low | Natural background |
| Temperature Single Value | Aquatic Life | Low | |
| Beryllium | Municipal or Domestic Supply | Low | The water quality standard needs to be revised |

NDEP's current Integrated Report lists the WFCR at state line as impaired by temperature, cadmium, silver, and beryllium (NDEP, 2022b). These impairments are all listed as low priority for TMDL development by NDEP. The cadmium and silver listings are considered natural background concentrations. NDEP is currently developing a Use Attainability Analysis UAA to revise the subcategory of designated aquatic life use, from cold-water to warm-water fishery, for segments of the Carson River in the Carson Valley. NDEP also classifies their beryllium listings as a standards issue, as Nevada's current standard is 0 µg/L, whereas the standard for the most sensitive beneficial use for the protection of drinking water standard is 4 µg/L and there are no exceedances of the 4 µg/L drinking water protection standard.

NDEP has also finalized TMDLs for the Carson River for phosphorus (NDEP,2005) and turbidity and Total Suspended Solids (NDEP, 2007) to address impairments for these constituents downstream in the Carson River. However, because nonpoint sources are the primary contributor to these impairments, TMDLs by themselves were ineffective at resolving these impairments under Nevada's legal and regulatory structure (NDEP, 2002a). Therefore, these constituents are also a focus of the NDEP's Alternative Restoration Plan for the Carson River (NDEP, 2022a) which takes advantage of work being done under NDEP's Nonpoint Source Program and under the Carson River Adaptive Stewardship Plan (CWSD and CRC, 2007 and 2017). The NDEP TMDLs for the Carson River noted that the concentrations and number of exceedances for these constituents increase in a downstream direction. These TMDLs did not require any reductions for the WFCR at the state line, since the WFCR met NDEP standards for these constituents at the state line. Nevertheless, further reductions of TSS, turbidity and phosphorus in the WFCR in California to meet California standards will help reduce downstream concentrations. For these TMDL constituents, high flow conditions were associated with the majority of the pollutant load, indicating that restoring riverbanks and preventing erosion will be the most effective way to achieve water quality standards for these constituents in the Carson River (NDEP 2022).

## 4.2. Available Water Quality Data and Studies

There are currently four monitoring programs collecting water quality data in the West Fork Carson River, as well as historical monitoring by the US Geological Survey. The data these programs generated in the WFCR are summarized in Table 4-3.

A description of these monitoring programs and completed monitoring studies in the Carson River watershed is available in Chapter 7 of the CRASP (CWSD, 2017). Table 4-4 contains a summary of studies in the WFCR. Table 4-4 is adapted from and can considered an update/addendum to table 7.2.12-1 of the CRASP, focused on the WFCR. All available data for WFCR water quality from these sources were compiled and used in the subsequent analysis in developing this Vision Plan. The data set used for the Vision Plan includes WFCR data that were not used in the most recent (2018) Integrated Report update. Recommendations for coordinating ongoing monitoring and integration of the data are included in Section 9 of this Vision Plan.

***Table 4-3. West Fork Carson Water Quality Data Sources***

| Organization | Program | Primary Locations | Timing and Frequency | Data Source |
|---|---|---|---|---|
| Lahontan Water Board | Surface Water Ambient Monitoring Program (SWAMP) | Downstream of Willow Creek, Woodfords, Paynesville | Quarterly 2010-present | CEDEN |
| Nevada Division of Environmental Protection (NDEP) | Ambient Monitoring | Woodfords, Paynesville | Approximately quarterly 1966-present | NDEP Water Quality Data Warehouse |
| Alpine Watershed Group | Upper Carson River Monitoring | Pickett's Junction, Woodfords, Paynesville | Approximately quarterly 2004-present | CEDEN |
| South Tahoe Public Utilities District | Alpine County Surface Water Monitoring | Downstream of Willow Creek, Woodfords, Paynesville | Monthly, 1980-present | Provided by STPUD |
| US Geological Survey | NAWQA | Downstream of Willow Creek | Quarterly, 2003-2005 | USGS water data library |

***Table 4-4. WFCR (in CA) Water Quality Completed Studies (Adopted from CWSD, 2017 Table 7.2.12-1, with updates)***

| Title/Program | Locations | Dates | Lead Organization & Partners | Description (reference) |
|---|---|---|---|---|
| Upper Carson River Water Quality Monitoring Program | East Fork, West Fork | March 2007 | Alpine County, CWSD, STPUD, DRI | The goal of the project was to provide baseline water quality data. Final report completed in June 2007. |
| Characterization of Turbidity and Total Suspended Solids in the Upper Carson River, Nevada | East Fork, West Fork, Carson River | September 2007 | DRI, NDEP | Report of monitoring done at four sites: Diamond Valley (West Fork); Riverview (East Fork); Genoa Lakes (Carson River); and Brunswick Canyon (Carson River). (Susfalk et al., 2008) |
| Analysis of Streamflow Trends, Groundwater and Surface Water Interactions, and Water Quality in the Upper Carson River Basin, Nevada and California | Upper Carson River Basin, Nevada and California | 2008 | USGS | USGS Scientific Investigations Report 2008-5238 |
| Alternative Restoration Plan for Improving Water Quality in Segments of the Carson River System in Carson Valley, Nevada. | Carson Valley | Completed 2002 | NDEP | Vision Plan for the Carson River in Nevada. Addresses NDEP TMDLs and impairments for the Carson River. Discusses upstream sources from the WFCR and East Fork Carson River. (NDEP, 2002a) |

## 4.3. Sediment and Turbidity

While turbidity levels are more variable in the upstream segments, turbidity in the WFCR generally increases as it flows downstream. The two lower segments of the WFCR (Hope Valley to Woodfords and Woodford to the state line) are listed on the 303(d) list as impaired for turbidity. The watershed-wide objective for turbidity in the West Fork Carson River hydrologic unit, including the WFCR, as stipulated in the Lahontan Basin Plan page 3-9, is a mean-of-monthly means not to exceed 2 NTU. For purposes of the Integrated Report assessments, the mean of monthly means is calculated on an annual basis, giving a single annual mean of monthly means (AMMM) for each year with available data. Figure 4-2 shows boxplots of AMMM turbidity for each reach of the WFCR. The State of Nevada’s turbidity water quality criteria of 10 NTU for the WFCR at state line as a single maximum value was rarely exceeded. Turbidity measurements from the WFCR from the Woodfords to state line exceeded the 10 NTU criterion concentration 27 times in over 1,500 measurements (approximately 2%), with 53 years of available data.

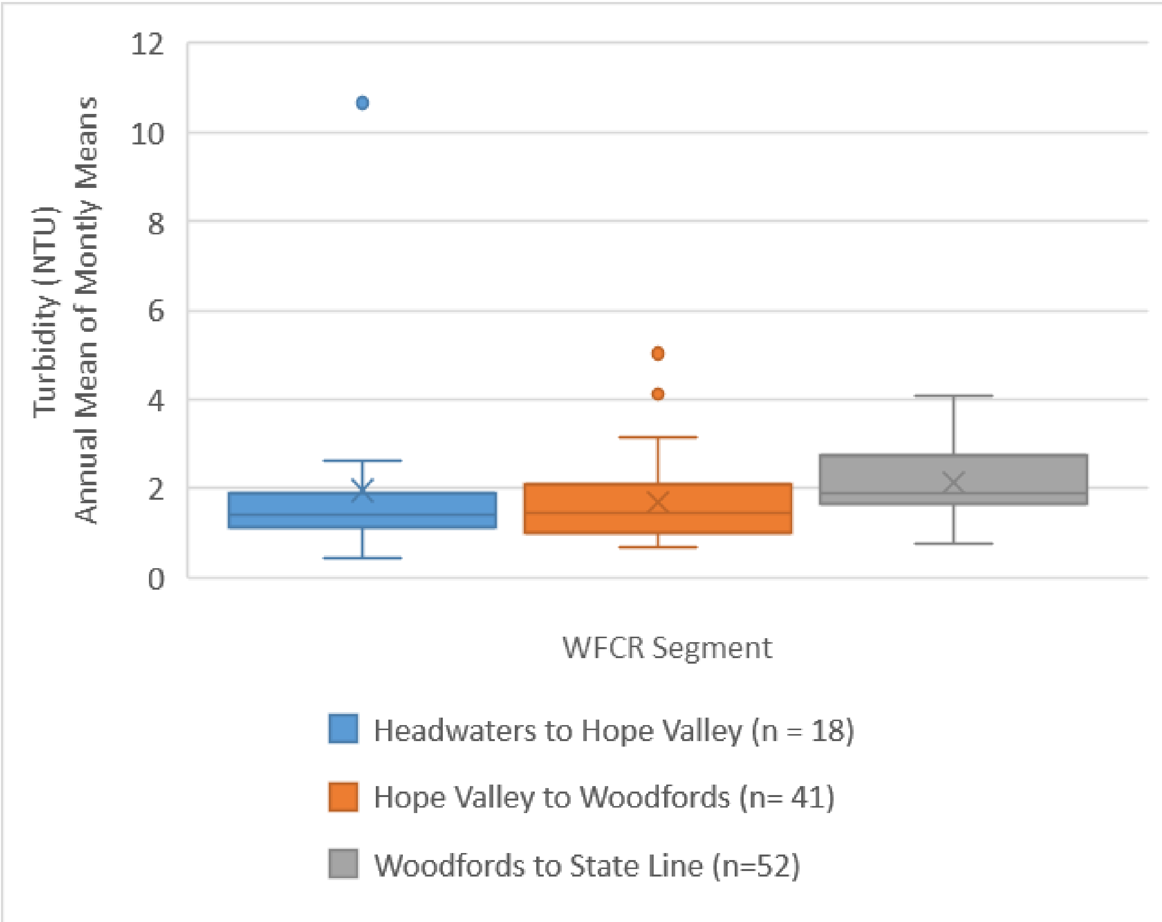


***Figure 4-2. WFCR Turbidity Boxplot[1]***

[1] *Explanation of the box plot:* The rectangular part (box) of the plot extends from the lower quartile (25th percentile) to the upper quartile (75th percentile), covering approximately the center half of the data. The horizontal lines within each box show the value of the median sample concentration. The whiskers extend from the box to the minimum and maximum concentration values, unless there are any values 'outside' 1.5 times the interquartile range (the range between the 25th and 75th percentile values, i.e., the inter-quartile range [IQR]). If there are concentration values beyond (above) 1.5 times the IQR, the whisker ends at the value equal to 1.5 times the IQR, and 'Outside' concentration values are plotted above or below the whisker as individual dots. The X shows the mean value.

Monthly average turbidity for all stations in the WFCR is shown Figure 4-3. Turbidity in the WFCR peaks with high flows in May. Elevated turbidity continues through late summer and early autumn, when flows are lower, but conditions favor algal growth in the river and its tributary streams and reservoirs. These algae may also contribute to turbidity, but the main cause appears to be sediment.

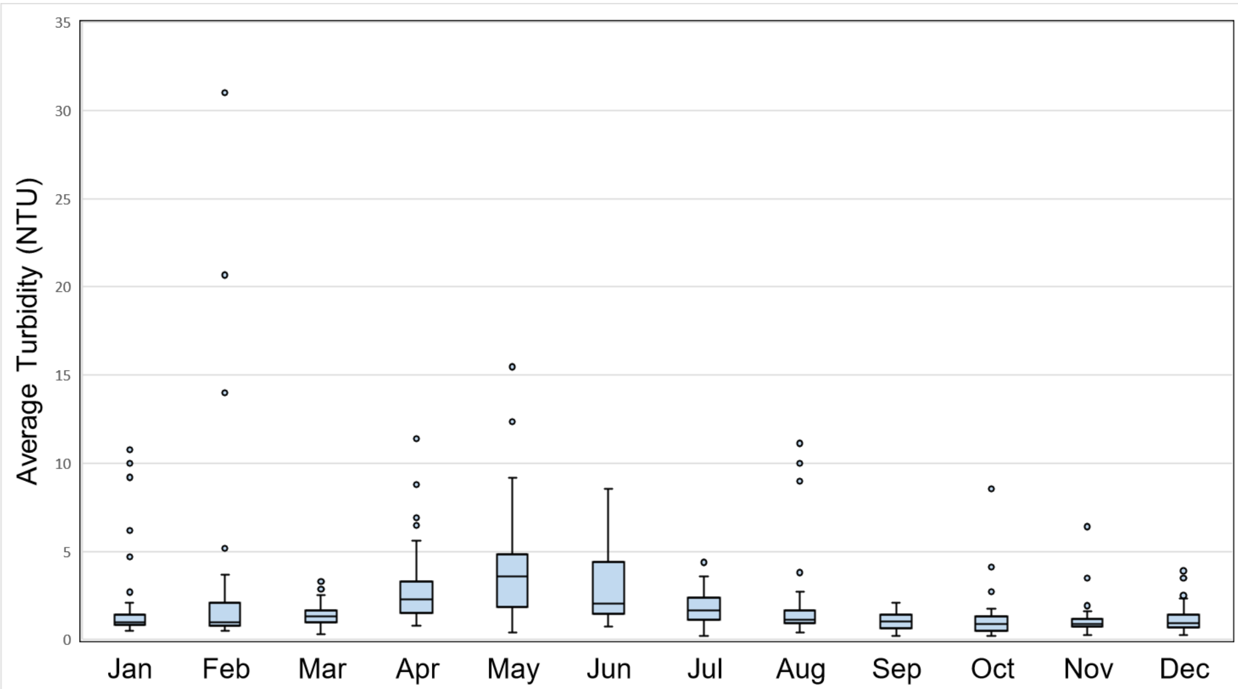


***Figure 4-3. Monthly Average Turbidity for all WFCR Stations***

The Listing Policy (SWRCB, 2015, Tables 3.2 and 4.2) gives the maximum number of allowable exceedances below which a segment is considered in attainment of standards for conventional pollutants. The number of exceedances from the Listing Policy can be used as a basis for adding or removing waterbody segment pollutant combinations from the 303(d) List. Table 4-5 shows the number of exceedances for each segment, the number of years with AMMM turbidity data, and the maximum number of allowable exceedances from the Listing Policy. Table 4-5 also shows the percent reduction of the AMMM turbidity that would result in a reduction in the number of exceedances to support de-listing – based on the existing AMMM turbidity data. Table 4-2 also includes descriptive statistics for the turbidity in each segment.

***Table 4-5. WFCR Turbidity***

| WFCR Segment | WFCR Headwaters to Hope Valley | Hope Valley to Woodfords | Woodfords to State Line |
|---|---|---|---|
| Years with AMMM Turbidity Data | 18 (2002-2019) | 41 (1981-2021) | 52 (1969-2021, except 1980) |
| Years with AMMM Turbidity > 2 NTU WQO | 4 | 11 | 23 |
| Maximum Exceedances to Delist | 4 | 6 | 8 |
| Median AMMM Turbidity | 1.4 | 1.5 | 1.9 |
| 90th Percentile AMMM Turbidity | 3.4 | 3.0 | 3.2 |
| Maximum AMMM Turbidity | 10.7 | 5.0 | 4.1 |
| Approximate% reduction needed to delist | NA | 24% | 33% |

The maximum reduction required was for the Woodfords to State Line segment, where a 33% reduction in AMMM Turbidity would reduce the number of exceedances from 23 to 8, which would support delisting of that segment.[2] Therefore a 33% reduction in turbidity concentrations would be expected to result in the turbidity standard being consistently attained in all three segments of the WFCR. During extremely high flow events or other times with high turbidity, the turbidity would still occasionally exceed the WQO, but if the WQO is attained during most years, the water quality standard could be considered in attainment.

The seasonality of the data, as well as the correlation of turbidity with total suspended solids (TSS) and flows indicate that sediment is the main cause of turbidity exceedances in the WFCR. Later in the year, algae contribute to the turbidity, but sediment appears to be the dominant source of turbidity. Flow, turbidity and TSS correspond very well for the WFCR (Susfalk, et al., 2008) with TSS and Turbidity increasing due to more erosion during high flow events. No clear long-term trend in TSS or turbidity was observed in the historical data.

To estimate the sediment reductions needed to consistently attain the turbidity water quality objective, a relationship of total suspended solids to turbidity was determined,

[2] The percent reduction was estimated using the historical data and the Excel "Goal Seek" analytical tool, which iteratively applied an increasing percent reduction in concentrations until the number of exceedances were reduced to a number that would support delisting.

and then load reduction estimates were determined using the TSS and the available flow data from the Woodfords gauge.

A TSS to turbidity correlation was determined using linear regression for data for all stations on the WFCR. There were 1,913 occasions when TSS and turbidity data were both available for the same site and collection time. A linear regression on these data pairs yielded the following relationship:

TSS (mg/L) = 2.4 * Turbidity (NTU)

This regression had an r squared value of 0.67, meaning 67% of the variability in TSS is explained by the variability in Turbidity. This relationship is adequate for providing an estimate of the sediment reductions needed to attain the turbidity standards for the WFCR. More complex models relating turbidity to sediment could produce a tighter correlation should data and resources be available in the future to refine this relationship.

Given the linear relationship between TSS and turbidity, the 33% reduction in turbidity needed to attain the turbidity WQO in the WFCR corresponds to approximately 33% reduction in TSS, or sediment loading.

Historic loading rates were calculated for the WFCR at Woodfords and the WFCR at Stateline using flow data from the USGS Gauge at Woodfords and TSS data collected at Woodfords, and in the WFCR from between Woodfords and the State Line (near Paynesville and at State Line). Annual loads were calculated by multiplying flow data and TSS concentrations, applying a conversion factor to get daily loads, daily loads were used to estimate monthly loads and monthly loads were summed to obtain annual TSS/sediment loads. The estimated annual loading rates are summarized in Table 4-6. Since there is not a flow gauge at State Line, the flow at Woodfords was used to estimate the loads there. There are not any significant tributaries entering the WFCR between Woodfords and the State Line, but there are diversions from the WFCR in that reach during summer and fall months. Therefore, the flows in those reaches might be overestimated, although these lower flow months have less of an effect on annual loading. This potential overestimation does not affect the estimates of sediment reductions needed, as the overall load would need to be reduced to bring concentrations down in the river with or without the diversions. The annual loading rates calculated here were compared to those developed using more rigorous methods by Susfalk, et al. (2008), who estimated sediment loads in the WFCR at Diamond Valley (near Paynesville) for water years 1995-2006 and are found to be similar for those years. Because turbidity and TSS tend to increase with flow, the monthly sediment loading follows a similar pattern as monthly flows, with the greatest average sediment loads occurring in May with high flows from snowmelt.
Table 4-6 also includes targets for the Median and 90$^{th}$ percentile sediment loads in the WFCR based on a 24% and 33% TSS reduction needed to attain the Turbidity WQO in the WFCR at Woodfords and Stateline, respectively. As discussed above, some

extreme events would still result in occasional exceedances, so no target is included for reducing loading above the 90th percentile.

***Table 4-6. Annual TSS Loading and Reductions Targets***

| | WFCR at Woodfords | WFCR at Stateline |
|---|---|---|
| Years included | 1981-2021 | 1980-2021 |
| Minimum loading (Metric tons/Year) | 60 | 69 |
| Median TSS load (Metric tons/Year) | 723 | 1,013 |
| 90th Percentile TSS Load (Metric tons/Year) | 3,199 | 3,749 |
| Maximum TSS Load (Metric tons/Year) | 7,820 | 10,215 |
| Target % Reduction (from Table 4-5) | 24% | 33% |
| Target Median Loading (based on target % of reduction) (Metric tons/Year) | 549 | 679 |
| Target Median Sediment Reduction (based on target % reduction) (Metric tons/Year) | 173 | 334 |
| Target 90th Percentile Loading (based on target % reduction) (Metric tons/Year) | 2,431 | 2,512 |
| Target Reduction in 90th Percentile Load (based on target % reduction) (Metric tons/Year) | 768 | 1,237 |

## 4.4. Phosphorous

Like turbidity, phosphorous tends to increase in the downstream direction in the WFCR (Alvarez and Seiler, 2004; NDEP,2005; NDEP, 2022a), although concentrations are more variable in the most upstream reach. The two upper segments of the river are identified as impaired by phosphorus on the most recent 303(d) list. As discussed below, the downstream reach of the WFCR from Woodfords to the state line also consistently exceeds the water quality objective when looking at a more complete data set than was used in the most recent 303(d) list update. The WQO for both the Headwaters to Hope Valley segment and the Hope Valley to Woodfords segment is

0.02 mg/L phosphorus expressed as a mean of monthly means. The WQO for the Woodfords to the state line is 0.03 mg/L, expressed as a mean of monthly means. For purposes of the Integrated Report assessments, the mean of monthly means is calculated on an annual basis, giving a single annual mean of monthly means (AMMM) for each year with available data. Figure 4-4 shows boxplots of AMMM phosphorous for each reach of the WFCR.

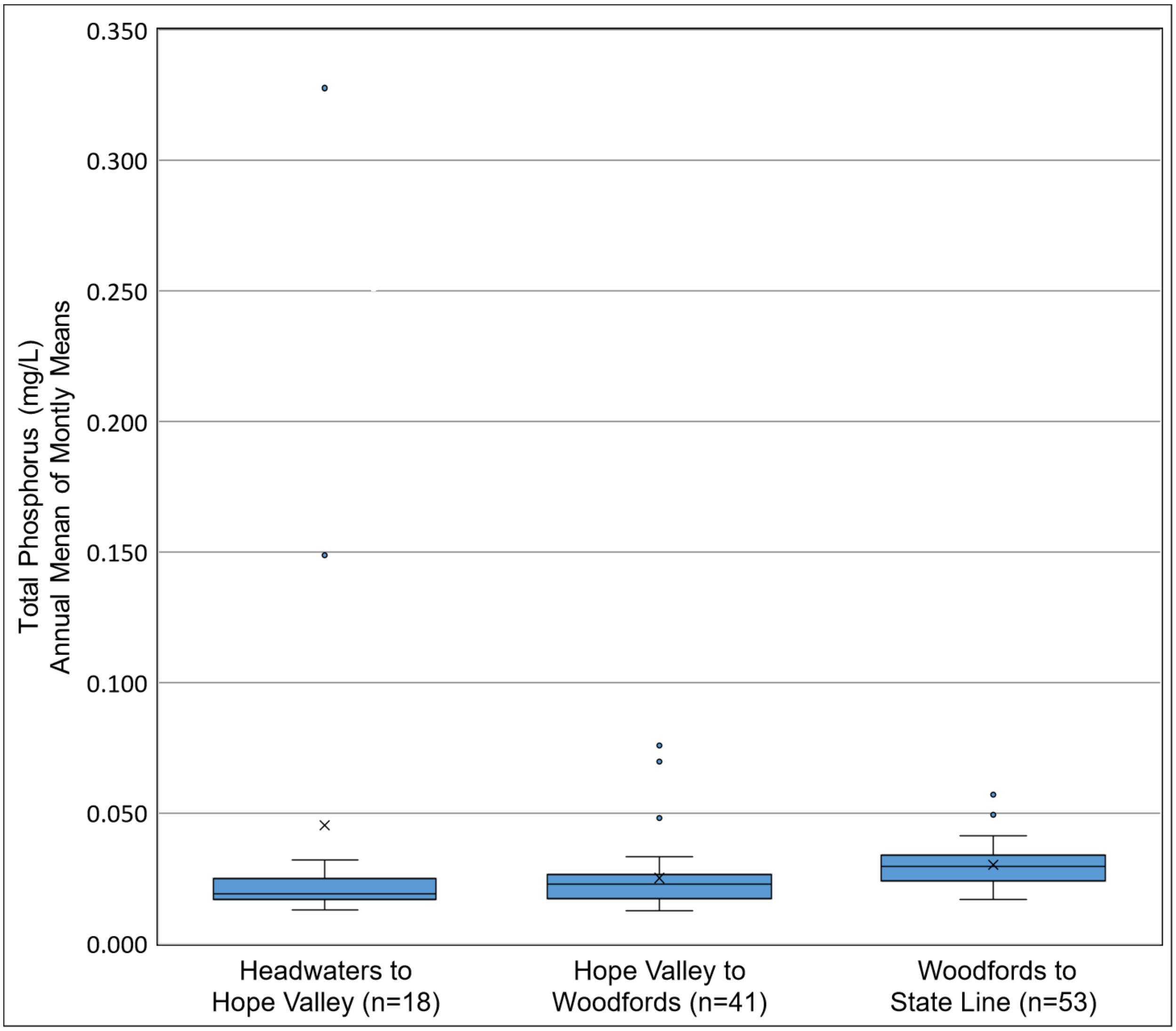


***Figure 4-4. Phosphorous Concentrations in the WFCR by Reach (Annual Mean of Monthly Means)***

A USGS report produced in 2004 (Alvarez and Seiler, 2004) describes likely sources of phosphorus to the WFCR. Those include natural inputs associated with the local geology which include granitic and volcanic bedrock formations that contain phosphorus. These bedrock formations are more prevalent in the upper portion of the WFCR watershed upstream of Woodfords. Sediment in runoff from nonpoint sources is another likely source of phosphorus together with erosion of unstable streambanks. Additional sources are seasonal inputs from agricultural return flow and the use of treated effluent for irrigation, grazing livestock and inputs from onsite wastewater treatment systems located near the river. It is also possible that nutrients from recreational uses associated with the improper disposal of gray water or human and pet wastes can also be a source of phosphorus to the WFCR. The USGS report considers whether atmospheric deposition may contribute to phosphorus in the Carson River and concludes that it is not likely to be a significant source.

Figure 4-5 shows average WFCR phosphorus concentrations for each month, using all available data. The concentrations follow a similar pattern as sediment concentrations, peaking in May at the time when flows in the WFCR are highest due to spring snowmelt. No long-term temporal trend was observed in the phosphorus data.

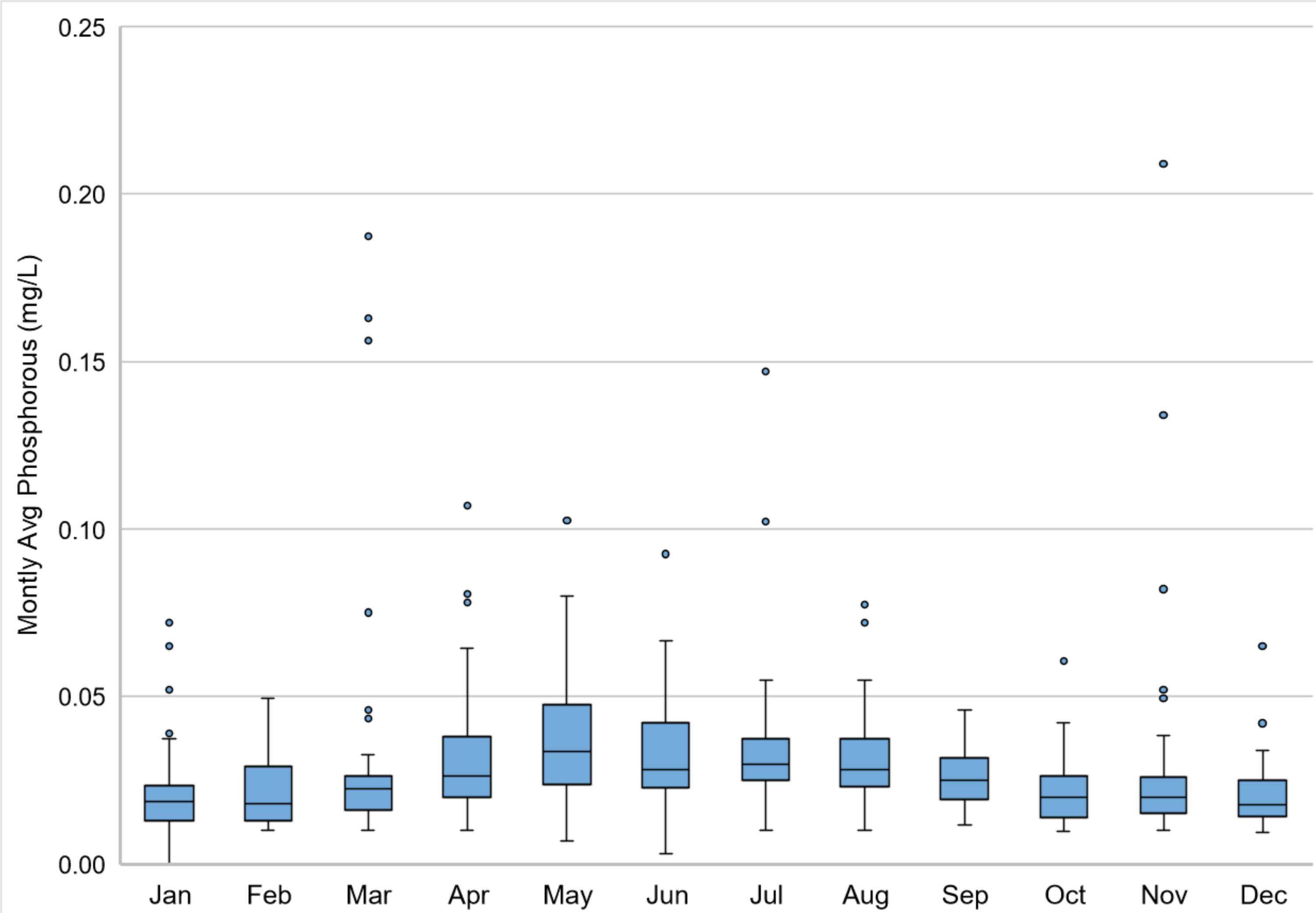


***Figure 4-5. Monthly Average WFCR Phosphorus Concentrations[3]***

[3] For readability, one outlier of 0.57 mg/L from June 2017 is not shown in the graph.

The State of Nevada's phosphorous water quality criteria for the WFCR at state line of 0.1 mg/L as an annual average was never exceeded in the 53 years for which phosphorous data were available. NDEP has developed a TMDL for phosphorous for downstream reaches of the Carson River in Nevada, and phosphorus reductions are a focus of the NDEP's Alternative Restoration Plan for the Carson River.

The Listing Policy (SWRCB, 2015, Tables 3.1 and 4.1) give the maximum number of allowable exceedances below which a segment is considered in attainment of standards for nutrients, such as phosphorous[4]. The number of exceedances from the Listing Policy can be used as a basis for adding or removing waterbody segment pollutant combinations from the 303(d) List. Table 4-7 shows the number of exceedances for each segment, the number of years with AMMM phosphorus data, and the maximum number of allowable exceedances from the Listing Policy. Table 4-7 also shows the percent reduction of concentrations that would result in a reduction in the number of exceedances to support de-listing – based on the existing AMMM phosphorus data and calculated as described above for turbidity. Table 4-7 also includes descriptive statistics for the phosphorus in each segment.

***Table 4-7. WFCR Phosphorous Data Summary***

| WFCR Segment | WFCR Headwaters to Hope Valley (WQO 0.02 mg/L) | Hope Valley to Woodfords (WQO 0.02 mg/L) | Woodfords to State Line (WQO 0.03 mg/L) |
|---|---|---|---|
| Years with AMMM Phosphorus Data | 18 (2002-2019) | 41 (1981-2021) | 53 (1969-2021) |
| Years with AMMM Phosphorous>WQO | 6 | 26 | 24 |
| Maximum Exceedances to Delist | 2 | 3 | 4 |
| Median AMMM P | 0.02 | 0.02 | 0.03 |
| 90th Percentile AMMM P | 0.2 | 0.03 | 0.04 |
| Maximum AMMM P | 0.33 | 0.08 | 0.05 |
| Approximate% reduction needed to delist | 44% | 43% | 27% |

Historic loading rates were calculated for the three WFCR segments using flow data from the USGS Gauge at Woodfords and phosphorus data collected in these three segments. Annual loads were calculated using the same method as described above for TSS loads. The estimated annual loading rates are summarized in Table 4-8.

[4] Nutrients are included in the definition of toxicants in the Listing Policy, so Tables 3.1 and 4.1 provide the applicable exceedance frequencies.

Table 4-8 also includes targets for the Median and 90th percentile phosphorus loads in the WFCR based on the target reductions needed to attain the WQOs in the WFCR from Table 4-7. As discussed above, some extreme events would still result in occasional exceedances, so no target is included for reducing loading above the 90th percentile.

***Table 4-8. WFCR Phosphorous Annual Load Estimates***

| Segment | Headwaters to Hope Valley | Hope Valley to Woodfords | Woodfords to State Line |
|---|---|---|---|
| Years with annual loads estimated | 18 (2002-2019) | 41 (1981-2021) | 53 (1969-2001) |
| Minimum (kg/yr.) | 131 | 369 | 439 |
| Median (kg/yr.) | 1,079 | 2,567 | 3,080 |
| 90th Percentile (kg/yr.) | 42,692 | 9,240 | 5,887 |
| Maximum (kg/yr.) | 194,891 (2017) | 40,222 (2017) | 34,118 (2017) |
| Target % Reduction | 44% | 43% | 27% |
| Target Median Loading (based on target % reduction) (kg/yr.) | 604 | 1,462 | 2,245 |
| Target Median Sediment Reduction (based on target % reduction) (kg/yr.) | 475 | 1,105 | 835 |
| Target 90th Percentile Loading (based on target % reduction) (kg/yr.) | 23,908 | 5,262 | 4,291 |
| Target Reduction in 90th Percentile Load (based on target % reduction) (kg/yr.) | 18,785 | 3,978 | 1,596 |

## 4.5. Nitrogen

Nitrogen impairments identified for the WFCR include listings for nitrate and total Kjeldahl nitrogen (TKN) for all three segments, while the lower two segments are also listed for total nitrogen. Potential sources of nitrogen to the river include natural sources and channel erosion, runoff from areas enriched by historic livestock, wastes from recreational users (including improper disposal of grey or blackwater), recreational users' pets and livestock, grazing livestock, and runoff of treated effluent for irrigation and onsite wastewater treatment systems located near the river. As with TSS and P, concentrations of all three of these forms of nitrogen tend to increase as the river flows downstream, as demonstrated by the summary statistics in Tables 4-10,11 and 12, below.

The objectives for total nitrogen and TKN, and nitrate (as N) in the West Fork Carson River hydrologic unit, including the WFCR, are shown in Table 4-9. These are established as a mean of monthly means. For purposes of the Integrated Report assessments, the mean of monthly means is calculated on an annual basis, giving a single annual mean of monthly means (AMMM) for each year with available data.

***Table 4-9. Nitrogen, TKN, and NO3-N WQOs for the WFCR***

| Surface Waters | Total Nitrogen (mg/L) Mean of monthly means | TKN (mg/L) Mean of monthly means | NO3-N (mg/L) Mean of monthly means |
|---|---|---|---|
| West Fork Carson River at Woodfords | 0.15 | 0.13 | 0.02 |
| West Fork Carson River at Stateline | 0.25 | 0.22 | 0.03 |

There appears to be an overall downward trend in nitrogen. Figure 4-6, below, shows AMMM total nitrogen data from the WFCR – Woodfords to Stateline segment. This segment has the most data, going back to 1978. Similar trends are also apparent for TKN and nitrate. These reductions indicate that the system is recovering from historic impacts and that practices and infrastructure are improving.

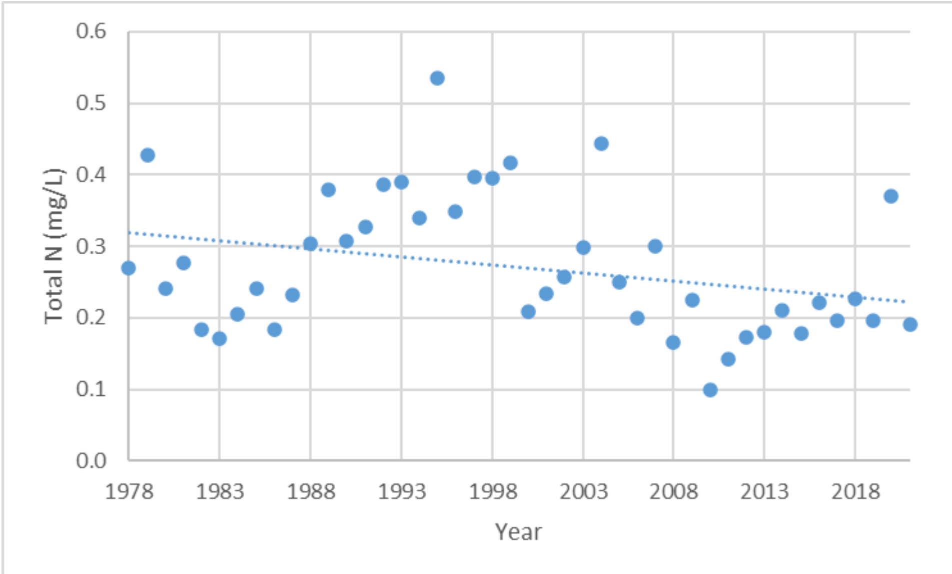


***Figure 4-6. Total Nitrogen in the WFCR, Woodfords to Stateline segment, Annual Mean of Monthly Means 1978-2021***

The Listing Policy (SWRCB, 2015, Tables 3.1 and 4.1) identifies the maximum number of allowable exceedances below which a segment is considered in attainment of standards for nutrients, such as nitrogen, nitrate, and TKN[5]. The number of water quality objective exceedances identified in the Listing Policy can be used as a basis for adding or removing waterbody segment pollutant combinations from the 303(d) List, based on the number of samples.

Tables 4-10 – 4-12 summarize for total N, TKN and nitrate, the number of exceedances for each segment, the number of years with AMMM data, and the maximum number of allowable exceedances from the Listing Policy. Tables 4-10 – 4-12 also show the percent reduction of concentrations that would result in a reduction in the number of exceedances to support de-listing – based on the existing data and calculated as described in section 4.3 for turbidity. Tables 4-10 – 4-12 also include descriptive statistics for nitrate in each segment. The data set used for the Vision Plan includes WFCR data that were not used in the most recent (2018) Integrated Report update. Based on the data available, it appears that the Headwaters to Hope Valley segment should also be listed for total N. Due to limited data for the headwaters to Hope Valley segment, statistics and percent reductions for nitrate and TKN were not calculated for that segment, but the concentrations and reductions needed for that segment are expected to be similar or less than those needed for the Hope Valley to Woodfords segment, since concentrations tend to increase downstream in the WFCR.

[5] Nutrients are included in the definition of toxicants in the Listing Policy, so Tables 3.1 and 4.1 provide the applicable exceedance frequencies.

***Table 4-10. WFCR Total Nitrogen Data Summary***

| WFCR Segment | Headwaters to Hope Valley (WQO 0.15 mg/L) | Hope Valley to Woodfords (WQO 0.15 mg/L) | Woodfords to State Line (WQO 0.25 mg/L) |
|---|---|---|---|
| Years with AMMM Total N Data | 8 (2012-2020) | 13 (2001-2004, 2012-2021) | 44 (1978-2022) |
| Years with AMMM Total N >WQO | 3 | 7 | 20 |
| Maximum Exceedances to Delist | 2 | 2 | 3 |
| Median AMMM Total N (mg/L) | 0.13 | 0.15 | 0.24 |
| 90th Percentile AMMM Total N (mg/L) | 0.3 | 0.24 | 0.40 |
| Maximum AMMM Total N (mg/L) | 0.44 | 0.36 | 0.54 |
| Approximate% reduction needed to delist | 11% | 36% | 40% |

***Table 4-11. WFCR Nitrate Data Summary***

| WFCR Segment | Hope Valley to Woodfords (WQO 0.02 mg/L) | Woodfords to State Line (WQO 0.03 mg/L) |
|---|---|---|
| Years with AMMM Nitrate Data | 37 (1984-2021, except 1997) | 38 (1983-2021) |
| Years with AMMM >WQO | 13 | 22 |
| Maximum Exceedances to Delist | 3 | 3 |
| Median AMMM Nitrate (mg/L) | 0.02 | 0.04 |
| 90th Percentile AMMM Nitrate (mg/L) | 0.03 | 0.06 |
| Maximum AMMM Nitrate (mg/L) | 0.04 | 0.07 |
| Approximate% reduction needed to delist | 34% | 55% |

*Table 4-12. WFCR TKN Data Summary*

| WFCR Segment | Hope Valley to Woodfords (WQO 0.13 mg/L) | Woodfords to State Line (WQO 0.22 mg/L) |
|---|---|---|
| Years with AMMM TKN Data | 41 (1981-2021) | 44 (1978-2021) |
| Years with AMMM >WQO | 31 | 11 |
| Maximum Exceedances to Delist | 3 | 3 |
| Median AMMM TKN (mg/L) | 0.15 | 0.19 |
| $90^{th}$ Percentile AMMM TKN (mg/L) | 0.23 | 0.25 |
| Maximum AMMM TKN (mg/L) | 0.32 | 0.33 |
| Approximate% reduction needed to delist | 46% | 23% |

Historic nitrogen loading rates were calculated for the three WFCR segments using flow data from the USGS Gauge at Woodfords and total nitrogen data collected in these three segments. Annual loads were calculated using the same method as described above for TSS loads. The estimated annual loading rates are summarized in Table 4-13. Loadings are determined in terms of total nitrogen, since this incorporates all nitrogen loading in the system, whereas nitrate and TKN are subject to natural transformation from one form to another as the river flows downstream.

Table 4-13 also includes targets for the Median and $90^{th}$ percentile total nitrogen loads in the WFCR based on the target reductions needed to attain all nitrogen related WQOs. The target reductions used in Table 4-13 were the largest percent reductions of those estimated for either total nitrogen, TKN or nitrate for each segment from Tables 4-10, 4-11 and 4-12.

*Table 4-13. WFCR Annual Total Nitrogen Load Estimates*

| Segment | Headwaters to Hope Valley | Hope Valley to Woodfords | Woodfords to State Line |
|---|---|---|---|
| Years with annual loads estimated | 7 (2011-2016, 2019) | 11 (2001, 2012-2021) | 37 (1978-2004, 2012-2021) |
| Minimum (kg/yr.) | 2,073 | 2,820 | 4,879 |
| Median (kg/yr.) | 8,004 | 16,337 | 18,365 |
| $90^{th}$ Percentile (kg/yr.) | 18,387 | 30,300 | 45,260 |
| Maximum (kg/yr.) | 20,967 | 31,304 | 81,211 |
| Target % Reduction | 46% (based on TKN[6]) | 46% (based on TKN) | 55% (based on nitrate) |
| Target Median Loading (based on target % reduction) (kg/yr.) | 4,322 | 8,822 | 8,264 |
| Target Median Sediment Reduction (based on target % reduction) (kg/yr.) | 3,682 | 7,515 | 10,101 |
| Target $90^{th}$ Percentile Loading (based on target % reduction) (kg/yr.) | NA | 16,362 | 20,367 |
| Target Reduction in $90^{th}$ Percentile Load (based on target % reduction) (kg/yr.) | NA | 13,938 | 24,893 |

## 4.6. Salt (TDS and chloride)

Salt related impairments identified for the WFCR are listings for TDS and chloride in the middle (Hope Valley to Woodfords) segment and a listing for TDS in the Woodfords to Stateline segment of the WFCR. Potential sources of salts include salt used for road de-icing, nonpoint source runoff and onsite wastewater treatment systems located near the river.

[6] For the Headwaters to Hope Valley segment where there was minimal TKN and nitrate data, the percent reduction for TKN for the Hope Valley to Woodfords segment was used in Table 4-13.

The Listing Policy (SWRCB, 2015, Tables 3.2 and 4.2) give the maximum number of allowable exceedances below which a segment is considered in attainment of standards for TDS and chloride[7]. The number of exceedances from the Listing Policy can be used as a basis for adding or removing waterbody segment pollutant combinations from the 303(d) List, based on the number of samples.

Table 4-14 and 4-15 summarize, for TDS and chloride, the number of years with AMMM data, the number of exceedances for each segment, and the maximum number of allowable exceedances from the Listing Policy. Tables 4-14 and 4-15 also show the percent reduction of concentrations that would result in a reduction in the number of exceedances to support de-listing – based on the existing data and calculated as described above for turbidity. Tables 4-14 and 4-15 also include descriptive statistics for chloride in each segment. A preliminary review of the data did not reveal any immediately apparent spatial or long-term temporal trends. TDS and EC concentrations were generally lower in the spring and summer months, and higher in winter.

Based on the data available (which includes data not that were not used in the most recent (2018) Integrated Report update) it appears that the Headwaters to Hope Valley segment should also be listed for TDS and the other two segments should remain listed. A reduction of approximately 14% would result in consistent attainment of standards and delisting for TDS in the Headwaters to Hope Valley segment. A 5% and 1% reduction would result in consistent attainment of standards and delisting for TDS in the Hope Valley to Woodfords and Woodfords to state line segments, respectively.

Based on the data available, it appears that the Headwaters to Hope Valley segment should be also listed for chloride, the Hope Valley to Woodfords segment should remain listed for chloride, and the Woodfords to state line segment should remain unlisted for chloride. A reduction of approximately 12% would result in consistent attainment of standards and delisting for TDS in the Headwaters to Hope Valley segment. A reduction of approximately 41% would be needed for consistent attainment of standards and delisting for TDS in the Hope Valley to Woodfords segment.

It should be noted, however, that the WQOs for chloride in the WFCR (1 and 2.5 mg/L) are orders of magnitude lower than drinking water or aquatic life, or agricultural use protection-based criteria. Additionally, the non-attainment is all due to exceedances of the upstream WQO of 1 mg/L.

[7] TDS and chloride are considered conventional pollutants in the Listing Policy, so Tables 3.2 and 4.2 provide the applicable exceedance frequencies.

***Table 4-14 WFCR TDS Data Summary***

| WFCR Segment | WFCR Headwaters to Hope Valley (WQO 55 mg/L) | Hope Valley to Woodfords (WQO 55 mg/L) | Woodfords to State Line (WQO 70 mg/L) |
|---|---|---|---|
| Years with AMMM TDS Data | 17 (2003-2019) | 41 (1981-2021) | 54 (1968-2021) |
| Years with AMMM TDS >WQO | 12 | 18 | 9 |
| Maximum Exceedances to Delist | 4 | 6 | 8 |
| Median AMMM TDS (mg/L) | 59 | 55 | 64 |
| 90th Percentile AMMM TDS (mg/L) | 67 | 58 | 71 |
| Maximum AMMM TDS (mg/L) | 74 | 63 | 85 |
| Approximate% reduction needed to delist/not list | 14% | 5% | 1% |

***Table 4-15 WFCR Chloride Data Summary***

| WFCR Segment | WFCR Headwaters to Hope Valley (WQO 1.0 mg/L) | Hope Valley to Woodfords (WQO 1.0 mg/L) | Woodfords to State Line (WQO 2.5 mg/L) |
|---|---|---|---|
| Years with AMMM Cl Data | 13 (2004, 2006-2011, 2013-2017, 2019) | 39 (1983-2021) | 38 (1984-2021) |
| Years with AMMM Cl >WQO | 7 | 31 | 6 |
| Maximum Exceedances to Delist | 4 | 5 | 6 |
| Median AMMM Cl (mg/L) | 1.0 | 1.3 | 1.8 |
| 90th Percentile AMMM Cl (mg/L) | 1.5 | 1.8 | 2.7 |
| Maximum AMMM Cl (mg/l) | 1.6 | 2.2 | 3.5 |
| Approximate% reduction needed to delist | 12% | 41% | NA |

Historic TDS and chloride loading rates were calculated for the three WFCR segments using flow data from the USGS Gauge at Woodfords and TDS, and chloride data collected in these three segments. Annual loads were calculated using the same method as described above for TSS loads. The estimated annual loading rates are summarized in Tables 4-16 and 4017. Tables 4-16 and 4-17 also include targets for the Median and 90th percentile total loads in the WFCR based on the target reductions needed to attain the TDS and chloride WQOs from Tables 4-14 and 4-15.

***Table 4-16. WFCR Annual TDS Load Estimates***

| Segment | Headwaters to Hope Valley | Hope Valley to Woodfords | Woodfords to State Line |
|---|---|---|---|
| Years with annual loads estimated | 17 (2003-2019) | 41 (1980-2021) | 54 (1968-2021) |
| Minimum (metric tons/yr.) | 874 | 1,318 | 1,602 |
| Median (metric tons/yr.) | 2,506 | 3,599 | 4,067 |
| 90th Percentile (metric tons/yr.) | 8,665 | 7,042 | 7,418 |
| Maximum (metric tons/yr.) | 8,669 | 11,459 | 11,167 |
| Target % Reduction (from Table 4-14) | 14% | 5% | 1% |
| Target Median Loading (based on target % reduction) (metric tons/yr.) | 2,155 | 3,419 | 4,027 |
| Target Median Sediment Reduction (based on target % reduction) (metric tons/yr.) | 351 | 180 | 41 |
| Target 90th Percentile Loading (based on target % reduction) (metric tons/yr.) | 7,452 | 6,690 | 7,344 |
| Target Reduction in 90th Percentile Load (based on target % reduction) (metric tons/yr.) | 1,213 | 352 | 74 |

*Table 4-17. WFCR Annual Chloride Load Estimates*

| Segment | Headwaters to Hope Valley | Hope Valley to Woodfords | Woodfords to State Line |
|---|---|---|---|
| Years with annual loads estimated | 13 (2004, 2006-2011, 2013-2017, 2019) | 39 (1983-2021) | 38 (1984-2021) |
| Minimum (metric tons/yr.) | 23 | 24 | 38 |
| Median (metric tons /yr.) | 52 | 82 | 36 |
| 90$^{th}$ Percentile (metric tons /yr.) | 122 | 160 | 98 |
| Maximum (metric tons /yr.) | 143 | 180 | 178 |
| Target % Reduction | 12% | 41% | NA |
| Target Median Loading (based on target % reduction) (metric tons /yr.) | 46 | 48 | NA |
| Target Median Sediment Reduction (based on target % reduction) (metric tons /yr.) | 6 | 34 | NA |
| Target 90$^{th}$ Percentile Loading (based on target % reduction) (metric tons /yr.) | 107 | 95 | NA |
| Target Reduction in 90$^{th}$ Percentile Load (based on target % reduction) (metric tons /yr.) | 15 | 66 | NA |

## 4.7. Iron

The WFCR is listed as impaired for iron in the lower segment of the river between Woodfords and Stateline due to exceedance of the WQO for Iron of 0.3 mg/L, which is evaluated as a not to exceed limit, rather than a mean of monthly means. The iron WQO is for protection of the Municipal and Domestic Supply (MUN) beneficial use. Potential sources of iron include weathering of iron bearing rocks and minerals, erosion, and nonpoint sources such as stormwater runoff from roadways.

The Listing Policy (SWRCB, 2015, Tables 3.1 and 4.1) give the maximum number of allowable exceedances below which a segment is considered in attainment of standards for metals, such as iron[8]. The number of exceedances from the Listing Policy can be used as a basis for adding or removing waterbody segment pollutant combinations from the 303(d) List, based on the number of samples.

Table 4-18 summarizes, for iron in samples from the WFCR, Woodfords to state line, the number of exceedances of the WQO, the number of samples, and the maximum number of allowable exceedances from the Listing Policy. Table 4-15 also shows the percent reduction of iron concentrations that would result in a reduction in the number of exceedances to support de-listing of this segment – based on the existing data and calculated as described above for turbidity. Table 4-15 also includes descriptive statistics for iron in each segment, but minimal data were available for the upstream segments. A preliminary review of the data did not reveal any immediately apparent long-term or seasonal temporal trends. The lack of upstream data also precluded looking at any spatial variation.

Based on the available data, a reduction of approximately 47% would result in consistent attainment of standards and delisting for iron. It should be noted, however, that the current WQO is very conservative in that it applies secondary MCL directly to unfiltered samples from surface waters. This secondary MCL was developed for regulation of drinking water supplied to consumers for the reduction of taste and odors in drinking water. As in most surface waters, the majority of the total iron measured in unfiltered samples from the WFCR is not in dissolved from. Therefore, most of the iron would be removed by filtration in any drinking water use. Additionally, the exceedance frequency for individual samples applied to iron is also very protective.



[8] Metals are included in the definition of toxicants in the Listing Policy, so Tables 3.1 and 4.1 provide the applicable exceedance frequencies.

***Table 4-18. WFCR Iron Data Summary***

| WFCR Segment | Headwaters to Hope Valley (WQO 0.3 mg/L) | Hope Valley to Woodfords (WQO 0.3 mg/L) | Woodfords to State Line (WQO 0.3 mg/L) |
|---|---|---|---|
| Iron samples | 4 | 2 | 70 |
| Years with data | 2007-2008 | 1999,2018 | 1979-2020 |
| Exceedances of the WQO (0.3 mg/L secondary MCL) | 1 | 1 | 21 |
| Maximum Exceedances to Delist | NA | NA | 6 |
| Median iron concentration (mg/L) | 0.20 | NA | 0.20 |
| 90th Percentile iron concentration (mg/L) | 0.37 | NA | 0.49 |
| Maximum iron concentration (mg/l) | 0.45 | 0.39 | 1.6 |
| Approximate% reduction needed to delist | NA | NA | 47% |

Historic iron loading rates were calculated for the WFCR from Woodfords to the State Line using flow data from the USGS Gauge at Woodfords and iron data from the WFCR Woodfords to State Line segment. Annual loads were calculated using the same method as described above for TSS loads. The estimated annual loading rates are summarized in Table 4-19. Since iron concentration data were only available once or twice per year, these load estimates have a very low level of precision. Table 4-19 also includes targets for the Median and 90th percentile total loads in the WFCR based on the target reductions needed to attain the Iron WQO from Table 4-18.

***Table 4-19. WFCR Annual Iron Load Estimates***

| Segment | Woodfords to State Line |
|---|---|
| Years with Annual Loads Estimated | 40 (1979-2020, except for 1986 and 2010) |
| Minimum Annual Loading (kg/yr.) | 474 |
| Median Annual Loading (kg/yr.) | 8,540 |
| 90th Percentile Annual Loading (kg/yr.) | 75,496 |
| Maximum Annual Loading (kg/yr.) | 116,887 |
| Target % Reduction | 47% |
| Target Median Loading (based on target % reduction) (kg/yr.) | 4,526 |
| Target Median Sediment Reduction (based on target % reduction) (kg/yr.) | 4,014 |
| Target 90th Percentile Loading (based on target % reduction) (kg/yr.) | 40,013 |
| Target Reduction in 90th Percentile Load (based on target % reduction) (kg/yr.) | 35,483 |

## 4.8. Sulfate

All three segments of the WFCR are listed as impaired for sulfate (SO4) based on exceedances of the WQO for sulfate of 2 mg/L expressed as a mean of monthly means, assessed on an annual basis. Potential sources of sulfate in surface waters include inputs from groundwater, the weathering of minerals (especially volcanic rocks), and the bacterial decomposition of organic matter. Atmospheric deposition can also be another possible source of sulfate to surface waters.

The Listing Policy (SWRCB, 2015, Tables 3.2 and 4.2) give the maximum number of allowable exceedances below which a segment is considered in attainment of standards for conventional pollutants, such as sulfate. The number of exceedances from the

Listing Policy can be used as a basis for adding or removing waterbody segment pollutant combinations from the 303(d) List, based on the number of samples.

Table 4-20 summarizes, for sulfate in samples from the WFCR, the number of exceedances of the WQO, the number of samples, and the maximum number of allowable exceedances from the Listing Policy. Table 4-16 also shows the percent reduction of sulfate concentrations that would result in a reduction in the number of exceedances to support de-listing of this segment – based on the existing data and calculated as described above for turbidity. Table 4-16 also includes descriptive statistics for sulfate in each segment. Sulfate concentrations tend to increase in a downstream direction in the WFCR. Sulfate concentrations are lower in the early spring and summer, and higher in the winter. There was an overall downward trend in sulfate concentrations over the years sampled.

Based on the available data, a reduction of approximately 15%, 51% and 62% would result in consistent attainment of standards and delisting for sulfate in the three segments of the WFCR. It should be noted, however, that the WQO for sulfate in the WFCR (2 mg/L) is orders of magnitude lower than drinking water or aquatic life protection-based criteria.

***Table 4-20. WFCR Sulfate Data Summary***

| WFCR Segment | WFCR Headwaters to Hope Valley WQO (2.0 mg/L) | Hope Valley to Woodfords WQO (2.0 mg/L) | Woodfords to State Line WQO (2.0 mg/L) |
|---|---|---|---|
| Years with AMMM SO4 Data | 18 (2002-2019) | 35 (1987-2021) | 35 (1987-2021) |
| Years with AMMM >WQO (2.0 mg/L) | 10 | 24 | 23 |
| Maximum Exceedances to Delist | 4 | 5 | 5 |
| Median AMMM SO4 (mg/L) | 2.15 | 2.22 | 2.76 |
| $90^{th}$ Percentile AMMM SO4 (mg/L) | 2.40 | 4.12 | 5.37 |
| Maximum AMMM SO4 (mg/l) | 2.54 | 4.88 | 6.18 |
| Approximate% reduction needed to delist | 15% | 51% | 62% |

Historic sulfate loading rates were calculated for the three segments of the WFCR using flow data from the USGS Gauge at Woodfords and sulfate data from each segment.

Annual loads were calculated using the same method as described above for TSS loads. The estimated annual loading rates are summarized in Table 4-21. Table 4-21 also includes targets for the Median and 90th percentile total loads in the WFCR based on the target reductions needed to attain the sulfate WQO from Table 4-20.

***Table 4-21. WFCR Annual Sulfate Load Estimates***

| Segment | Headwaters to Hope Valley | Hope Valley to Woodfords | Woodfords to State Line |
|---|---|---|---|
| Years with annual loads estimated | 18 (2002-2019) | 35 (1987-2021) | 35 (1987-2021) |
| Minimum (kg/yr.) | 20,259 | 47,583 | 67,624 |
| Median (kg/yr.) | 95,298 | 143,479 | 165,000 |
| 90th Percentile (kg/yr.) | 241,050 | 368,212 | 370,310 |
| Maximum (kg/yr.) | 251,474 | 1,248,391 | 1,172,051 |
| Target % Reduction | 15% | 51% | 62% |
| Target Median Loading (based on target % reduction) (kg/yr.) | 81,004 | 70,305 | 62,700 |
| Target Median Sediment Reduction (based on target % reduction) (kg/yr.) | 14295 | 73174 | 102,300 |
| Target 90th Percentile Loading (based on target % reduction) (kg/yr.) | 204,892 | 180,424 | 140,718 |
| Target Reduction in 90th Percentile Load (based on target % reduction) (kg/yr.) | 36,157 | 187,788 | 229,592 |

## 4.9. Fecal indicator bacteria

At the time of the development of the most recent update for the Integrated Report for the Lahontan Region in 2018, there were two numeric fecal indicator bacteria (FIB) WQOs, one for fecal coliform bacteria from the Basin Plan and a statewide standard for E. Coli from the from the Water Quality Control Plan for Inland Surface Waters, Enclosed Bays, and Estuaries of California (SWRCB, 2018). The downstream segment of the WFCR, Woodfords to state line, is listed as impaired by fecal indicator bacteria, based on exceedances of the Basin Plan WQO for fecal coliform bacteria.

A Basin Plan Amendment proposing to remove the fecal coliform WQOs from the Basin Plan was adopted by the Lahontan Water Board in June 2023, and is expected to be considered for approval by the State Water Resources Control Board, Office of Administrative Law and finally USEPA in 2024. More information on this Basin Plan Amendment can be found at the Water Board's Basin Planning webpage.

Table 4-22 summarizes available water quality data for E. Coli in the WFCR in comparison to the E. coli WQO. The E. Coli WQO has two parts. The first is a maximum six-week rolling geometric mean of 100 colony forming units (CFU)/100, calculated weekly and a single threshold value. The second part is a single threshold value (STV) - that no more than 10% of samples can be above 320 CFU/100 mL in any calendar month. While there are some very infrequent exceedances of the WQO in the most downstream segment, the data indicate overall attainment of the E. coli WQO.

If the Lahontan Water Board removes its fecal coliform water quality objective as proposed, the FIB impairment for the WFCR on the 303(d) list would likely be recommended for de-listing. It should still be noted, however, due to land uses and occasional exceedance of E. coli WQO concentrations, that there still is some potential for FIB issues in the WFCR. Therefore, ongoing efforts that protect the WFCR from FIB contamination should continue.

*Table 4-22. WFCR E. Coli Data Summary*

| WFCR Segment | WFCR Headwaters to Hope Valley | Hope Valley to Woodfords | Woodfords to State Line |
|---|---|---|---|
| Number of samples | 66 | 125 | 177 |
| Years with data available | 2013-2019 | 2010-2019 | 2010-2019 |
| Exceedances of WQO STV (320 CFU/100 ml) | 0 | 0 | 5 |
| Maximum allowable exceedances | 10 | 20 | 29 |
| Median E. coli (CFU/100 ml) | 2.5 | 2 | 30 |
| $90^{th}$ Percentile E. coli (CFU/100 ml) | 18 | 10.6 | 147 |
| Maximum E. coli (CFU/100 ml) | 34 | 143 | 1,100 |
| Number of 6-week averages of E. coli | 24 | 62 | 87 |
| Exceedances of WQO 6-wk geomean (320 CFU/100 ml) | 0 | 0 | 0 |
| Maximum allowable exceedances of 6-wk. geomean | 4 | 10 | 14 |
| Median 6- wk. geomean E. coli (CFU/100 ml) | 14 | 13 | 13 |
| $90^{th}$ Percentile 6-week geomean E. coli (CFU/100 ml) | 18 | 21 | 21 |
| Maximum 6- week geomean E. coli (CFU/100 ml) | 21 | 26 | 26 |

# 5. Causes and Sources

This section identifies and discusses the probable causes and sources of pollution contributing to the water quality impairments in the WFCR that need to be controlled to attain WQOs. In addition to probable sources, climate change and fire are also identified and discussed as factors with potential to contribute to water quality impairments in this Vision Plan. Actions that reduce potential impacts of climate change and fire will make the improvement and protection of water quality in the WFCR more robust and comprehensive.

## 5.1. Historical Activities

The WFCR watershed has been impacted by historical activities, which, despite decades of recovery, continue to affect the river and its watershed function. A more detailed description of these historical activities and impacts is available in the Upper Carson River Watershed Stream Corridor Assessment (Upper Watershed Assessment, MACTEC, et al., 2004) among other sources.

In the 1800's the entire watershed was logged, mostly to supply timber for the mines outside of the WFCR watershed. While previously forested, through the 1920's, the country was described as an area covered by brush and non-marketable woodlands. The river was used to transport logs downstream for use in the mines, and these log drives caused significant impacts to the channel. Log drives on the Carson River often damaged bridges roads and buildings and agricultural lands in the Carson Valley.

Beginning in the late 1800's heavy grazing by sheep and cattle became common in the watershed. Before the establishment of the Forest Service and Grazing Service in the early 1900's, grazing activities were largely unregulated. In 1870 over 100,000 sheep were estimated to be grazing in Alpine County (MACTEC et al., 2004). Livestock numbers and impacts have been reduced over the twentieth century as the Forest Service and Bureau of Land Management exerted increased control over the number of animals and season of use.

These historical activities have impacted the hydrology of the river and its watershed, compacting soils, decreasing infiltrations, increasing stream incision, reducing the connection between the river and its floodplains, decreasing baseflows, and increasing peak flows, thus increasing the erosive potential of the river and affected tributaries. Additionally, nitrogen concentrations in soil could be elevated in areas with historic high grazing animal concentrations, thus contributing to increased nitrogen concentrations in the WFCR. The Upper Watershed Assessment (MACTEC, et al., 2004). indicated that management actions and resource utilization 150 years ago probably had a greater impact on the geomorphology of streams in the watershed than grazing or other land uses that had occurred over the 20 years prior to that assessment.

## 5.2. Roads and Road Maintenance

There are several roads traversing and paralleling watercourses in the watershed. Roads can be a source of sediments due to erosion, suspended solids from sand and cinder used as abrasives for traction during icy conditions, and salts applied to reduce ice. An important source of sediment from roads is where culverts fail, due to clogging by wood and/or sediment and/or high flows, or when undersized culverts increase downstream energy and channel erosion.

The Upper Watershed Assessment (MACTEC et al., 2004) recommended that a detailed assessment of road conditions be prepared that identifies potential sources of sediment along roadways in the vicinity of Blue Lakes Road and Burnside Lake Road.

The 2004 Upper Carson River Watershed Stream Corridor Assessment Identified a list of bridges for hydrologic analysis. For the WFCR these were the Highway 88 bridge over the WFCR in Hope Valley upstream of the 88/89 Intersection at Pickett's Junction and the Highway 88 bridge over the WFCR at Woodfords. The Hope Valley Bridge over the WFCR on Highway 88 was found to have adequate capacity for 100-year flow but was found to restrict the flow of the river, thus increasing its erosion potential. The Woodfords Bridge on Highway 88 was found to have adequate capacity to convey the 100-year event without overtopping the roadway and did not appear to narrow the flow path of the river. (MACTEC Engineering and Consulting, et al., 2004).

A 2019 study by the State Water Resources Control Board (Hanks, 2019) characterizes road coverage in the watershed, and assessed where state highways and county roads crossed watercourses in the watershed.

Table 5-1 summarizes miles of roads and number of watercourse crossings in the watershed.

*Table 5-1. WFCR Watershed Road Stream Crossings (From Hanks, 2019)*

| Roadway | Watercourse Crossings | Miles of Roadways |
|---|---|---|
| **County Roads** | 29 | 37.3 |
| **Forest Service Roads** | 43 | 75.4 |
| **Trails** | 12 | 16.8 |
| **Highways** | 36 | 24.3 |
| **Private Roads** | 9 | 17.6 |
| **Other Federal Roads** | 10 | 14.8 |
| **Private Driveways** | 0 | 0.7 |
| **Shared Driveways** | 0 | 0.3 |
| **Total** | **139** | **187.2** |

There are 187 total miles of roads and 139 watercourse crossings within the watershed. There are 24 miles of highways in the watershed. The two highways passing through the watershed, Highways 88 and 89, are owned and operated by the California Department of Transportation (Caltrans). Alpine County and the WFCR watershed are in Caltrans District 10.

There are 90 miles of roads within the watershed that are Forest Service and/or other federally maintained roads. There are 37.3 miles of county-maintained roads, 17.6 miles of private roads and 16.8 miles of trails. Private and shared driveways collectively make up 1 mile of road within the watershed. All highways are paved, all trails are unpaved, and forest service roads are a mix of paved and unpaved. Unpaved forest service roads are made of native material and paved forest service roads are made of asphalt or bituminous surface treatment (Hanks, 2019). There are 36 highway watercourse crossings, 12 trail watercourse crossings, and 43 forest service road watercourse crossings.

Table 5-2 summarizes the 69 road watercourse crossings assessed in Hanks, 2019. Of the 86 county road and highway watercourse crossing sites identified for assessment, 69 were accessible and assessed. Assessment included written field assessment and photo monitoring at each site. Of the 69 county road and highway watercourse crossing sites assessed, 25 (36%) were flagged for qualitative indicators of failure (13 county roads crossings and 12 highway crossings).

*Table 5-2. Summary of Road Watercourse Crossings from Hanks, 2019*

| Road Type | Number Assessed | Qualitative Indicators of Failure Observed | Poor Inlet Condition | Poor Outlet Condition | Poor size of the stream crossing in comparison to the stream channel at the inlet | Poor size of the stream crossing in comparison to the stream channel at the outlet |
|---|---|---|---|---|---|---|
| **Highways** | 37 | 13 | 8 | 10 | 2 | 4 |
| **County Roads** | 32 | 12 | 6 | 9 | 2 | 3 |

Caltrans applies sand, cinders, and salt which are diluted with water into a 23% brine (Brewer, 2022) according to standard procedures as outlined in the Caltrans Maintenance Manual Volume 1 Chapter R (Caltrans, 2023). Caltrans ran a three-year study on the amount of brine created for State Route 89 in Alpine County. The three-year average of de-icing salt bulk came out to 1,131.9 tons per year (Brewer, 2022). While not directly applicable to the WFCR watershed, this gives a relative estimation of the amounts applied to highways 88 and 89 in Alpine County, since it did not include highway 88, and did include parts of highway 89 not in the WFCR watershed.

## 5.3. Onsite Wastewater Treatment Systems (OWTS)

Onsite wastewater treatment systems, also known as septic systems, can be a source of nitrogen, bacteria, salts and other anthropogenic pollutants to nearby streams. Downstream of Hope Valley, there are several residences as well as camping areas and rental properties immediately along the WFCR. Most of these are along the Hope Valley to Woodfords reach of the WFCR. The watershed is not serviced by a regional wastewater collection and treatment system. OWTS, mainly septic tanks, are the main method utilized to treat human waste. Some facilities have human waste removed and hauled to treatment plants outside the watershed. Due to their proximity to the river, local densities, systems age, and known performance issues with some local OWTS, OWTS are a probable source of nitrogen, phosphorous, bacteria and salts to the WFCR.

In addition to individual residential systems, one resort facility along the river has had historical issues with its OWTS. In the past failure of its OWTS resulted in discharges of partially treated wastewater to the river during wet years.

## 5.4. Grazing

In addition to the significant impacts from historic grazing activities to the WFCR, current grazing in the watershed can be a source of sediment, trace elements, nutrients and bacteria. Grazing can result in direct erosion via cattle in the channel and can contribute to erosion by promoting compaction and incision.

Starting near Woodfords, there is grazing on several parcels of private land, many of which are along the river. Given their proximity to the WFCR, these parcels have the potential to contribute to sediment/turbidity, nitrogen, and salt impairments in the WFCR. Some of the grazing lands along the WFCR receive irrigation water from STPUD, which is treated effluent from South Lake Tahoe stored in Harvey Place Reservoir and delivered to ranchers along the WFCR. This irrigation water is much higher in nutrients than the WFCR and is thus a potential source of nutrients to the WFCR. Some of the ranchers along the WFCR have installed management practices, such as riparian fencing, alternative water supplies, and limiting cattle access to the River to reduce potential impacts.

On the USFS land in the watershed, there is one active grazing allotment. Grazing in this allotment is regulated under a Term Grazing Permit issued by the HTNF (HTNF, 2014) and Annual Operating Instructions available online at https://www.fs.usda.gov/detail/htnf/landmanagement/resourcemanagement/?cid=fseprd640556#Carson%20RD that dictate the conditions that must be followed during grazing on the allotment. The current permit allows 106 cow-calf pairs (212 animals). Cattle initially start grazing the Scott's Lake Unit in late June until mid-August and then are gathered at the holding pasture on Luther pass and split into 2 groups. Half go up to Willow Creek Rd. within the Horse Meadows Unit, and half go up to Horsethief Canyon. They are fenced out of state land and cannot directly access the WFCR. There are a few other allotment areas on USFS land in the Hope Valley. However, these have been vacant since the late 1990s and would require a completed analysis to authorize grazing again. (C.Ghileri, personal communication on 2/17/2022)

## 5.5. Camping and Recreational Use

Much of the WFCR's upper watershed is publicly owned land (mostly USFS) which is popular for recreational use, including off-road vehicle use and dispersed camping. As the area has become more popular, and population in general in the region has increased, recreational use in the watershed has been increasing. Therefore, there is potential for impacts from these uses to increase. Vehicle use can increase erosion which can be a source of sediment/turbidity/TSS and other trace minerals, as discussed in the Roads and Road Maintenance section. Human and animal waste associated with recreational use can be a source of nutrients and bacteria. Improperly buried human waste as well as improper disposal of greywater and blackwater by campers in the area are a likely source of nitrates and bacteria to the WFCR.

Areas of particular concern are along Blue Lakes Road in Hope Valley and Faith Valley along the WFCR. These areas are popular for dispersed camping, some of which is long-term (Eddy, 2022). There have been reports of campers in these areas emptying their greywater and blackwater onto the ground. Another area of heavy use where waste disposal is a concern is the area around Scotts Lake. USFS has limited resources to patrol these lands, making these impacts more likely. Efforts are underway to increase the USFS presence in these areas, discussed in Section 6, below.

CDFW also manages lands within the watershed including the Hope Valley Wildlife Area, along the river near Pickett's Junction. However overnight car camping does not occur in these areas and sanitation facilities are provided, so these areas are not identified as a significant source of pollution to the WFCR.

CDFW also manages lands within the watershed including the Hope Valley Wildlife Area, along the river near Pickett's Junction. The Hope Valley Wildlife Area is managed for day use and backpack camping only, and CDFW maintains sanitation facilities at their parking lot near Pickett's Junction. Therefore, recreation in these areas is not currently identified as a source of pollution to the WFCR.

## 5.6. Hydrologic Modification

While the WFCR is in a largely rural area, the watershed has been significantly altered. As an effect of the impacts discussed in the Historical Activities section, the river has been channelized and separated from its floodplain, and its floodplain damaged. This results in increased flows during high flow periods, and reduced baseflows later in the year. Multiple reservoirs have been constructed in the WFCR headwaters, including Blue, Lakes, Red Lake, and Scotts Lake. It should be noted, however, that the overall capacity of these reservoirs is small relative to the total discharge in the watershed. The reservoirs change the hydrology, reducing peak runoff flows and increasing flows when releases are occurring. Retention of water in lakes further into the summer affects stream temperature, reservoir temperature and growth of algae. Recently, there have been harmful algal blooms in Red Lake in August and September of most years. Releases from Red Lake go into Red Lake Creek which is a significant tributary to the WFCR. Algae and other constituents in Red Lake, entering the WFCR via Red Lake Creek, can significantly affect water quality in the WFCR, contributing to elevated turbidity and other effects.

There are several withdrawals of water from the WFCR, via riparian well pumping and diversion of river flows into adjacent ditches/canals. River withdrawals and reduced baseflow due to the hydrologic impacts such as those discussed in section 5.1 can result in lower flows in the summer and fall. Lower flows in the WFCR during the summer and fall can result in higher pollutant concentrations, higher temperature, lower dissolved oxygen, and increased potential for eutrophic conditions. There are also several flow diversion structures in the WFCR channel. These structures can slow flows, increasing eutrophication potential, and contribute to channel erosion.

## 5.7. Climate Change, Fire and Other Factors

This Vision Plan recognizes that other factors can contribute to the water quality impairments in the WFCR. Identified factors for potential impacts are climate change, fire, invasive species, and development in the WFCR watershed.

Foremost are the potential impacts of two related factors, climate change and fire. In the WFCR watershed, as elsewhere in the Lahontan Region, impacts of climate change include increasing frequency of extreme weather events such as extreme storm events and extended drought, and prolonged fire seasons with larger and more intense fires. Changes in hydrology include more precipitation falling as rain versus snow, declining snowpack, and changes in the timing and volume of peak runoff (Scribe, 2021). These can result in erosion, flooding and related risks to water supply and wastewater infrastructure.

Wildfires pose a substantial risk to water quality in the WFCR, and climate change is expected to increase that risk. Wildfires can lead to severe flooding, erosion, and delivery of sediment, nutrients, and metals to receiving waters. The Tamarack fire, which occurred in the summer of 2021, only burned a small amount of the WFCR watershed, but provided a local example of potential wildfire impacts on rivers and watershed. The fire burned a significant amount of land in the East Fork Carson River Watershed. In summer of 2022, a summer storm resulted in flash flooding and mudslides coming out of the burn scar which impacted the town of Markleeville and washed out a portion of Highway 89. These flows also severely impacted water quality in the East Fork Carson River.

Other factors that contribute to increased constituents include development in the watershed which can reduce riparian areas and connection to floodplains and increase concentrations of pollutants associated with stormwater flows such as sediment, metals, bacteria, and trace elements. Finally, invasive species in the watershed can increase fire risk and increase erosion potential.

# 6. Implementation Actions for Attainment of Water Quality Standards

This chapter outlines implementation actions for restoring water quality in the WFCR to meet the overall Vision Plan goal of attainment of all water quality standards in the WFCR by October 2033.

The overall approach, Lahontan Water Board authorities and role, and potential funding sources are described. Management measures to achieve the reductions identified in Chapter 4 are described for all identified sources, estimates of financial and technical assistance needed are provided, an information and education component is provided, and a schedule for implementation of actions is provided. Table 6.1 Summarizes impairments in the WFCR and Management Measures to address those Impairments.

***Table 6-1 Management Measures*** [9]

| Segment | Impairments from CA Integrated Report | Potential Sources/ Contributing Factors | Management Measures | Performance Indicator for Implementation | Performance Indicators for Progress Towards Attaining WQOs |
|---|---|---|---|---|---|
| Headwaters to Hope Valley | Nitrogen (Nitrate, TKN), Phosphorous, Sulfates | Historical logging, grazing, road building, channel alteration.<br><br>Roads and road maintenance.<br><br>Camping and recreational use.<br><br>Water management.<br><br>Climate change, wildfire, invasive species, development | Stream channel restoration.<br><br>Road/culvert maintenance/ Improvements.<br><br>Salt management.<br><br>Recreation management and education.<br><br>Sanitation facilities improvements:<br><br>Improved water management to reduce eutrophication.<br><br>Fuels reductions.<br><br>Invasive species removal | Development of plans for recreation management, road management, salt management, stream restoration.<br>Miles of channel restored,<br><br>Miles of roads improved/removed.<br><br>Number of Culverts maintained/restored,<br><br>Improvement in salt management,<br><br>Increase in recreation management staffing,<br><br>Increase in education outreach,<br><br>decrease in fuels, invasive species presence,<br><br>Acres of floodplain preserved. | Decreasing annual loading, frequency of standards exceedances |



[9] While this Vision Plan is an independent document, it is useful to note that information about management measures was previously provided in the WFCR section of Table 8.2 in the CRASP (CWSD, 2017; https://www.cwsd.org/wp-content/uploads/2017/12/Final-CRWASP-2017-Update-Plan-Part-1.pdf , page 74).

| Segment | Impairments from CA Integrated Report | Potential Sources/ Contributing Factors | Management Measures | Performance Indicator for Implementation | Performance Indicators for Progress Towards Attaining WQOs |
|---|---|---|---|---|---|
| Hope Valley to Woodfords | Chloride,<br><br>Nitrogen (Nitrate, TKN),<br><br>Phosphorous, Sulfates,<br><br>Total Dissolved Solids,<br><br>Turbidity | Historical logging, grazing, road building, channel alteration.<br><br>Roads and road maintenance.<br><br>Camping and recreational use.<br><br>Water management.<br><br>Climate change, wildfire, invasive species, development<br><br>OWTS | Stream channel restoration.<br><br>Road/culvert maintenance/ Improvements.<br><br>Salt management.<br><br>Recreation management and education.<br><br>Sanitation facilities improvements:<br><br>Improved water management to reduce eutrophication.<br><br>Fuels reductions.<br><br>Invasive species removal<br><br>OWTS maintenance and improvements | Development of plans for recreation management, road management, salt management, stream restoration.<br><br>Miles of channel restored,<br><br>Miles of roads improved/removed.<br><br>Number of Culverts maintained/restored,<br><br>Improvement in salt management,<br><br>Increase in recreation management staffing,<br><br>Increase in education outreach,<br><br>Decrease in fuels, invasive species presence,<br><br>Number of OWTS systems upgraded/improved<br><br>Acres of floodplain preserved. | OWTS LAMP revisions/implementation improvements, permits.<br><br>Decreasing annual loading, frequency of standards exceedances |

| Segment | Impairments from CA Integrated Report | Potential Sources/ Contributing Factors | Management Measures | Performance Indicator for Implementation | Performance Indicators for Progress Towards Attaining WQOs |
|---|---|---|---|---|---|
| Woodfords to State Line | Indicator Bacteria,<br><br>Iron,<br><br>Nitrogen, (Nitrate, TKN),<br><br>Sulfates,<br><br>Total Dissolved Solids,<br><br>Turbidity | Historical logging, grazing, road building, channel alteration; Roads and road maintenance; Camping and recreational use; Water management; Climate change, wildfire, invasive species, development; OWTS; Grazing | Stream channel restoration.<br><br>Road/culvert maintenance/ Improvements.<br><br>Salt management.<br><br>Recreation management and education.<br><br>Sanitation facilities improvements:<br><br>Improved water management to reduce eutrophication.<br><br>Fuels reductions.<br><br>Invasive species removal<br><br>OWTS maintenance and improvements<br><br>Grazing BMPs | Development of plans for recreation management, road management, salt management, stream restoration.<br>OWTS LAMP revisions/implementation improvements, permits<br><br>Grazing management plans.<br><br>Miles of channel restored,<br><br>Miles of roads improved/removed.<br><br>Number of Culverts maintained/restored,<br><br>Improvement in salt management,<br><br>Increase in recreation management staffing,<br><br>Increase in education outreach,<br><br>Decrease in fuels, Decrease in invasive species presence,<br><br>Number of OWTS systems upgraded/improved<br><br>Acres of rangeland under plans & BMPs.<br><br>Miles of rangeland with riparian fencing.<br><br>Acres of floodplain preserved. | Decreasing annual loading, frequency of standards exceedances |

Table 6-2, 6-3, and 6-4 summarize completed, ongoing, proposed and potential future projects in the WFCR which have and/or are expected to improve water quality. Tables 6-2 (Completed WFCR Watershed Projects), 6-3 (Ongoing WFCR Watershed Projects) and 6-4 (Proposed and Potential Future WFCR Watershed Projects) can be used in conjunction with Table 6.1 (Management Measures to be Implemented), as these are projects to implement the management measures in Table 6.1.

***Table 6-2. Completed WFCR Watershed Projects*[10][11]**

| Waterbody Reach(es) | Location | Project Title | Lead Organization/ Partners | Implementation Date(s) | Budget | Funding Source |
|---|---|---|---|---|---|---|
| All | | Upper Carson River Watershed Stream Corridor Condition Assessment | Sierra Nevada Alliance, AWG, LWB | 2004 | ~ | CA Prop 13 |
| WFCR Headwaters to Hope Valley | Hope Valley | American River's Hope Valley Meadow Restoration | American Rivers/ USFS, CWSD, FOHV, Alpine County, Trout Unlimited, Institute for Bird Populations | 2012-2015 (planning) 2015- 2016 (implementation) | ~ | ~ |
| WFCR Headwaters to Hope Valley | Hope Valley | AWG's Hope Valley Meadow Restoration and Aquatic Habitat Enhancement. | AWG/CDFW, FOHV, American Rivers, CWSD, HTNF, SWRCB | 2020 (Monitoring Through 2024) | $244,000 Implementation | Phase 1 - planning SWRCB, Phase 2 Implementation - NFWF, CDFW, Phase 3 - Monitoring and adaptive mgmt. - Funded by NFWF, CDFW |

[10] While this Vision Plan is an independent document, it is useful to note that information about completed studies/projects was previously provided in the WFCR section of CRASP Table 8.5, (CWSD, 2017; https://www.cwsd.org/wp-content/uploads/2017/12/Final-CRWASP-2017-Update-Plan-Part-1.pdf.

[11] ~ indicates the information has not yet been collected.

| Waterbody Reach(es) | Location | Project Title | Lead Organization/ Partners | Implementation Date(s) | Budget | Funding Source |
|---|---|---|---|---|---|---|
| WFCR Headwaters to Hope Valley | HTNF- Alpine County | 2013 Route Adjustment EA | HTNF/ Alpine County, CWSD, AWG, FOHV | 2013 | ~ | ~ |
| WFCR Woodfords to State Line | Ace Herford Ranch. Along WFCR Woodfords to Stateline | Rivers and Ranches - Ace Herford Ranch Meadow rehabilitation/ Water Quality Enhancement | Ace Herford Ranch/AWG, LWB, SBC | 2016 | ~ | CA proposition |
| Upper Carson - East and West Fork. | Alpine County | Alpine County Hazardous Fuels Reduction & Healthy Watershed Project | AWG, Alpine County, Sierra Nevada Conservancy, Alpine Fire Safe Council, American Rivers, HTNF, CWSD, Eastern Alpine County Volunteer Fire Department, Washoe Tribe of Nevada and California, Woodfords Washoe Community Council | 2017 | ~ | ~ |

*Table 6-3. Ongoing WFCR Watershed Projects*[12]

| Waterbody Reach(es) | Location | Title | Lead Organization/Partners | Dates | Budget | Funding Source |
|---|---|---|---|---|---|---|
| WFCR Headwaters to Hope Valley | Faith Valley | Faith Valley Meadow Restoration | American Rivers/ USFS, Wildlife Conservation Board, National Fish and Wildlife Foundation, FOHV, AWG, CDFW, Institute for Bird Populations, Trout Unlimited | 2023 | ~ | ~ |
| WFCR Headwaters to Hope Valley, Hope Valley to Woodfords | Multiple locations throughout the watershed. | USFS-HTNF West Carson River Habitat Improvement Project | HTNF/ Alpine County, CWSD, AWG, FOHV | ~ | ~ | ~ |
| Upper Carson River Watershed | ~ | Geomorphologic Model | CWSD, AWG, TBD | March 2024-March 2025 | $250,000 | 319 |
| Carson River Watershed | ~ | Carson River Watershed – Agricultural Producers Workgroup, BMP White Paper, Outreach | CRC, CWSD | 2021-2024 | $40,000. | CWA Section 208 |
| Carson River Watershed | ~ | Carson River Watershed Outreach and Education Programs | CWSD, CRC, AWG, FoHV | ~ | ~ | ~ |

[12] While this Vision Plan is an independent document, it is useful to note that information about ongoing projects/studies in the WFCR watershed was previously provided in the WFCR sections of CRASP Table 8.4, (CWSD, 2017; https://www.cwsd.org/wp-content/uploads/2017/12/Final-CRWASP-2017-Update-Plan-Part-1.pdf.

| Waterbody Reach(es) | Location | Title | Lead Organization/Partners | Dates | Budget | Funding Source |
|---|---|---|---|---|---|---|
| WFCR (all reaches) | Along routes 88 and 89 | Culvert Inspection Program | Caltrans District 10 | 2023 | ~ | ~ |

***Table 6-4. Proposed and Potential Future WFCR Watershed Projects and Actions[13]***

| **Waterbody Reach(es)** | **Location** | **Title** | **Lead Organization/Partners** | **Dates** | **Budget** | **Potential Funding Source(s)** |
|---|---|---|---|---|---|---|
| WFCR Hope Valley to Woodfords | private lands | OWTS effluent connection to STPUD C-Line | Alpine County, private landowners, possibly STPUD | TBD | TBD | TBD |
| WFCR Hope Valley to Woodfords, Woodfords to State Line | private lands | OWTS education, outreach, improvements | Alpine County, private landowners, possibly STPUD. | TBD | TBD | TBD |
| WFCR Woodfords to State Line | Rangelands | Support for Development of Ranch Management Plans, Implementation of Agricultural BMPs | AWG, CWSD, CRC, LWB, NRCS | TBD | TBD | CWA section 319 Grants |
| WFCR watershed | Forested Areas | Fuels Reduction Projects | USFS-HTNF, Alpine County, Washoe Tribe, AWG, CWSD, CRC, National Forests Foundation | TBD | TBD | TBD |

[13] While this Vision Plan is an independent document, it is useful to note that information about proposed and potential future projects and studies in the WFCR watershed was previously provided in the WFCR sections of CRASP Tables 8.3 and 8.8, (CWSD, 2017; https://www.cwsd.org/wp-content/uploads/2017/12/Final-CRWASP-2017-Update-Plan-Part-1.pdf.

| Waterbody Reach(es) | Location | Title | Lead Organization/Partners | Dates | Budget | Potential Funding Source(s) |
|---|---|---|---|---|---|---|
| Hope Valley, Scotts Lake, | Dispersed Camping Areas | Recreation Management & Facilities Improvements | USFS – HTNF | 2023-2033 | TBD | CWA section 319 Grants |
| WFCR Headwaters to Hope Valley | Along Blue Lakes and Burney Lake Rd. | Detailed Road Assessment | USFS, HTNF, AWG, CWSD | 2026 | $10,000 | |
| WFCR Headwaters to Hope Valley | Hope Valley, Faith Valley | Meadow/Channel Restoration | USFS – HTNF, AWG, CWSD, RB6 | TBD | TBD | CWA section 319 Grants |
| WFCR (all reaches) | River Channel | River Channel/Riparian Restoration | AWG, CWSD, CRC, LWB | TBD | TBD | CWA section 319 Grants |
| WFCR Hope Valley to Woodfords, Woodfords to State Line | private lands | Low impact development | Alpine County, private landowners | TBD | TBD | TBD |
| WFCR Woodfords to State Line | riparian areas | Riparian/Floodplain preservation | Alpine County, private landowners, land trusts | TBD | TBD | private/land trust funding |
| WFCR (all reaches) | In-channel | Removal/improvement of flow diversion structures | TBD | TBD | TBD | TBD |

## 6.1. Overall Approach to Implement the Vision Plan

The Plan builds on ongoing stakeholder actions to restore water quality, and the greater effort for restoring water quality in the Carson River watershed identified in the CRASP (CWSD, 2017). The Vision Plan relies on local stakeholders, property owners and state, local and federal government agencies to implement necessary actions to reduce pollutant discharges to the WFCR. The Vision Plan also relies on existing Lahontan Water Board regulatory and non-regulatory programs, authorities and responsibilities under the California Water Code and Federal Clean Water Act to facilitate and support the implementation of those actions. Much of the overall approach focuses on reducing erosion, restoring hydrologic function, and connecting floodplains to the river, all of which can have benefits for soil health and water resource availability. Reducing erosion will greatly reduce its associated water quality impacts – primarily turbidity, phosphorus and to a lesser extent nitrogen, iron, and sulfates.

The approach described was developed with the overall goal of the reasonable protection of beneficial uses included in the California's Porter Cologne Water Quality Control Act and therefore recognizes environmental and other social benefits of activities and land uses which may be contributing to water quality impairments.

## 6.2. Lahontan Water Board Authorities, Means and Role

The Lahontan Water Board has responsibility and authority for regional water quality control of point and nonpoint sources of pollution. The Lahontan Water Board uses its permitting authorities (waste discharge requirements and waivers of waste discharge requirements) to implement the requirements of applicable State policies and state and regional water quality control plans. The Lahontan Water Board regulates point sources with National Pollutant Discharge Elimination System (NPDES) permits, which regulate pollutant discharges into waters of the United States, and Clean Water Act section 401 certifications for discharges of dredge or fill material to waters of the United States. The Lahontan Water Board's approach to nonpoint source regulation is guided by the State Water Resources Control Board's (State Water Board's) Policy for Implementation and Enforcement of the Nonpoint Source Program (SWRCB, 2004), which allows flexibility in regulation of nonpoint source discharges.

The Lahontan Water Board also coordinates for water quality protection with other state, federal and local governments, tribes, and non-governmental organizations; implements grant and loan programs to fund water quality related projects; and conducts education and outreach to promote water quality protection.

The Lahontan Water Board may use one or more of the following regulatory tools, as needed, to achieve water quality objectives:

- Basin Plan Section 4.1 Regionwide Prohibitions and Carson River Hydrologic Unit Prohibitions

- California Water Code section 13267, which authorizes the Lahontan Water Board to require technical or monitoring program reports from dischargers.
- California Water Code section 13263 and 13383, which authorize the Lahontan Water Board to issue individual WDRs to regulate discharges of waste.
- California Water Code section 13304, which authorizes the Lahontan Water Board to require cleanup of unauthorized discharges to waters of the state.
- California Water Code section 13261, which allows the Lahontan Water Board to issue waivers of WDRs. These waivers must be renewed every five years.
- Development of a Total Maximum Daily Load (TMDL) for impairments in the WFCR watershed, including a program of implementation.

In addition to using regulatory tools as appropriate, the Lahontan Water Board will implement the following activities for water quality protection in the WFCR:

- Solicitation and management of Clean Water Act Section 319 Grants for nonpoint source pollution reduction projects, Clean Water Act Section 205(j) water quality planning grants, and grants from other funding sources which the Lahontan Water Board and State Water Resource Control Board manage.
- Providing notices of available funding for other funding sources, such as DWR, Alpine County, CDFW, CWSD and others. In addition to other notifications, the Lahontan Water Board provides to appropriate groups, within the next few months, the Lahontan Water Board will create a region-wide funding opportunities email list to share funding opportunities with stakeholders in the Lahontan region.
- Providing letters of support for proposals for projects and actions which will benefit water quality.
- Coordination with State, Federal, and Local Agencies and Tribal governments including development and updates of Management Agency Agreements.
- Coordination with non-governmental organizations doing water quality related work, including providing technical and regulatory assistance, and assistance with grant proposals for other agencies.
- Education and outreach.

Table 6-5 provides an overview summary of the categories of sources and entities potentially contributing to the impairments in the WFCR, existing regulatory tools and means to achieve reductions from those sources, and the proposed Vision Plan approach for requiring/achieving control actions, and partner agencies and organizations. Table 6-5 also lists other potential mechanisms that could be used if necessary or appropriate for one or more source categories. The subsequent sections in Chapter 6 further describe the plan for addressing each source category.

Other regulatory and non-regulatory mechanisms could be determined to be necessary if monitoring does not show progress in water quality improvement and/or if adequate progress at meeting implementation milestones is not achieved. They also could be implemented for other reasons, such as consistency with program priorities.

The regulatory mechanisms used could be implemented as individual orders/actions for a specific discharger, watershed, or category of dischargers. A Basin Plan Amendment, if necessary or appropriate, could establish a TMDL and/or other requirements in the Basin Plan which would provide a formal framework for addressing one or more sources or water quality impairments in the WFCR. The Lahontan Water Board’s general plan for collecting data and information and evaluating progress, as well as considerations for adaptive management, are discussed in the Evaluation and Adaptive Management section below.

*Table 6-5. Sources and Means to Achieve Reductions*

| Source Category | Entities | Existing Regulatory Tools & Means | WFCR Vision Plan Proposed Tools and Means | Partner Agencies and Organizations | Other Potential Mechanisms[14] |
|---|---|---|---|---|---|
| Historical Impacts such as logging, grazing, road building, channel alteration; | NA | Some projects are regulated under the Restoration General Order or individual WDRs/401 Certifications | CWA 319 grants and grants from other sources | AWG, CWSD, HTNF, CDFW, Multiple NGOs | CAOs, Waiver, WDR |
| Roads and road maintenance; | Caltrans | Caltrans Stormwater Permit. | Caltrans Stormwater Permit. | | Permit revisions |
| Roads and road maintenance | Alpine County | NA | CWA 319 grants and grants from other sources | AWG, CWSD | MAA, Waiver, WDR |
| Roads and road maintenance | Private Landowners | NA | Education, Grants | AWG, CWSD, Alpine County | Waiver, WDR |
| Roads and road maintenance | USFS-HTNF | NA | Informal | AWG, CWSD | 13267 Orders, MAA, Waiver, WDR |
| Camping and recreational use | USFS-HTNF | NA | RAC grant | AWG, CWSD | 13267 Orders, MAA, Waiver, WDR |

[14] These could be implemented as individual orders/actions or as under Basin Plan implementation program such as a TMDL.

| Source Category | Entities | Existing Regulatory Tools & Means | WFCR Vision Plan Proposed Tools and Means | Partner Agencies and Organizations | Other Potential Mechanisms[14] |
|---|---|---|---|---|---|
| OWTS | Wilder Ranch | WDRs | WDRs | | Enforcement orders such as CDO, CAA |
| OWTS | Private Residences | OWTS Policy Waiver Alpine County LAMP | OWTS Policy Waiver Alpine County LAMP | Alpine County, AWG, CWSD | WDRs |
| Grazing | Private ranches | NA<br><br>6 Users of recycled STPUD water have water reclamation requirements | Education, Grants, NRCS EQIP, CWA 319 | NRCS, CWSD, AWG | WDRs, waiver of WDRs or NPDES permit/WDRs |
| Grazing | HTNF | HTNF - Term Grazing Permit and Annual Operating Instructions | HTNF - Term Grazing Permit and Annual Operating Instructions | HTNF | WDRs, waiver of WDRs, MAA |
| Climate change, wildfire, invasive species, | USFS-HTNF CalFire | NA | Grants, outreach, education | NRCS, CDFW, CDFA | NA |

## 6.3. Potential Funding Sources

There are numerous sources of funding for implementing the projects and activities identified in this Vision Plan. Stakeholders can be informed about funding opportunities from the Lahontan Water Board's upcoming funding opportunities email list, as well as the Sierra Nevada Conservancy Funding Opportunities Newsletter (a hub for environmentally focused grants).

Some of these funding sources are available to individual landowners. Some funding sources are available to agencies and nonprofit organizations, such as resource conservation districts (RCDs), which then manage the grants for projects on private lands. There is currently not an RCD in Alpine County, so it could be beneficial for an Alpine RCD to be formed to facilitate funding for projects on private lands.

Sources of funding include:

- The State and Regional Water Boards' Nonpoint Source (NPS) Grant Program, which supports projects to reduce and mitigate the effects of nonpoint source pollutants to waters of the state. The funding for this grant program comes from a grant to the State Water Resources Control Board (State Water Board) from U.S. EPA under Clean Water Act (CWA) section 319 (CWA 319h grant). More information on CWA 319 grants can be found at the Lahontan Water Board's Nonpoint Source Program webpage, and the guidelines for 2023 applications can also be accessed online at the Lahontan Board's Clean Water Act Section 319 website: https://www.waterboards.ca.gov/lahontan/water_issues/programs/nps/cwa-319-grant-program.html

- The State and Regional Water Boards' Cleanup and Abatement Account, which provides grants for the cleanup or abatement of a condition of pollution when there are no viable responsible parties available to undertake the work. The Cleanup and Abatement Account is supported by court judgments and administrative civil liabilities assessed by the State Water Board and the Regional Water Quality Control Boards. More information is available at: https://www.waterboards.ca.gov/water_issues/programs/grants_loans/caa/cleanup_and_abatement.html

- Clean Water Act section 205(j) water quality planning grants – These funds are allocated to the Water Boards by USEPA for a competitive grant process.

- NRCS Environmental Quality Incentives Program (EQIP), and the Conservation Stewardship Program (CSP), both of which also serve as sources of technical assistance. Information about NRCS Financial Assistance Programs is available at: https://www.nrcs.usda.gov/getting-assistance

- USFS - Secure Rural Schools and Community Self Determine Act Funds – Under this act, a portion of USFS revenues are provided for projects in counties with USFS lands, such as Alpine County, to help fund schools and roads and create employment opportunities through projects that maintain current infrastructure and improve the health of watersheds and ecosystems on national forests. In Alpine County, the Alpine County Resource Advisory Committee (RAC) is responsible for reviewing projects and making recommendations for funding. Information about this committee is available at: https://www.fs.usda.gov/main/htnf/workingtogether/advisorycommittees

- Funding from other government agency funds as the Department of Water Resources and CDFW.

- Funding from private entities, including individual dischargers, or private entities, which provide services to dischargers in the watershed.

## 6.4. Historical Impacts - Stream/Watershed Restoration

Restoration of the WFCR channel and its watershed to reduce impacts from historical activities has been ongoing for several years through multiple projects and is expected to continue in the future. Restoration reduces erosion and restores connection between the channel and its floodplains, improving hydrologic function by slowing flows during high runoff events and increasing flows later in the year. These changes in flow regime also improve water quality by decreasing erosion from high flows and increasing assimilative capacity during lower flow periods.

There are several techniques that can be used to restore the river channel and watershed function in the WFCR, mitigating the damage from historical impacts in the watershed. Techniques appropriate for the WFCR include streambank stabilization, biotechnical streambank protection, and bank strengthening by vegetation restoration. Appendix A contains a more complete description of these techniques, their costs, benefits, and other considerations.

Many of the projects on the WFCR also involve planting willows and aspen along the river channel and in other wet areas. This vegetation helps reduce erosion and provide habitat. Planting willows and aspen instead of more flammable conifers also helps reduce fire risk, which reduces the risk of fire impacts on WFCR water quality. Additionally beaver dams and beaver dam analogues have been identified as potentially beneficial in the upper reaches of the WFCR as they provide check dams which slow the flow and allow better connection to meadow floodplains. An in-depth discussion of beaver dam analogs is available at: https://www.beaverinstitute.org/wp-content/uploads/2017/08/Beaver-Restoration-Guide-v.2.0-2017.pdf

### 6.4.1. Existing and Recent Projects/efforts

There are multiple current and recent restoration projects in the watershed which are already improving water quality in the WFCR. They are described below. The science and art of channel and meadow restoration is continuously evolving, and the lessons learned from each project contributes to the design of subsequent projects.

The Upper Carson River Watershed Stream Corridor Assessment (MACTEC, et al., 2004), was developed with funding from CA Proposition 13, and support from AWG, and several other agencies, organizations, and individuals. The Assessment describes in detail the geomorphologic condition of specific reaches of the WFCR. The assessment of the Upper Carson River noted widespread incision with unstable, eroding banks, and some headcutting, as well as discontinuous riparian canopy in Hope and Faith Valleys. The project team developed a list of impacted reaches which would most benefit from restoration and developed specific recommendations for these reaches. For the WFCR these were, moving from downstream to upstream:

- “Reach WF8”, an incised meadow in Lower Hope Valley, immediately downstream of the Highway 88 bridge.
- “Reach WF10”, an incised meadow in Upper Hope Valley.
- “Reach WF14”, a meadow in Faith Valley.
- “Reach WF15”, a meadow in Faith Valley.

Restoration projects have been implemented on portions of reaches WF8, WF10 and WF 14. Figure 6-1 shows the location of these reaches as well as current and recent restoration projects.

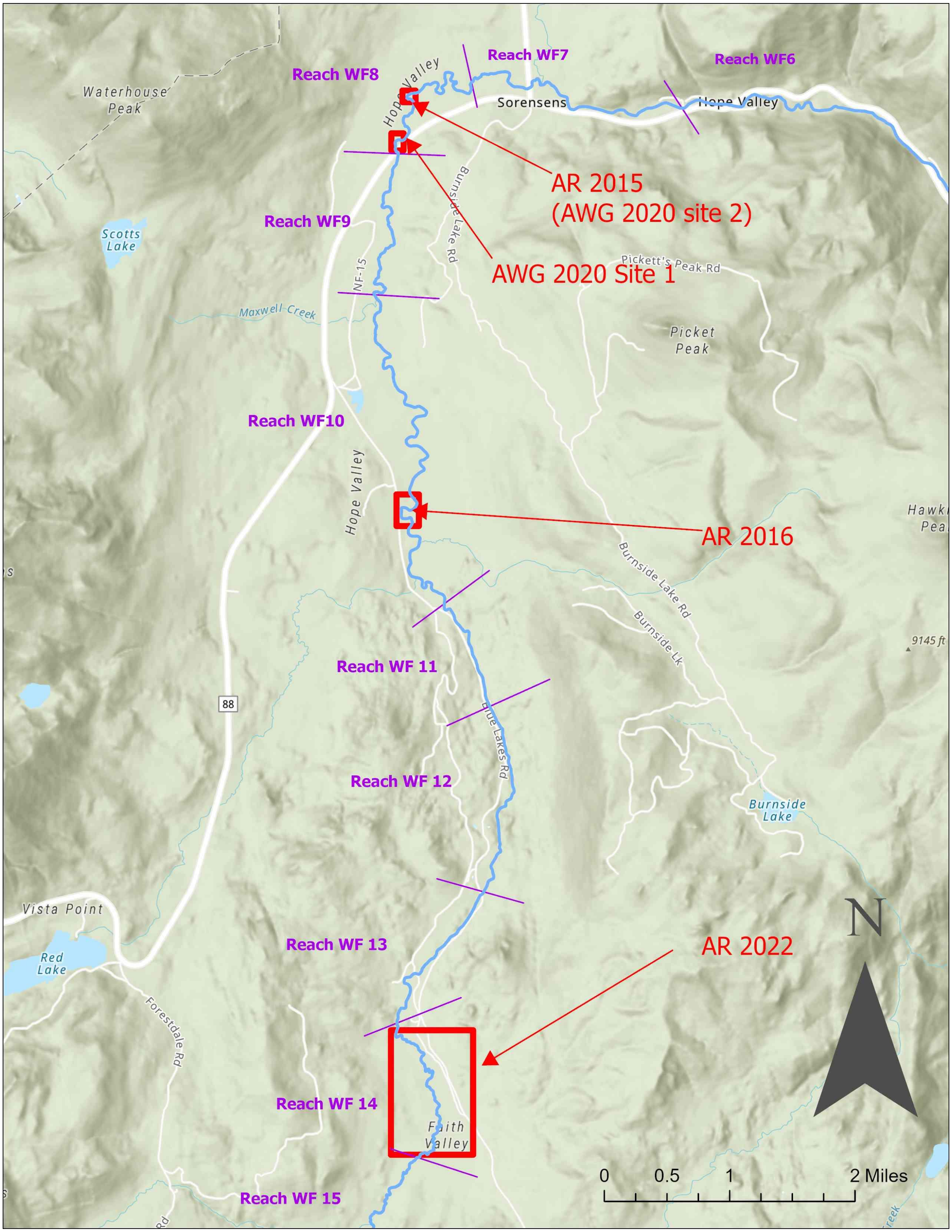


*Figure 6-1 WFCR Restoration Sites*

*American River's Hope Valley Meadow Restoration*

Staring in 2015, and finished in fall of 2016, the environmental organization American Rivers led the Hope Valley Meadow Restoration project, which restored about one mile of stream channel on the WFCR, (in reaches WF8, and WF 10) by stabilizing banks, planting willows, and reconnecting the channel with its floodplain.

In 2015 a log-crib structure was installed to stabilize a particularly high, eroding bank and enhance fish habitat along a 130 feet section of stream channel in reach WF8 (AR 2015 in Figure 6-1). Starting August 2016 and ending October 2016, meadow restoration approximately 3 miles upstream (AR 2016 in Figure 6-1), on Reach WF 10, installed root wads, riprap boulders, willow stakes, and logs to stabilize banks and reduce the amount of sediment washing into the river. Specific activities included toe stabilization, cutoff protection, headcut repair, and bank and bar revegetation.

This project was a collaborative effort that involved American Rivers, Friends of Hope Valley, AWG, USFS-HTNF, CDFW, Waterways Consulting, Habitat Restoration Sciences, Institute for Bird Populations, Trout Unlimited, Great Basin Institute and more. Funding came from the National Fish and Wildlife Foundation, Sierra Nevada Conservancy, CA Wildlife Conservation Board, CDWR, Wildlife Conservation Society and the Bella Vista Foundation.

> More information about this project is available at: https://www.americanrivers.org/2017/01/major-meadow-restoration-in-hope-valley-complete/

*Alpine Watershed Group's Hope Valley Restoration and Aquatic Habitat Enhancement Project.*

The AWG-led Hope Valley Restoration and Aquatic Habitat Enhancement Project was constructed in Fall 2020. The goals of this project were to reduce erosion, improve aquatic habitat, and create a more connected river channel and floodplain. The project took place at two sites which are both river meanders downstream of the highway 88 crossing of the WFCR in Hope Valley. The first site (AWG 2020 Site 2 in Figure 6.1) was immediately downstream of the highway (shown with the Label AWG 2020 Site 1 on figure 6.1) and the second site (AWG 2020 Site 2 in Figure 6-1) was about half a mile further downstream at the meander where the log crib structure from American Rivers' Upper Hope Valley Meadow Restoration project.

At the first site, restoration techniques were utilized to mimic an abandoned oxbow. A floodplain bench about 2.5 feet deep, 14 feet wide, and 300 feet long was excavated behind a failing bank on the outside of a river meander. This structure was filled with locally harvested sod blocks and willow stakes and live willow transplants. This design allows vegetation to establish before coming in contact with the actual river channel. This vegetation will provide natural armor for the channel in high flows, and the lowered area will also make it easier for the river to access the flood plain during high flows if the stream erodes the riverbank back to the project site.

At the second site, anchored slash piles were placed upstream and downstream of the previously installed log crib structure to reduce erosion and willows were planted throughout the site. Most of the work was done on the downstream end, where some minor excavation was performed to grade back the bank and allow for vegetation to be planted. Willow fascines, (dormant branch cuttings bound together into long cylindrical bundles) were also installed near the waterline, below installed sod and slash[15].

This project was implemented in three phases. The first phase, project planning, was funded by the State Water Board. The second phase, project construction, and the third phase, monitoring and adaptive management was funded by the National Fish and Wildlife Foundation and California Department of Fish and Wildlife, Office of Spill Prevention and Response and from the Water Boards' Cleanup and Abatement Account as part of the settlement of State Water Board enforcement actions.

> More information about this project is available at https://www.alpinewatershedgroup.org/hope-valley-restoration-and-aquatic

*HTNF-WFCR Fuels Reduction, Aspen and Meadow Restoration Project*

The HTNF is implementing a project to reduce fuels, thin more fire prone conifers, and plant aspen along the WFCR. By thinning conifers and planting aspen, fire reduction is greatly reduced, and meadow function is improved while erosion potential is reduced. The project timeline is spring 2022 through fall 2024, and the work will incorporate 349 acres. Work is being completed by California Conservation Corps crews, American Conservation Experience crews, and private contractors. AWG will be completing monitoring of aspen groves. Funding for the project was provided by the CDFW Watershed Restoration Grant Program.

> More information about this project is available at https://www.nationalforests.org/who-we-are/press-news/west-fork-carson-fuels-reduction-aspen-and-meadow-restoration-project
>
> http://bondaccountability.resources.ca.gov/Project.aspx?ProjectPK=42027&PropositionPK=48

[15]These fascines were intended to help reduce erosion and sprout new willows, however less than a month after the project was complete a beaver repurposed the willow fascines into a dam, so they did not end up serving their intended purpose.

*American River's Faith Valley Meadow Restoration*

The Faith Valley Meadow Restoration Project (AR 2022 in Figure 6-1) aims to reestablish the hydrological connectivity between the WFCR and surrounding 120-acre Faith Valley meadow through the implementation of beaver dam analogs (BDAs), a rocked grade control, and habitat enhancements. The project also includes forest road improvement work on the dirt road adjacent to Faith Valley Meadow to improve recreation experience and reduce impacts from recreation. The first phase of the project constructed the rocked grade control and 14 pilot BDAs in the summer of 2022. Those BDAs are being monitored to track performance and impacts on stream flow so American Rivers can observe and learn from the pilot set of BDAs. Phase 2 is anticipated to be completed in 2023 and will include additional BDAs and dirt road repairs.

The Faith Valley Meadow Restoration is a collaborative effort led by American Rivers alongside the U.S. Forest Service, Humboldt-Toiyabe National Forest, Alpine Watershed Group, Institute for Bird Populations, Friends of Hope Valley, and Trout Unlimited.

For more information, please contact Julie Fair at jfair@americanrivers.org or the Humboldt-Toiyabe National Forest, Carson District Office at 775-882-2766.

*Alpine Watershed Group's Markleeville Creek Day*

Markleeville Creek Day is a community-wide, volunteer-based watershed restoration event that AWG has been coordinating since 2001. While Markleeville Creek is actually a tributary of the East Fork Carson River, the work often takes place throughout the Upper Carson River watershed. This event involves numerous restoration activities such as installing willow stakes, removing trash, pulling invasive weeds, addressing erosion issues, wrapping aspens. Markleeville Creek Day involves dozens of volunteers working on a handful of projects. More information about this day is available at:

https://www.alpinewatershedgroup.org/creek-day

*Friends of Hope Valley Annual Workday*

The non-profit organization Friends of Hope Valley also hosts a volunteer annual workday. Projects include such activities as planting willows, general clean-up, adopt a highway litter pick up, and replacing old fencing along the highway.

### 6.4.2. Ongoing and Future Projects/Actions, Schedule and Resources Needed.

Ongoing restoration will continue through the efforts of key partners, such as AWG and CWSD, to obtain funds and implement restoration of the reaches identified in the 2004 Stream Channel Assessment. Of the four reaches identified as priorities for restoration in the 2004 Upper Watershed Assessment, projects have been implemented on reaches WF8, WF10 and WF14, but additional projects could be applied in other parts of these reaches, as well as the reach WF15.

The proposed geomorphological modeling effort by AWG and CWSD may provide further insight into which reaches, or possibly which tributaries, would be the most beneficial to restore in terms of water quality improvements. This model is proposed to be developed over the next few years and be completed by the end of 2026.

As discussed in Appendix A, river restoration can reduce sediment concentrations significantly; up to 50% sediment reductions have been observed in past restoration projects. Similar reductions should be attainable in the WFCR when restoration is combined with efforts at reducing erosion from roadways and other uses in the watershed. For the Headwaters to Hope Valley Segment of the WFCR an approximately 44% reduction in phosphorus is needed to attain standards as discussed in Section 4. Historic impacts, roads, and recreation are the only pollution sources in this upstream reach. In addition to the activities to address road and recreation sources, it is likely that additional restoration will be needed, to attain phosphorus WQOs in the WFCR by reducing in-channel sources and improving hydrologic function.

While an exact schedule cannot be proposed since funding is not definite, it is likely that a restoration project could be completed every 4 years, starting when modeling is concluded in 2026 and with some potential overlap, 2-3 restoration projects could be completed over the lifespan of this Vision Plan.

The cost of the proposed geomorphological model for the Upper WFCR is approximately $250,000. River restoration projects for a river of this size can have costs in the $500,000 - $1M range. Therefore, the total cost of assistance needed for watershed and channel restoration to implement 3 additional restoration projects is estimated to be in the range of $2M.

All restoration projects which involve changes to a streambed require Clean Water Act section 401 permitting from the Lahontan Water Board. To streamline this process as much as possible, where possible, projects will be permitted under the State Water Board’s Order for Clean Water Act Section 401 Water Quality Certification and Waste Discharge Requirements for Restoration Projects Statewide (Statewide Restoration General Order, Order No. WQ 2022-0048-DWQ). USFS-HTNF will also continue to be a partner in restoring the WFCR and its tributary watershed, most of which is on HTNF land.

### 6.5. Roads

The entities responsible for roads in the WFCR include Caltrans, Alpine County, USFS-HTNF, and private landowners. The Lahontan Water Board, as well as AWG and stakeholder groups, continue working with these entities to reduce pollution from roads. Many existing activities and projects are underway and will continue. Additional projects and practices are also expected to be implemented, as well as studies to prioritize and target these practices for effectiveness.

The State Water Board regulates the California Department of Transportation's stormwater discharges under a statewide NPDES municipal stormwater permit. (https://www.waterboards.ca.gov/water_issues/programs/stormwater/docs/Caltrans/Caltrans_Permit_Final_DIT.pdf). Like all NPDES permits, the Caltrans permit is renewed approximately every five years. The current Caltrans permit was adopted by the State Water Board on June 22, 2022. The Caltrans permit does not set numeric effluent limitations but requires Caltrans to implement BMPs to comply with the permit. Upon determination that Caltrans is causing or contributing to an exceedance of applicable water quality standards, the Caltrans must engage in an iterative process of proposing and implementing additional control measures to prevent or reduce the pollutants causing or contributing to the exceedance. The Caltrans permit requires Caltrans to update, maintain and implement as effective Storm Water Management Plan (SWMP) that describes how they will meet the requirements of this Order. The Caltrans permit requires Caltrans to submit an Annual Report each year to the State. The Annual Report serves the purpose of evaluating, assessing, and reporting on each relevant element of the storm water program, and revising activities, control measures, BMPs, and measurable objectives.

The stormwater discharges from the remainder of the roads and highways which are not managed by Caltrans are not currently regulated by the State Water Board or the Lahontan Water Board through a permit or any other formal mechanism.

There are three basic types of management measures that can be implemented to reduce pollution from roads. Pollution prevention measures that reduce the generation of pollutants, transportation of polluted runoff away from where it may enter waterways, and treatment of polluted road runoff.

Since failing roads and culverts can be a source of sediment, pollution prevention practices include general road and culvert maintenance, as well as replacing undersized culverts and failing roads. Pollution prevention can also include reducing erosive potential resulting from concentrated flows from impervious surfaces. In some cases, removal of some failing roads may also be appropriate. More precise applications of salt, brine, and abrasives could help reduce the overall amounts applied. Improved roadway traction abrasive specifications, as are used in the Tahoe Basin can reduce the load of fine sediment in stormwater runoff from roadways. Increased sweeping frequency, more efficient sweepers can also reduce abrasives and salts available to enter surface waters.

Transportation and treatment practices include low impact development measures where feasible that utilize features such as swales or infiltration basis to capture stormwater runoff and reduce discharge to surface waters.

The Handbook for Forest, Ranch and Rural Roads (Weaver et al., 2015) provides an extensive description of practices for reducing erosion from unpaved rural roads. It is available for free download at http://www.pacificwatershed.com/roadshandbook. A video summary of the handbook is available at: https://www.youtube.com/watch?v=7cbN6YvRTSo .

### 6.5.1. Existing and Recent Projects/Efforts

Existing road maintenance and improvement by the parties responsible for roads help prevent erosion from road and culverts failures. Caltrans implements many practices to reduce pollution from its highways under the Caltrans permit. Caltrans has a culvert inspection program, created in 2005 to inventory and assess all the State's culverts. The program goal is to assess all culverts in the State by 2023. Culverts are assessed and rated and documented. Culverts assessed in poor or fair condition are put into a project for the needed repairs, replacement, or cleaning. The State Highway System Management Plan sets targets for the number of linear feet, based on the goal for 90% of culverts to be in good or fair condition.

HTNF and Alpine County also have programs for maintaining and improving their road systems.

The Road system in the Carson Ranger District of the HTNF is managed according to their Travel Analysis Process (TAP) report (HTNF, 2011). The TAP report provides information related to travel analysis in conjunction with the identification and management of the minimum road system. It includes recommendations that the district can use to identify where both USFS roads and unauthorized routes could be decommissioned, or added to improve recreation access, administration, and protection of the National Forest System lands on the district. The TAP also includes preliminary analysis of the effects of the FTS on biophysical and human resources.

HTNF has a road maintenance crew, which has a budget of approximately $500,000 per year, which is all needed for regular maintenance. HTNF does not have a regular road evaluation and inspection program, but road staff crews regularly identify safety issues and roads or features with potential to cause resource damage. Decommissioning of USFS roads or illegally created routes is done on an Ad-hoc basis. (Jorgensen, 2023). BMPs to protect water quality on USFS roads are installed following the USFS BMP Manual (USFS, 2012)

HTNF recently received additional funding for a wildfire crisis strategy, $6 million of which was dedicated for forest road improvements, shared between the Carson Ranger District of the HTNF and Elko area. The purpose of this funding is to improve access to high fuels areas for fire control, but improvements in these roads will also make them more stormproof sustainable reduce their potential for erosion and resulting water quality impacts. BMPs to be applied to these roads include adding rolling dips, reconstructing sections or roads, adding cross slope, adding ditches and grading and filling in ruts.

HTNF has agreements with Alpine County to maintain some paved roads, such as Blue Lakes Road.

The American Rivers and USFS-HTNF Faith Valley Restoration Project, described above, also includes forest road improvement work on the dirt road adjacent to Faith Valley Meadow, which will help reduce sediment going into the WFCR.

### 6.5.2. Ongoing and Future Projects/Actions, Schedule and Resource Needs.

The Lahontan Water Board will work with Caltrans, HTNF, Alpine County, and local landowners to support improvements for roads with high erosion potential, including pursuing funding from grants or other sources.

Since there are many miles of roads and highways in the WFCR watershed, investigations should be performed to identify which areas are hydrologically connected with the WFCR or its tributaries, and if additional BMPs or other repairs are needed in those areas. An example of such a prioritization is the Natural Environment as Treatment (NEAT) study (Wood Rodgers, 2010) performed to develop a consensus-based approach for the prioritization and selection of water quality improvements for Caltrans highways within the Lake Tahoe Basin. The NEAT study classified segments of highways into 3 distinct categories of depending on hydrologic connectivity with waters: In some highway segments, the pollutants transported by storm water runoff would be adequately treated by the natural environment, other segments needed minor modifications could treat highway runoff, and other segments where storm water should be collected and treated prior to discharge.

The Lahontan Water Board will work with Caltrans, the HTNF, and Alpine County to ensure the development of investigations, identifying roads and road maintenance activities with the greatest potential for discharges to surface waters in the WFCR watershed. These investigations should be completed within the next three years. This will allow time for development and implementation of projects over the next several years, so they can be completed in the timeframe of the overall Vision Project.

Currently, Caltrans is the only party in the West Fork Carson River watershed whose stormwater discharges are covered under a State Water Board or Lahontan Water Board permit. USFS logging activities are regulated under the Lahontan Water Board's Timber Waiver, but the Lahontan Water Board does not currently have a permit covering other activities on USFS land. In the future, the Lahontan Water Board may issue orders requesting information or regulating discharges associated with road activities of the USFS, Alpine County, or other parties.

On an annual basis, the Lahontan Water Board will request information from Caltrans, Alpine County, and the USFS-HTNF about their progress in identifying and resolving culvert issues and other road erosion issues as well as let them know of any identified areas of greater potential water quality impact. The Lahontan Water Board will also work with them to request salt and sand use reporting on an annual basis and to investigate the potential use of materials with less impact to water quality. For Caltrans, this information can be included in their annual report submitted to the State Water Board.

Caltrans' program for addressing culvert issues for its highways, described above, should result in identification and resolution of highway culvert related erosion sources in the WFCR watershed.

The Lahontan Water Board will work with State Water Board staff to suggest findings and requirements in the Caltrans Permit when it is updated to address the potential for state highways to be a source of contributions to water quality impairments in the WFCR. The Caltrans permit is not likely to be updated until approximately 2027 due to the 5-year NPDES permit cycle. In the meantime, Lahontan Water Board staff will work with the State Water Board and Caltrans to include studies and BMPs for the WFCR in the Caltrans SWMP.

The Lahontan Water Board will also work with Alpine County to support improvements for roads and culverts with high erosion potential, including pursuing funding from grants or other sources. The Lahontan Water Board will work with the USFS to support improvements for roads and culverts with high erosion potential and decommissioning of especially problematic roads.

State Water Board investigations identified twelve culvert features on Alpine County roads showing signs of failure and are therefore in need of repair (Hanks et. al, 2019). It is envisioned that these should be repaired within the next six years, by 2029, and should be a priority for grant or other funding. The Lahontan Water Board will also work with Alpine County, local landowners, and watershed groups to identify and address roads and culverts with high erosion potential on private lands.

For dirt roads in the HTNF, studies need to be performed to identify roads in need of repair and any dirt roads or ORV trails that should be removed. The Upper Carson River Watershed Stream Corridor Assessment (MACTEC, et al., 2004) recommended that a detailed assessment of road conditions be prepared that would identify potential sources of sediment along roadways in the vicinity of Blue Lakes and Burnside Lake Roads. These studies should be performed within the next 5 years, so that any projects identified can be implemented in a timely manner to meet the goal of attainment of water quality standards in the Vision Plan timeframe. Utilizing the cost estimate from the Upper Carson River Watershed Stream Corridor Assessment and adjusting for just the portion of the area in the WFCR watershed, as well as adjusting from 2004 to 2023 dollars, the cost of the road assessment is estimated at $10,000. Once this study is complete, it is likely that specific roads and road features will be identified for needing repairs/decommissioning, or improvements. Based on the SWRCB study (Hanks et. al, 2019) – approximately 1/3 of crossings in the watershed are in need of some form of repair or replacement. Improvements on HTNF roads could be funded with a 319 grant, and/or USFS Secure Rural Scholls and Community Self Determine Act Funds.

Education and outreach are also critical elements of addressing impacts from roads and vehicular use of HTNF lands. Education topics related to roads are included as a topic for outreach in the Information and Education section below.

## 6.6. Onsite Wastewater Treatment Systems (OWTS)

The Lahontan Water Board will continue to work with OWTS owners and Alpine County to reduce water quality impacts to the WFCR form OWTS. Residential OWTS in Alpine County are covered by the OWTS Policy Waiver and are regulated by the County under a Local Area Management Plan (LAMP) which was approved by Alpine County Board of Supervisors in May 2019, and the Lahontan Water Board in July 2019. The OWTS for one resort facility near the river, Wylder Hope Valley used to be regulated under a WDR under its former owner. As described below, the Lahontan Water Board is working with the new owner to get this facility regulated under waste discharge requirements.

Under the California Water Code, the State and Regional Water Boards have full regulatory authority to regulate discharges to surface waters and groundwater, including those from OWTS, under Waste Discharge Requirements.

The State Water Resources Control Board's *Water Quality Control Policy for Siting, Design, Operation and Maintenance of Onsite Wastewater Treatment Systems* (OWTS Policy) (SWRCB, 2012) waived the requirement for OWTS owners to submit a report of waste discharge, obtain waste discharge requirements, and pay fees for discharges from OWTS covered by the Policy and that meet the conditions of the OWTs Policy Waiver. In July 2019, the Lahontan Water Board adopted Resolution R6T-2019-0254, approving the Alpine County Local Area Management Plan (LAMP). Eligible new and replacement OWTS must comply with the requirements of the LAMP to be covered under the OWTs Policy Waiver.

The LAMP is designed to protect groundwater and surface waters from contamination through the proper design, placement, installation, maintenance, and assessment of OWTS. The LAMP includes minimum standards for the treatment and ultimate disposal of sewage using OWTS in Alpine County. The Alpine County Environmental Health Department is responsible for permitting and inspecting the installation of residential septic systems. The County also follows up on septic systems which are failing or in need of repair. The implementation of the Alpine County LAMP by the County will continue to be an important means of protecting water quality in the WFCR. If water quality data or other information indicate that additional protections are needed to ensure water quality in the WFCR is protected from OWTS impacts, the Lahontan

Water Board will work with the county to amend the LAMP and/or follow up on any failing OWTS, whose owners are required to implement corrective actions per Tier 4 of the OWTS Policy. Additionally, education about potential impacts of OWTS on the WFCR will be a focus of outreach by the Lahontan Water Board, the Alpine County and others. OWTS owners and operators will be encouraged to upgrade their systems and operate them as efficiently as possible. Where needed, grant funding could be pursued for upgrading OWTS. Potential sources include:

- Clean Water Act Section 319 grants.
- Clean Water State Revolving Fund (SRF):

  OWTS Policy Section 14.0 states that local agencies may apply to the State Water Board for funds from the Clean Water SRF for use in mini-loan programs. Local agencies are also responsible for administering SRF mini-loans.
- United States Department of Agriculture (USDA) Rural Development:

  The USDA Section 504 Home Repair Program provides loans to very-low-income homeowners to repair, improve or modernize their homes or grants to elderly very-low-income homeowners to remove health and safety hazards. More information about this program is available at https://www.rd.usda.gov/programs-services/single-family-housing-programs/single-family-housing-repair-loans-grants

To help identify potential OWTS impacts, the Lahontan Water Board will conduct and/or support monitoring in the WFCR, downstream from OWTS areas. This monitoring, described in the monitoring section below, will include anthropogenic substances such as sucralose and caffeine which can provide an indication of OWTS impacts in receiving waters. Such monitoring should be completed before the Lahontan Water Board evaluation of progress in 2029, to inform timely actions and adaptive management.

Ultimately, if impacts to the WFCR from OWTS increase, due to population increases or other factors, other solutions for wastewater treatment, such as construction of a community wastewater treatment system, should be considered in long term planning for the area.

One resort facility along the river, Desolation Hotel Hope Valley, has had historical issues with its OWTS. The facility was formerly Sorensen’s Resort and Cafe but changed ownership in 2018. This facility was under Waste Discharge Requirements (WDRs) and a cleanup and abatement order (CAO) to resolve issues with failure of its OWTS resulting in discharges of partially treated wastewater to the river during wet years. The leach field was subject to high groundwater intrusion, and not allowing the treated wastewater to percolate and continue treatment. The wastewater/groundwater mix was surfacing at the low side of their property (parking lot) and traveling to WFCR via the roadside storm drainage ditch.

The WDRs for this facility were not transferred to the new owners during purchase. Lahontan Water Board will work with the new owner to finalize their application and get this facility under waste discharge requirements. A new package treatment plant has been installed at this facility after its purchase in 2018. The long-term solution for this facility's wastewater could be for it to meet the requirements that would allow it to discharge to the STPUD C-line, and discharge to the C-line, with onsite storage as a backup. This solution would eliminate all discharges to the WFCR. The Lahontan Water Board will continue to work with the owners of this facility to get it coverage under WDRs and ensure that the discharge from this facility is not impacting the WFCR or groundwater in the area.

## 6.7. Grazing

There are many practices, processes, and programs which help reduce the impacts of grazing to surface waters in the WFCR watershed. These are expected to continue to be utilized to effectively address the potential water quality impacts to the WFCR from grazing. While the Basin Plan generally describes potential control measures for Grazing in Section 4.9, currently the Lahontan Water Board has not issued waste discharge requirements or a waiver of waste discharger requirements to regulate grazing in the WFCR watershed. The one exception is that use of recycled STPUD water for irrigation on six ranches in the WFCR watershed is regulated under Wastewater Reclamation Requirements issued by the Lahontan Water Board (CRWQCB-LR, 1989 a-1989f). These requirements specify the location of use of irrigations water, and prohibit discharge to surface waters, and require reporting of the adequacy of tailwater controls to prevent surface water runoff.

Practices to reduce NPS pollution include riparian fencing and buffers, rotational grazing, hardened stream crossing, salt block placements, and provision of alternative water sources. Appendix B contains a summary of potential grazing practices for the WFCR.

### 6.7.1. Existing and Recent Projects/efforts

There are current and recent efforts to reduce NPS pollution from grazing in the WFCR. The local NRCS office in Minden Nevada provides technical and financial assistance to growers in the area. Grants continue to be available to fund implementation of practices. Watershed groups, CWSD and AWG, provide a forum for education and collaboration on reducing NPS pollution through their projects and programs.

*Carson River Coalition Agricultural Producers Working Group*

The Carson River Coalition Agricultural Producers Working Group (CRC-APWG) was launched by CWSD in 2022. This working group performs direct outreach to the Carson River Watershed's farming and ranching community regarding soil health and water quality related best management practices. CWSD is also developing an agricultural

BMPs white paper. The white paper will provide a user-friendly document that explains different types of agricultural BMPs suited to the local area, the benefits of these practices to water quality and soil health, and how they help sustain the producer and the environment. The document will include local case studies, look at barriers to implementation, and outline steps producers could take to seek funding and to implement BMPs. The Lahontan Water Board will track and participate in these efforts as they are relevant to ranchers in the WFCR watershed.

*Rivers and Ranches Project*

In 2016, the owner of Ace Hereford Ranch, a 914-acre ranch along the WFCR in partnership with AWG and others, implemented a project to improve the ranch's management practices, pasture utilization, and infrastructure. The project received funding from a Proposition 84 grant.

The project included:

- Installation of exclusion fencing to improve pasture utilization, inhibit nutrient loading, and disperse grazing.
- Fencing out riparian areas and other sensitive habitats that disperse, filter, and capture nutrients.
- Repairing and improving irrigation infrastructure that allows the ranch to utilize pastures away from the river.
- Planting grasses, aspen, and evergreens to stabilize slopes and inhibit erosion while dispersing and capturing nutrients.
- Enhancing an existing wetland to trap sediment and filter nutrients before water returns to the Carson River
- Enhancing a bridge to allow cattle to safely cross the river without walking through the stream channel.

### 6.7.2. Ongoing and Future Projects/Actions

The Lahontan Water Board will continue to work with ranchers in the watershed, with priority on those immediately along the WFCR, to support and encourage the development and implementation of ranch water quality plans to reduce current and potential future impacts on water quality. The Lahontan Water Board will promote and facilitate voluntary implementation of BMPs focused on reducing NPS pollution to the WFCR. Voluntary implementation will be facilitated through *Ranch Water Quality Planning* in conjunction with the Natural Resources Conservation Service (NRCS) and potentially University of California Davis Cooperative Extension (UCCE).

Lahontan Water Board staff review of the grazing permit and annual operating instructions for grazing the Humboldt-Toiyabe National Forest indicated that adequate practices are required to keep these cattle from impacting water quality so no additional actions are currently proposed for cattle on the HTNF land.

A goal of this Vision Plan is for all grazing lands along the WFCR to be implementing ranch water quality plans (RWQPs) within the next two years, by October 2025. RWQPs should identify practices and areas which have the most potential to cause sediment, nutrients, or bacteria to be discharged to the WFCR or its tributaries, and relevant best management practices (BMPs) to prevent or mitigate the pollution potential from those practices and areas. Since the Lahontan Water Board does not currently have an inventory of what practices are already being applied, the level of improvement needed is not known. Some ranches may need minimal improvement, and could document that in their RWQP, while others may need more significant changes. An important aspect of RWQPs is the control of the use of recycled water, which is high in nutrients.

For the RWQP process, NRCS and UCCE are likely to be able to provide technical assistance. Clean Water Act section 205(j) water quality planning grants could also potentially be used to help with the water quality planning process. For the implementation of projects and practices to reduce nonpoint source pollution, funding is potentially available from NRCS EQIP Grants and Clean Water Act section 319 grants.

The Lahontan Water Board will need to collect information about management plans and practices being implemented. The Lahontan Water Board will request submittal RWQPs by October 2025. Starting in 2026, an annual reporting of BMP installations will be crucial for measuring progress. This will enable the Lahontan Water Board to track the ranchers' installed or maintained BMP efforts to help reduce grazing related water quality impacts in comparison to the water quality data results. This information could be collected and submitted to the Lahontan Water Board through a third party such as a ranchers' association or watershed group. The CWSD's web map-based tool for project tracking could be one way to report progress. The Lahontan Water Board may also request this information directly from the grazing landowners or operators if necessary and/or appropriate.

Lahontan Water Board staff will reach out to grazing landowners through stakeholder forums such as AWG meetings and through direct communication by the end of 2023 to ensure that this expectation, and available resources and opportunities for collaboration are clearly communicated. The Lahontan Water Board will continue to track progress, provide feedback to stakeholders, and report and discuss progress and opportunities for collaboration and funding at forums, watershed group meetings and Lahontan Water Board meetings.

The long-term approach will also be influenced by the Lahontan Water Board's overall approach to regulating grazing lands in the region through the forthcoming Regional Grazing Strategy. If necessary or appropriate, the Lahontan Water Board may also modify the Waste Discharge Requirements for the users of recycled STPUD water. The Lahontan Water Board will also request that STPUD, by the end of 2025 provide an analysis of potential long-term impacts of the use of recycled water on the WFCR. The Lahontan Water Board may also request STPUD to help facilitate water quality planning and reporting for the users of recycled STPUD water along the WFCR.

## 6.8. Camping and Recreational Use

There are several ongoing and planned future efforts to mitigate the impacts of camping and recreational use in the WFCR watershed. These efforts include increased management of recreational use by land managers, improvements in sanitation facilities, and education and outreach to recreational users. These efforts will result in an increase in proper disposal of waste and reduced vehicular erosion. Section 6.2 describes activities to reduce road impacts and is applicable to activities to reduce impacts which occur due to roads in these recreational areas.

Discharges from recreational use in the watershed are currently not under a permit, waiver, or other order of the Lahontan Water Board. However, reducing these impacts is identified in this Vision Plan as priority of the Lahontan Water Board's NPS Program. The NPS Program will work with the land managers and stakeholders in these areas to encourage and support their ongoing implementation of these measures, work with land managers, and watershed groups to support public education efforts and continue to pursue funding for these measures.

### 6.8.1. Existing and Recent Projects/efforts

The HTNF has several activities they perform to control and reduce impacts or recreational use in the HNTF watershed. There is a 14-day limit on camping in the HTNF and other regulations to reduce recreational impacts. However, there are currently limited resources to provide education and enforce the 14-day limit and other regulations. There is one recreational technician and one law enforcement officer to help educate visitors and enforce rules for the entire 600,000-acre Carson Ranger District.

CWSD had an ongoing campaign to outreach to recreational users in the watershed, which is one of its activities identified in the Carson River Adaptive Stewardship Plan (CWSD, 2017), and is further described in the Information and Education section, below.

### 6.8.2. Ongoing and Future Projects/Actions

HTNF staff are aware of the impacts of camping and recreational use on their lands in the WFCR watershed and have been implementing and pursuing funding for practices to address these impacts. The Lahontan Water Board, AWG, and others will continue to support funding for these projects and practices.

Additional staffing to provide education and outreach on forest rules and assist enforcement could greatly reduce recreational impacts. HTNF has obtained Resource Advisory Committee (RAC) funding for an additional seasonal (May-October) recreation tech, starting in 2024 which will cost approximately $35,000 per year.

For the Scotts Lake dispersed camping area, the USFS has obtained RAC funding (approximately $80,000) to install two restroom facilities by the end of 2024. HTNF is also working on obtaining funding to make this area into a fee site, due to its increasing usage.

For the dispersed camping areas along Blue Lakes Road, the USFS is increasing their presence in the area through an additional recreational technician, as described above, as well as an additional volunteer campground host for the area. The host would be present in the summer, provide outreach to campers, and work with USFS staff to address any issues observed in the area. The USFS has already begun advertising for a host for the area on Volunteers.gov. A volunteer host for the area is expected in the summer of 2023 (Eddy, 2022).

For both the Scotts Lake area and the dispersed camping areas along Blue Lakes Road, the USFS has obtained RAC funding for educational kiosks to better inform forest visitors of forest rules and regulations, fire prevention, and the importance of proper dispersed camping to protect valuable resources. The kiosks will be constructed to be resistant to vandalism and the harsh weather conditions of the area and will cost approximately $10,000 to be installed. Lahontan Water Board and AWG were identified as partners on the project and will have input on the messaging regarding water quality. These are expected to be installed by the end of 2024.

Another potential improvement identified in these areas is the lack of a pump out station for human waste. Currently the nearest pump-out stations are either in South Lake Tahoe or down in the Carson Valley. The Hope Valley Campground, currently managed by a concessionaire, could be a site for a pump-out station, which would likely reduce dumping of greywater and blackwater. Lahontan Water Board staff will continue to discuss this with HTNF and other stakeholders.

Lahontan Water Board staff will continue to check in with HTNF staff and stakeholders on at least an annual basis on the progress at reducing impacts from camping and recreational use, to assess effectiveness and identify other potential projects and funding sources that may be needed.

## 6.9. Hydrological Modification

Generally, increasing the flows in the WFCR during the summer and fall, when flows are typically low, would help reduce pollutant concentrations, lower temperature, increase dissolved oxygen and reduce potential for eutrophic conditions. Therefore, this Vision Plan recognizes that projects that improve hydrologic function and increase flow in the

WFCR will help meet the Vision Plan's goal of standards attainment in the WFCR. Regulation diversions is outside of the authority of the Lahontan Water Board. Lahontan Water Board staff will support restoration projects, as described above in historical impact, which benefit flows in the WFCR and hydrologic function of the river and its watershed. These include restoration projects such as those described in historical impacts, above.

The Lahontan Water Board and AWG will continue to monitor algal blooms in Red Lake. The Lahontan Water Board will also request that CDFW prepare a report which evaluates potential ways to manage the Red Lake to reduce algal blooms.

## 6.10. Climate Change, Fire, and Other Factors

This Plan recognizes that other factors can contribute to the water quality impairments in the WFCR and supports efforts to reduce those potential impacts. Identified factors for potential impacts are climate change, fire, invasive species, and development in the WFCR watershed.

The Lahontan Water Board has a Climate Change Mitigation and Adaption Action Plan (Scribe, 2021) which provides a framework for how Lahontan Water Board staff will develop, implement, and report on actions to adapt to and mitigate impacts from climate change. This Vision Plan includes actions that implement two of the Policy Statements from the Climate Change Mitigation and Adaption Action Plan, namely Protection of Wetlands, Floodplains and Headwaters, and Protection of Headwater Forests and Promoting Fire Resiliency.

The increase in potential for erosion, hydrologic impacts, and flooding due to climate change further emphasizes the need for the erosion control actions proposed in this Vision Plan and the benefits of restoration projects which improve hydrologic function. Lahontan Water Board staff will continue to require and encourage erosion control and support external restoration efforts by facilitating necessary permitting and supporting restoration projects.

Given the potential devastating impacts of wildfire on water quality in the WFCR watershed, this Vision Plan recognizes the water quality benefits of projects that reduce fuels and otherwise decrease the potential for wildfires. An example of this is the HTNF's WFCR Fuels Reduction, Aspen and Meadow Restoration Project, discussed in the Historical Impacts – Stream and Watershed Restoration section above. Other recent and ongoing efforts to reduce fire fuels include the activities of the Alpine Biomass Collaborative ( https://alpinebiomasscommittee.wordpress.com/about/), and the recent construction of a new sawmill near Carson City on Washoe Tribe land. The Vision Plan also recognizes the water quality benefits of reducing the presence of invasive species in the watershed since these can increase fire risk and erosion potential.

Consistent with the CRASP, this Vision Plan recognizes that local governments and stakeholders should consider, and where most needed work to remove floodplains from development and establish conservation easements or designated open spaces. This recognition should be considered in the Lahontan Water Board's approach to regulating grazing lands, since economic impacts of the regulatory approach could otherwise result in changes to land uses which have a more severe impact on floodplains, hydrologic function and water quality.

## 6.11. Information and Education

Information sharing and education will be key to the success of this Vision Plan. There are a number of ongoing activities, forums and campaigns which support education about the health of the Carson River, and waters in Alpine County.

AWG actively engages in Outreach and Education projects in the WFCR watershed. AWG has quarterly meetings which are open to the public and sometimes recorded and available online. The AWG also leads educational watershed tours and visits to restoration project sites.

CWSD is another organization that engages in educational activities to promote understanding and awareness of watershed resources and issues. CWSD works with partners to coordinate, plan, and fund outreach and education actions and activities. CWSD and the Carson River Coalition host an annual Carson River Watershed Management forum which focuses on actions to protect water quality and the health of the Carson River Watershed. The CWSD has an ongoing "I am Carson River Watershed" environmental education campaign, which airs public on local television and online, and is expected to continue into the future. More information about that campaign is available at https://iamcarsonriver.org/

The Lahontan Water Board's reports evaluating progress on implementation of the Vision Plan will help inform stakeholders and other parties about progress. This information will also be posted on the Lahontan Water Board's and/or AWG's WFCR Vision Plan website. A comprehensive 5-year review of the plan will occur in 2029 and 2034. This will be an opportunity where the Lahontan Water Board, agencies, and stakeholders can share monitoring and study results, progress implementation of the Vision Plan, and gather information and feedback to inform adaptive management of the implementation of the Vision Plan.

NRCS provides information to local agricultural producers about practices to improve water quality and funding opportunities.

The USFS provides education to users of the forest on how they can lessen their impacts. The HTNF also identified in its Travel Analysis Process (TAP) document, several educational activities that could help reduce impacts from roads and vehicular use in the HTNF. These include increased signage educating users about USFS rules and potential impacts to water quality, as well as increased USFS field presence, as discussed in the Recreation and Camping section, above.

Lahontan Water Board staff will continue to participate and support these activities and forums and education projects to improve knowledge of potential impacts and how they can be reduced. Table 6-6 presents key educational topics and partners for those topics.

***Table 6-6 Key Educational Topics***

| Sources | Key Educational Topics | Partners |
|---|---|---|
| All | Water quality and impacts of pollutants of concern on the WFCR | AWG<br>CWSD |
| Recreation and Camping | How recreational activities, fire and improper management of human wastes can contribute to water quality degradation, and how these can be prevented (including the location of the nearest locations for proper disposal. | HTNF<br>AWG |
| Roads | How vehicular use can contribute to water quality degradation | HTNF, Caltrans<br>AWG |
| OWTS | How septic tanks can contribute to water quality degradation, and how they can be managed and upgraded to minimize these impacts. | Alpine County, AWG |
| Grazing | How grazing can impact water quality and how these impacts can be minimized | NRCS, UCCE, AWG |
| All | Volunteer Opportunities | AWG, CWSD, Friends of Hope Valley |
| All | Potential sources of funding and technical assistance | NRCS, AWG, CWSD, Sierra Nevada Conservancy |

# 7. Stakeholder Engagement

There has been considerable stakeholder engagement in the development of this Vision Plan. Alpine Watershed Group hosted, and Lahontan Water Board Staff presented at, the following Vision Plan Stakeholder forums:

- September 8, 2020: Roads & Water Quality on September 8.2020
- Restoration Projects in the West Fork Carson River Watershed November 10, 2020:
- March 9, 2021: Recreation: Trends, Impacts, and Solutions for the West Fork Carson Watershed—
- Ranching for Improved Water Quality March 8, 2022:

Videos of the AWG forums are available at https://www.alpinewatershedgroup.org/west-fork-carson-river-vision-proje

In October 2022, Lahontan Water Board staff and AWG hosted a tour to discuss grazing best management practices at Ace Hereford Ranch, the site of the Rivers and Ranches project. Lahontan Water Board staff also met with staff from the HTNF, AWG, and CWSD in the development of this Vision Plan.

This document is currently a draft. Lahontan Water Board staff welcomes comments or discussion with stakeholders to further improve this Vision Plan. Details of the comment period will be distributed using the project listserv and will also be on the project website (https://www.waterboards.ca.gov/lahontan/water_issues/programs/tmdl/west_fork_carson_river.html).

Lahontan Water Board staff will make appropriate changes in response to comments and release a proposed final version for consideration of approval by the Lahontan Water Board at its October 2023 Board meeting.

Lahontan Water Board staff will also look at opportunities to make this Vision Plan more of a living document to incorporate new information and adaptive management. This can be done through the utilization of electronic means to provide regular updates on the status of projects and water quality through tools such as the CWSD's GIS web viewer and partner portal.

Lahontan Water Board staff will continue to engage with stakeholders during implementation at forums and opportunities discussed in the Information and Education section. Stakeholders can always provide feedback to Board Staff, or at any Lahontan Water Board meeting. Stakeholders will also have an opportunity to discuss WFCR water quality issues during the comprehensive 5-year reviews of the Vision Plan in 2029 and 2034.

# 8. Monitoring

Ongoing monitoring and proposed water quality monitoring programs and studies in the WFCR are summarized in Table 8-1. This table can also be considered an update/addendum to Table 7.2.12-2 in the CRASP (CWSD, 2017).

A goal of monitoring in the WFCR should be to provide enough information to answer the following questions:

1) Are WQOs being met in the WFCR?
2) Are concentrations and pollutant loads in the WFCR increasing or decreasing?
3) Are the actions to improve water quality in the watershed effective?
4) What should be the focus of any future actions to improve water quality?

*Table 8-1 WFCR Water Quality Projects/Studies Underway/Proposed*

| Title/Program | Locations | Timing and Frequency | Lead Organization & Partners | Description |
|---|---|---|---|---|
| Surface Water Ambient Monitoring Program (SWAMP) | Downstream of Willow Creek, Woodfords, Paynesville | Quarterly 2010-present | Lahontan Water Board | Routine water quality monitoring |
| Harmful Algal Bloom Studies | Red Lake, other waterbodies in the WFCR watershed as needed | Monthly June-Oct 2019 – present | Lahontan Water Board, AWG, CDFW | Routine water quality monitoring, nutrients, pigments, and cyanobacteria |
| NDEP Ambient Monitoring | Woodfords, Paynesville | Approx. quarterly 1966-present | Nevada Division of Environmental Protection (NDEP) | Routine water quality monitoring |
| AWG Upper Carson River Monitoring | Pickett's Junction, Woodfords, Paynesville, Blue Lakes Road | Approx. quarterly 2004-present | Alpine Watershed Group | Routine water quality monitoring |
| STPUD Alpine County Surface Water Monitoring | Downstream of Willow Creek, Woodfords, Paynesville | Monthly, 1980-present | South Tahoe Public Utilities District | Routine water quality monitoring |
| OWTS Impacts | Multiple sites between Willow Creek and state line | Proposed weekly in summer of 2025 and 2026 | Lahontan Water Board, Alpine County | |

There is a significant amount of monitoring on the WFCR by the existing programs listed in Table 8-1 above. Also proposed is a study on potential OWTS impacts to the WFCR, discussed below. These monitoring programs should generate data adequate to answer the monitoring questions listed above. To better meet that goal, it would be beneficial to coordinate these activities and resources, to the extent practicable, to get better temporal coverage and increase consistency. Therefore, coordinating water quality monitoring will be discussed with the individual monitoring entities on an annual basis.

Ongoing monitoring for all programs should include all the parameters associated with the impairments to the WFCR – turbidity, phosphorus, all nitrogen species, TSS, iron, sulfates, and indicator bacteria. Ongoing monitoring should also include both TSS and, if possible, Suspended Sediment Concentration (SSC). These parameters are currently not part of SWAMP monitoring in the WFCR but at least TSS will be added in the near future. TSS is useful for comparing to historic data and readily affordable to test at approximately $30 per sample. SSC is recommended by USGS as an improved measure of sediment concentrations and loads but is less affordable at approximately $300 per sample. Data for TSS (and if feasible SSC) can be used to refine the relationship of these measurements to turbidity, and for characterizing sediment loads and load reductions.

Ongoing monitoring should all be performed under an approved Quality Assurance Project Plan (QAPP) or equivalent so that data are of known and documented quality. All California data should be entered into the Environmental Data Exchange Network (CEDEN) database
CEDEN - California Environmental Data Exchange Network

The NDEP monitoring is done under a QAPP and entered into a readily-accessible database: https://ndep.nv.gov/water/rivers-streams-lakes/water-quality-monitoring/water-quality-data-warehouse-viewer

SWAMP, AWG, and harmful algal bloom monitoring are done under QAPPs and entered into CEDEN. The data from STPUD surface water monitoring, while a valuable data source, was available in multiple spreadsheet formats, with less quality assurance program documentation than would be available under a full QAPP. The compilation of data from disparate data sets was a significant task in the preparation of this Vision Plan. Having the data from STPUD and any other sources integrated into CEDEN would make future evaluations of data to assess water quality improvements more feasible with limited resources. Having the data collected under an approved QAPP and in CEDEN will also improve understanding of data quality and allow it to be assessed in the Integrated Report, since having a QAPP or equivalent is required for its use as a primary line of evidence under the State's Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List (SWRCB, 2015).

Preparing QAPPs and putting the data into CEDEN will be a significant expense for programs like the STPUD Surface Water Monitoring. However, this will be worth an investment or redirection of monitoring resources, since these changes will make these valuable data and their quality more understandable and readily available to the public, the Lahontan Water Board, and others. Therefore, the Lahontan Water Board will work with STPUD so that data are collected under a QAPP and entered into CEDEN within two years, or by October 2025. This should allow adequate time for the development of a QAPP and any needed changes to the current STPUD data infrastructure.

Also, if possible, to better characterize sediment loads, a turbidity meter should be added to the USGS flow monitoring site at Woodfords. This would allow continuous estimation of sediment and phosphorous loads and help better capture key runoff events. A flow gauge in the WFCR at state line would also be beneficial for determining pollutant loads entering Nevada and assessing progress reducing pollutant loads.

To help identify potential OWTS impacts, the Lahontan Water Board will conduct and/or support monitoring in the WFCR, downstream from OWTS areas. This monitoring will occur in times when the OWTS are most likely to impact the river – in the Summer when cabins are occupied and flows in the river are lower, at least two times per month until fall. The monitoring should include anthropogenic substances such as sucralose and caffeine which can provide an indication of OWTS impacts in receiving waters, as well as nitrates, fecal indicator bacteria, and salt. This monitoring should occur in the summers of 2025 and 2026 – so results and follow up monitoring can be concluded well before the 2028 renewal of the OWTS Policy. Lahontan Water Board staff will seek monitoring funds from the SWAMP and TMDL program as well as other sources, to support this monitoring. Lahontan Water Board staff will coordinate with Alpine County on the draft monitoring design.

# 9. Evaluation and Adaptive Management

This section describes how the Lahontan Board will evaluate progress at meeting goals and objectives and junctures at which it will consider adaptation of the Vision Plan approaches.

Development and implementation of the Vision Plan does not eliminate the requirement to develop TMDLs. If water quality objectives for the constituents of concern are not attained within 10 years, the Water Board will consider prioritization of completion of TMDLs for the constituents causing the remaining impairments. At a minimum, the Lahontan Water Board will evaluate progress in 2029, after five years, which is halfway to the Vision Plan attainment date, and in 2034, after 10 years, which is the target date for WQO attainment. This timeline will allow the data and analysis used in the Vision Plan assessments to inform the subsequent 2032 and 2038 303(d) Lists/Integrated Reports.

The Lahontan Water Board will need to collect information about sources and actions being implemented from stakeholders in each source category. The collection of water quality and implementation information under this Vision Plan will help inform the Lahontan Water Board's assessment of progress, consideration of appropriate actions and regulatory mechanisms, and consideration of potential changes to the Basin Plan to establish TMDLs or other requirements, or to revise water quality standards. CWSD is currently developing a web access system capable of viewing, editing and tracking

CRASP projects. It may be possible to utilize that system to help facilitate the Lahontan Water Board's collection of information and tracking of Vision Plan projects and to share that information with stakeholders and the public. Therefore, if needed, funding for the CWSD system is identified as a potential project to implement this Vision Plan.

The Lahontan Water Board will annually evaluate and report on progress of implementation of this Vision Plan. This annual progress can also be discussed at forums such as the CWSD's annual Carson River Watershed Forum, or AWG meetings, where the Board can gather more information and feedback to inform adaptive management. Regularly evaluating the status of implementation actions alongside water quality data will determine the level of progress towards achieving the Vision Plan goals and help the Board determine if additional actions are needed to meet water quality objectives, as part of the adaptive management approach.

Key questions that for these evaluations are:

- Is water quality improving over time (with consideration of hydrologic and weather conditions)?
- Has progress been made to implement the necessary BMPs and other actions described in this Vision Plan?
- Are the current water quality objectives providing an appropriate level of protection or should they be revised to be more attainable or protective?

Criteria for identifying if pollutant reductions are being attained over time will be comparison of the monitoring data to the water quality objectives, and comparison of pollutant loads to the loading reductions listed in Section 4. Section 10 contains a summary of key milestones for implementation actions for the Vision Plan that can be used to determine if adequate progress is being made on implementation. Should implementation actions not occur and/or those actions not achieve the expected reductions in contaminant concentrations the Lahontan Water Board can reevaluate the regulatory approach to one or more parties/sources as discussed in Section 6.1, potentially implementing alternative approaches listed in Table 6-5.

The Lahontan Water Board could, also as part of its evaluation of progress, decide to consider revising the water quality objectives for one or more constituents in the WFCR. The water quality objectives would still need to be protective of all beneficial uses, but could potentially be adjusted, via a Basin Plan Amendment, to reflect the consideration of updated information the Lahontan Water Board will have about what criteria are reasonably protective of beneficial uses in the WFCR. A decision on pursuing changing water quality objectives would be made after the 10-year target date for attainment, when there will be sufficiently more data and information collected on WFCR water quality. A decision on pursuing changing water quality objectives could also be made by the Lahontan Water Board during one of its triennial reviews of Basin Plan water quality standards.

# 10. Summary of Implementation, Studies, and Adaptive Management Schedule

Table 10-1 Summarizes the schedule for implementation actions and key milestones.

***Table 10-1 Schedule for Implementation, Studies and Adaptive Management***

| Source Category | Implementation Action | Target Start Date | Implementing Party | Target Milestone Date |
|---|---|---|---|---|
| All | Annual evaluation of Vision Plan Implementation | 2024 | Lahontan Water Board, AWG | Annually |
| All | Geomorphological modeling of the WFCR | 2024 | AWG | 2025 – completion of modeling and prioritization |
| Historic Impacts | Stream Restoration on the WFCR | 2025 | AWG, CWSD, American Rivers | 2033 – completion of 2-3 additional restoration projects identified as priority |
| Roads | Road erosion source survey | 2023 | Caltrans | 2026 complete study |
| Roads | Salt/abrasives alternatives/BMP investigation | 2023 | Caltrans | 2026 complete investigation |
| Roads | Road source survey | 2023 | Alpine County | 2026 complete study |
| Roads | Road source survey | 2023 | HTNF | 2026 complete study |
| Roads | Road/Culvert Restoration | 2023 | Caltrans Alpine County USFS-HTNF | 2036 projects completed |
| Roads | Caltrans Permit – Add WFCR actions/studies | 2025 | SWRCB LWB Caltrans | 2027 Caltrans Permit Update |
| Grazing/agriculture | Development of ranch water quality management plans | 2023 | Ranchers, STPUD | End of 2025 |

| Source Category | Implementation Action | Target Start Date | Implementing Party | Target Milestone Date |
|---|---|---|---|---|
| Grazing/ agriculture | CRC-APWG meetings and BMP white paper | 2021 | CRC, CWSD, | 2024<br><br>Agricultural BMPs white paper, Outreach to ranchers. |
| Grazing/ agriculture | Analysis of potential effects of recycled wastewater on the WFCR | 2023 | STPUD | End of 2025 |
| OWTS | OWTS targeted WFCR monitoring | 2025 | LWB | 2029 – completed monitoring and evaluation |
| OWTS | WDRs for Sorensen's Resort | 2026 | LWB | 2028 |
| Recreation and camping | Seasonal volunteer at Hope Valley Campground | 2023 | HTNF | 2023 and annually |
| Recreation and camping | Seasonal Recreation Technician | 2024 | HTNF | Annually May-Oct<br>Starting in 2024 |
| Recreation and camping | Scotts Lake restroom installation. | 2023 | HTNF | End of 2024 |
| Recreation and camping | Kiosk installations in Scotts Lake and Faith Valley | 2023 | HTNF | End of 2024 |
| Recreation and camping | Development of fee area at Scotts Lake | TBD | HTNF | TBD |
| All (Monitoring) | STPUD Surface Water Monitoring QAPP and CEDEN data entry | 2023 | STPUD, LWB | 2025 |
| All | LWB review of progress | 2029 | Lahontan Water Board | 2028 Board meeting workshop. Consideration of adaptive management of approach(es). |

| Source Category | Implementation Action | Target Start Date | Implementing Party | Target Milestone Date |
|---|---|---|---|---|
| All | LWB Review – targeted WQO attainment | 2034 | Lahontan Water Board | 2033 Lahontan Water Board meeting – assessment of WQOs attainment. Consideration of adaptive management of approach(es). |

# 11. References


Alpine County, 2019. Local Area Management Plan (LAMP). Onsite Wastewater Treatment Systems. https://www.waterboards.ca.gov/lahontan/water_issues/programs/owts/docs/lamp_tracking/alpine_lamp_11_2_2016.pdf

Alvarez, N.L.and R.L. Seiler, 2004. Sources of Phosphorus to the Carson River Upstream from Lahontan Reservoir, Nevada. US Geological Survey (USGS) Scientific Investigations Report 2004-5186. UGSS. Carson City, Nevada and California, Water Years 2001–02

California Regional Water Quality Control Board, Lahontan Region, 2021. Water Quality Control Plan for the Lahontan Region (Basin Plan). https://www.waterboards.ca.gov/lahontan/water_issues/programs/basin_plan/references.html

Carson Water Subconservancy District (CWSD), 2006. Carson River Watershed Adaptive Stewardship Plan. https://www.cwsd.org/carson-river-watershed-adaptive-stewardship-plan/

CWSD, 2017. Carson River Watershed Adaptive Stewardship Plan. (2017 supplemental update). Final-CRWASP-2017-Update-Plan-Part-1.pdf (cwsd.org)

Eddy, C., 2022. Phone conversation, between Danny McClure, Lahontan Water Board, and Chris Eddy, Recreation Specialist, Humboldt Toiyabe National Forest, Carson Ranger District on 10/26/2022.

Glancy, P.A., and Katzer, T.L., 1975 [1976], Water-resources appraisal of the Carson River Basin, western Nevada. Reconnaissance Report 59. USGS. Carson City, Nevada.

Hanks, M., 2019. West Fork Carson Watershed Vision Project Water Quality Assessment. California State University, Fresno.

Humboldt-Toiyabe National Forest (HTNF), 2011. "Travel Analysis Process" Report. USFS, HTNF, Carson Rangers District, Carson City, Nevada.

Humboldt-Toiyabe National Forest (HTNF), 2014. Term Grazing Permit, Hope Valley C&H allotment. USFS, HTNF, Carson Rangers District, Carson City, Nevada.

Hess, G.W., 1996, Progress report on daily flow-routing simulation for the Carson River, California and Nevada: U.S. Geological Survey Open-File Report 96-211, 41 p

Jorgensen, T. 2023. Personal communication between Troy Jorgensen, HTNF Transportation Engineering Program Manager and Danny McClure, April 21, 2023.

MACTEC Engineering & Consulting, Swanson Hydrology & Geomorphology, River Run Consulting, C.G. Celio & Sons, 2004. Upper Carson River Watershed Stream Corridor Assessment. Prepared for Alpine Watershed Group and the Sierra Nevada Alliance. MACTEC Engineering & Consultants. Carson City, Nevada.

Nevada Division of Environmental Protection, 2022a. Alternative Restoration Plan for Improving Water Quality in Segments of the Carson River System in Carson Valley, Nevada. NDEP, Carson City, Nevada.

Nevada Division of Environmental Protection, 2022b. Nevada 2020-2022 Water Quality Integrated Report. NDEP, Carson City, Nevada.

State Water Resources Control Board (SWRCB), 2012. Water Quality Control Policy for Siting, Design, Operation and Maintenance of Onsite Wastewater Treatment Systems (OWTS Policy).
https://www.waterboards.ca.gov/water_issues/programs/owts/board_adopted_policy.html

Scribe, L., 2021. Climate Change Mitigation and Adaptation Action Plan for the Lahontan Region. California Regional Water Quality Control Board, Lahontan Region. South Lake Tahoe, CA.
https://www.waterboards.ca.gov/lahontan/water_issues/programs/climate_change_adaptation/docs/2022/cc-actionplan.pdf

State Water Resources Control Board (SWRCB), 2004. Policy for Implementation and Enforcement of the Nonpoint Source Pollution Control Program.
https://www.waterboards.ca.gov/water_issues/programs/nps/docs/plans_policies/nps_iepolicy.pdf

State Water Resources Control Board (SWRCB), 2015. Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List.
https://www.waterboards.ca.gov/board_decisions/adopted_orders/resolutions/2015/020315_8_amendment_clean_version.pdf

SWRCB, 2018. Part 3 of the Water Quality Control Plan for Inland Surface Waters, Enclosed Bays, and Estuaries of California – Bacteria Provisions and a Water Quality Standards Variance Policy. https://www.waterboards.ca.gov/bacterialobjectives/

State Water Resources Control Board (SWRCB), 2021. 2018 Integrated Report for Clean Water Act Sections 305(b) and 303(d). https://www.waterboards.ca.gov/water_issues/programs/water_quality_assessment/2018_integrated_report.html

Susfalk, R.B. Fitzgerald, B., Kunust A.M., 2008. A Characterization of Turbidity and Total Suspended Solids in the Upper Carson River, Nevada. DHS Publication No. 41242. Desert Research Institute, Reno, Nevada.

U.S. Environmental Protection Agency (USEPA), 2010. "9 Key Elements" For Watershed-Based Plans.

USEPA. 2012. Recreational Water Quality Criteria EPA-820-F-12-058. Washington, DC: Office of Water.

USEPA, 2022. 2022 - 2032 Vision for the Clean Water Act Section 303(d) Program. Washington, DC. https://www.epa.gov/system/files/documents/2022-09/CWA%20Section%20303d%20Vision_September%202022.pdf

USFS, 2012. National Best Management Practices for Water Quality Management on National Forest System Lands. US Forest Service, Washington, DC. https://www.fs.usda.gov/naturalresources/watershed/pubs/FS_National_Core_BMPs_April2012.pdf

Weaver, W.E., Weppner, E.M. and Hagans, D.K., 2015, Handbook for Forest, Ranch and Rural Roads: A Guide for Planning, Designing, Constructing, Reconstructing, Upgrading, Maintaining and Closing Wildland Roads (Rev. 1st ed.), Mendocino County Resource Conservation District, Ukiah, California. http://www.pacificwatershed.com/roadshandbook

Wood Rodgers, 2010. NEAT Report (Natural Environment as Treatment). Prepared for California Department of Transportation District 3. Sacramento, Ca.

# Appendix A: River and Channel Restoration and Costs

River restoration is the process of modifying or rehabilitating the rivers. There are many techniques that can be used that support ecosystem function and improve water quality.

## Streambank Stabilization

Streambank stabilization is a strategy used to protect or restore riverbanks. It can be defined as “a vegetative, structural or combination treatment of streams designed to stabilize the stream and reduce erosion” (Department of Public Works, 2008).

## Biotechnical Streambank Restoration

One type of streambank restoration that has been recommended for West Fork Carson area is biotechnical streambank protection (MACTEC et al., 2004). The USDA defines biotechnical streambank restoration as infrastructure that “utilizes living plant materials to reinforce soil and stabilize slopes” (Wells, 2002). Some components that have specifically been recommended are “willow wattling, brush mattressing, brush layering or revetment, placement of fascines, and brush packing” (MACTEC et al., 2004). Benefits of biotechnical streambank restoration include stabilized streambanks, reduced bank erosion, improved water quality, improved terrestrial and aquatic habitat, improved soil quality, and colder water temperature (Wells, 2002).

## Bank Strengthening by Vegetation Restoration

One type of biotechnical streambank restoration is bank strengthening by vegetation restoration. Bank strengthening by restoration of wet meadow vegetation has been shown to decrease stream migration by 84% and decrease failure numbers and erodibility by 90% (Micheli and Kirchner 2002, as cited in Lake Tahoe TMDL, 2008). In addition, BSTEM modeling has estimated this method to reduce sediment load by 52.7% (Lake Tahoe TMDL, 2008). Bank strengthening by restoration of woody riparian vegetation showed a reduction in sediment load of 44 to 60% when compared to agricultural land (Micheli et al. 2004, as cited in Lake Tahoe TMDL, 2008). This strategy also includes ecological benefits, such as providing terrestrial and aquatic habitat (Wells, 2002). On average, the 20-year cost per meter of bank strengthening is $336 per meter (Lake Tahoe TMDL, 2008).

## Selected Placement of Woody Debris

Selected placement of woody debris jams has been recommended as a strategy for the West Fork Carson area (MACTEC et al., 2004). Large woody debris can be defined as “fallen trees, logs and branches that are at least four inches wide and six feet long” (Rhea, 2021). Large woody debris may have many benefits including increased floodplain connectivity, slower water flow, decreased erosion and sediment, and habitat creation (Rhea, 2021). They can also promote bank stabilization (MACTEC et al., 2004). Salvage logging can be used and costs about $300 per log (MACTEC et al., 2004).

### Channel Reconstruction

Channel Reconstruction can be defined as “restoring the natural geomorphic characteristics of streambank through construction” (Lake Tahoe TMDL, 2008). It has been shown to be 20 to 34% effective at reducing sediment in the waterway (Stubblefield et. Al 2005, as cited in Lake Tahoe TMDL, 2008). On average, for small to moderate streams, the 20-year cost of channel reconstruction is $2,718 per meter. For larger streams, the cost can be more. For example, in the Upper Truckee River, the 20-year cost of channel reconstruction is $11,882 per meter.

### Bank Lowering

Bank lowering by either floodplain excavation or angle reduction can be effective at reducing sediment load to waterways (Lake Tahoe TMDL, 2008). Bank lowering and flood plain excavation has been shown to reduce sediment load by 23-93% (Phillips 1989, as cited in Lake Tahoe TMDL, 2008). Bank lowering and angle reduction has been shown to reduce the sediment load by 8-93% (Van der Lee et al. 2004, as cited in Lake Tahoe TMDL, 2008). Nutrient retention Bank lowering and floodplain excavation costs about $1,601 per meter for 20 years. For a large stream the 20-year cost can be about $6,997 per meter. The 20-year cost of bank lowering and angle reduction, for small to moderate streams, is about $268 per meter. For a larger stream, the 20-year cost is about $1,170 (Lake Tahoe TMDL, 2008).

### Stone Toe Bank Protection

Structural streambank stabilization uses permanent structures to stabilize streambanks (“Structural Streambank”, 1992). One example is stone toe bank protection. In this strategy, stone is placed at the toe of the streambank, and overtime, the streambank stabilizes (“Stone Toe”, n.d.) Bank protection by stone toe can reduce sediment load by up to 100% (Lake Tahoe TMDL, 2008). The 20-year cost of bank toe protection with stone is $700 per meter (Lake Tahoe TMDL, 2008).

### Culvert Removal or Replacement

Replacing or removing outdated or undersized culverts can improve water quality (Moore, 2017). Badly designed culverts can cause erosion and bank slumping. This can cause increased sediment in waterways (Moore, 2017). The 20-year cost per meter of a culvert removal or replacement is $476 per meter (Lake Tahoe TMDL, 2008). For a bigger stream, such as the Upper Truckee, the 20-year cost is $2,079 (Lake Tahoe TMDL, 2008).

## Effects of Combined Approaches

It is common for multiple strategies to be used when restoring river channels. Here are some and the effects of using these strategies. In the Tahoe TMDL, BSTEM modeling was used to calculate sediment and phosphorus reductions for Blackwood Creek, Upper Truckee River, Ward Creek, General Creek, and Third Creek. From there cost per pollutant reduction was also calculated. The load reduction and average cost reduction is an average of all 6 streams. Both pollutant reduction times and costs were assumed over a 20-year period.

### Channel Restoration

For channel restoration, a river channel was restored by "modifying the existing unstable stream's planform, increasing its length and sinuosity, and decreased slope" (Lake Tahoe TMDL, 2008). This reduced sediment by 44.1%. The cost to reduce 1 metric ton of sediment was $97,528. It also reduced phosphorus by 44.2%. The cost per metric ton of phosphorus reduced was $641,633,554 (Lake Tahoe TMDL, 2008). This also has been shown to increase plant and animal biodiversity, including in the land that surrounds the stream (Oehrli et al., 2013).

### Bank Protection

For bank protection, an unstable streambank was modified "without changes to the channel planform, length, sinuosity, or slope" ... "reaches might also have had grade control installed along with bank treatments" (Lake Tahoe TMDL, 2008). This reduced fine sediment by 82.3%. The cost per metric ton of fine sediment reduced was $5,050. Phosphorus was also reduced by 82.3%. The cost per metric ton of phosphorus reduced was $110,364,583 (Lake Tahoe TMDL, 2008).

### Mixed-Treatment

In the mixed treatment method, some areas of a river use channel restoration, others use bank protection, and some used both (Lake Tahoe TMDL, 2008). This reduced fine sediment by 68.1%. The cost per metric ton of fine sediment reduced was $5,140. It also reduced the phosphorus load by 68.1%. The cost per metric ton of total phosphorus reduced was $33,816,010 (Lake Tahoe TMDL, 2008).

## Potential Sources of Funding

There are many potential sources of funding that can help finance river restoration in the West Fork Carson River (The Environmental Protection Agency, 2022). These include the Bella Vista Ecosystem Restoration Grants, WaterSMART: Basin Studies, California Landowner, Incentive Program (LIP), California Integrated Regional Water Management Implementation Grant Program, California Proposition 1 Water Quality, Supply, and Infrastructure Improvement, Act of 2014, California Floodway Corridor Program (FCP) (Prop 1E), California Clean Water Act (CWA) Section 319 Nonpoint Source Management Grant, California Forest Conservation Program, California Riparian Habitat Conservation Program, California Habitat Enhancement and Restoration Program, Fish and Wildlife Coordination Act Program, Mary A. Crocker Trust Environment Grants, The California Wellness Foundation Grants, and the WaterSMART Cooperative Watershed Management Program for Implementation of Watershed Management Projects (Phase II) (The Environmental Protection Agency, 2022).

## Conclusion

In conclusion, there are many river restoration strategies that improve water quality and have other ecological benefits. Also, there are many resources to fund these strategies.

## References for Appendix A


California State Water Resources Control Board and Nevada Division of Environmental Protection. (2008, March). *Lake Tahoe TMDL pollutant reduction opportunity report*. California State Water Resources Control Board. Retrieved December 29, 2022, from http://www.swrcb.ca.gov/rwqcb6/water_issues/programs/tmdl/lake_tahoe/docs/presentations/pro_report_v2.pdf

Carson Water Subconservancy District, Lyon County GIS Department, Carson Valley Conservation District, Dayton Valley Conservation District, Western Nevada Resource Conservation and Development, Natural Resource Conservation Service, C.G. Celio and Sons Co., & Carson River Coalition. (2007, May). *Carson River Watershed Adaptive Stewardship Plan*. Carson Water Subconservancy District. https://www.cwsd.org/carson-river-watershed-adaptive-stewardship-plan/

Department of Public Works: Stormwater Design Standards. (2008, October 1). *Streambank stabilization*. City of Springfield. https://www.springfieldmo.gov/DocumentCenter/View/3455/Streambank-Stabilization-PDF?bidId=

Environmental Protection Agency. (2022, March 22). *Funding Resources for Watershed Protection and Restoration*. EPA. https://www.epa.gov/nps/funding-resources-watershed-protection-and-restoration

MACTEC Engineering and Consulting, Swanson Hydrology & Geomorphology, River Run Consulting, & C.G. Celio & Sons. (2004, June). *Upper Carson River Watershed stream corridor condition assessment*. https://ndep.nv.gov/uploads/water-spec-rpts-docs/upper_carson_covertoc_1004.pdf

Massachusetts Department of Environmental Protection. (n.d.). *Stone toe protection*. Massachusetts Clean Water Toolkit. Retrieved January 9, 2023, from https://megamanual.geosyntec.com/npsmanual/stonetoeprotection.aspx#:~:text=Definition,the%20weight%20of%20the%20bank.

Moore, L. (2017, April 10). *Healthy culverts make for healthy drinking water*. US Forest Service. https://www.fs.usda.gov/features/healthy-culverts-make-healthy-drinking-water

Oehrli, C., Norman, S., Gross, S., & Zanetti, S. (2013, November). *Cookhouse meadow restoration five-year effectiveness assessment*. Forest Service. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd498686.pdf

Rhea, D. (2021, March 1). *Benefits of large woody debris in streams*. Penn State Extension. https://extension.psu.edu/benefits-of-large-woody-debris-in-streams

*Structural Streambank Stabilization*. Virginia Department of Environmental Quality. (1992). https://www.deq.virginia.gov/home/showpublisheddocument/2418/637437336793000000#:~:text=STRUCTURAL%20STREAMBANK-,STABILIZATION,erosive%20forces%20of%20flowing%20water.

Wells, G. W. (2002, March). *Biotechnical streambank protection: The use of plants to stabilize streambanks*. Forest Service: United States Department of Agriculture. https://www.fs.usda.gov/nac/assets/documents/agroforestrynotes/an23sa06.pdf

# Appendix B: Grazing and Ranching Management Practices and Costs

There are several practices that can be used to reduce nonpoint source pollution to the WFCR from grazing, including fencing off riparian areas, streambank restoration, alternative water sources, heavy use protection areas, manure management, rotational grazing, and other sources of shade. These also improve water and soil retention, soil health, and forage quality in pasturelands.

## Stream Bank Fencing

***Table B-1 Streambank Fencing Benefits and Costs***

| Environmental Benefits | Livestock Benefits | Potential Challenges | Estimated Costs |
|---|---|---|---|
| -decreased fecal matter in waterways<br>-decreased nitrogen and phosphorus in waterways<br>-less erosion of banks and decreased sediment deposition in waterways<br>-less erosion and decreased loss of topsoil, organic matter in pastureland<br>-increased vegetation cover and standing litter<br>-decreased bare soil and soil bulk density<br>-increased biodiversity in fenced areas | -decreased risk of injury<br>-decreased risk of disease<br>-healthier pastureland for livestock | -materials and labor cost<br>-general maintenance<br>- need for an alternate water source<br>-potential initial loss of forage<br>-potential entanglement | -Barbed or Smooth Wire: $5.94/ft<br>-Barbed or Smooth Wire (Difficult Installation): $8.20/ft<br>-Woven Wire: $7.43/ft<br>-Electric: $3.31/ft<br>-Safety or Heavy Use: $10.33/ft<br>-Organic Fence: $6.48/ft |

Stream bank fencing is a technique used to reduce the effects of grazing and ranching on waterways. Fences are built along the stream as far away from the stream as possible to promote a buffer between the grazed land and waterways (Davis et al., 2022). Streambank fencing is a commonly used strategy in grazing and ranching management, and its effectiveness has been researched.

**Benefits:**

*Water Quality and Riparian Health:*

Fencing off riparian areas on grazing and ranching lands is one of the most effective ways to improve and maintain water quality (Davis et al., 2022). One of the ways that this strategy can improve water quality is to prevent livestock from depositing feces in the waterways (Muirhead, 2019). In fact, riparian fencing was found to be on average 62% effective in reducing fecal indicator bacteria (Muirhead, 2019). It was also found to be effective at reducing the nutrient load of the waterways (Galeone et al., 2016). In a study by United States Geological Survey, areas in which stream bank fencing was installed, had an annual nitrogen decrease of 27% and an annual phosphorus decrease of 33% (Galeone et al., 2016). Another effect of fencing off the riparian zone is the prevention of streambed erosion and sediment deposition (Galeone, 2000). In one study, after streambank fencing was installed, suspended sediment was found to decrease as much as 26% during low flow periods and as much as 54% during storm flow periods.

This reduction in erosion was also shown in land beyond the riparian buffer (Galeone, 2000). This is important because erosion in the pastureland can lead to loss of organic topsoil, organic material, and nitrogen (Brackenrich & Duiker, 2018). All of this is important for healthy forage which will keep livestock fed and their environment healthy. In addition, erosion in the pastureland can also make its way downstream to pollute the water (Brackenrich & Duiker, 2018). In other words, maintaining a healthy riparian buffer prevents erosion and sediment deposition into the stream from the streambed and from the pastureland. Another study, Miller et al. (2010), found that "Rangeland health was improved (health score increase from 55 to 72%); vegetation cover (13-21%) and standing litter (38-742%) were increased; and bare soil (72-93%) and soil bulk density (6-8%) were decreased under cattle exclusion, indicating an improvement in environmental quality from streambank fencing." A health score is defined as how similar five variables: ecological status, community structure, litter, site stability, and noxious weeds are to the reference community (Miller et al., 2010). The evidence shows how streambank fencing can make the entire pasture healthier.

Streambank fencing is important to the animal biodiversity of the area. Fenced areas have 88% more species than unfenced areas do (Giuliano, 2006). For streambank fencing specifically, a study by the United States Geological Survey, found an increase of 30% in benthic-macroinvertebrate taxa in the streams (Galeone, 2000). Additionally, good riparian fencing helps exclude cattle from most of the waterways, while still allowing for wildlife crossing (Paige, 2012). Overall, stream bank fencing is an effective choice to mitigate the environmental impacts of grazing and ranching and to promote healthy habitat for conservation.

*Livestock Health:*

Apart from benefitting ecosystem health, streambank fencing also keeps livestock safe and healthy. Stream bank fencing helps prevent some cattle diseases, such as leptospirosis, by limiting access to waterborne bacteria (Davis et al., 2022). In addition, riparian fencing reduces the risk of livestock injury. This is because of the risk livestock have of getting stuck in streams. That risk increases when livestock are around unstable streambanks. The more time livestock spend around streams, the more unstable the banks tend to become due to increased erosion (Davis et al., 2022). The more unstable banks become, the greater risk of livestock injury is presented. In terms of livestock well-being, streambank fencing is an effective prevention measure.

**Associated Costs:**

There is the risk of livestock or other animal entanglement (Paige, 2012). This means that fences may need to be designed with visibility in mind and checked regularly. This could add to the time and resources needed, making the initial cost higher than expected (Paige, 2012). In addition, loss of forage will have to be compensated for (Zeckoski et al., 2007). Distributing waterers is one way to do this that could add to the initial cost (Zeckoski et al., 2007). Another potential cost is the need to replace the water sources for the livestock multiple ways to do this (Dressing, 2003). One example is to install troughs. Replacing and maintaining the alternate water source adds to the initial cost (Dressing, 2003). If stream needs to be crossed, then a stream crossing must be implemented as well.

A barbed or smooth wire fence costs about $5.94/foot (“California Practice”, 2023). Barbed or smooth wire fence with difficult installation costs about $8.20/foot. Electric fencing costs about $3.31/foot. Woven Wire is about $7.43/foot. Safety or Heavy Use fencing costs about $10.33/foot. Organic Fencing Costs about $6.48/foot. All these estimates include cost of materials and labor (“California Practice”, 2023).

## Alternate Water Sources

***Table B-2 Alternative Water Sources Benefits and Cost***

| Environmental Benefits | Livestock Benefits | Potential Challenges | Estimated Costs |
|---|---|---|---|
| -less erosion in any one area especially close to waterways<br>-less direct fecal matter deposition in waterways | -cleaner water for livestock<br>-livestock gain weight faster<br>-less risk than drinking directly from stream | -costs of alternate water sources<br>-water transportation<br>-labor | -tire trough: $3.00/gal<br>-frost free trough: $40.57/gal<br>-above ground storage tank: $2.36/gal<br>-below ground storage tank: $3.21/gal<br>-stock trough: $8.52/gal<br>-livestock pipeline (PVC): $3.96/ft<br>-livestock pipeline (PVC, difficult to install): $6.47/ft<br>-livestock pipeline (HDPE): $4.30/ft<br>-Barbed or Smooth Wire: $5.94/ft |



Another management practice which can be implemented is providing alternate water sources, so cattle do not need to access the river to drink. Alternative water sources must be properly planned for the wellbeing of the livestock and environment. There are many alternative ways to give livestock water, and it is common for a combination of methods to be implemented.

### Troughs

A trough is one example of a way for animals to access alternative water. They allow livestock to have water away from streams, in which the quality can be controlled. Willms et. al (2002) found that cattle would choose clean water in a trough over manure contaminated water in a pond or trough. In addition, cows that had access to clean water gained 23% more weight (Willms et. al, 2002). Water from the West Fork Carson River is relatively clean. Troughs can be placed in strategic locations, cleaned, and some can be moved. West Fork Carson River water is a relatively clean water source that can be used for livestock.

### Controlled Direct Access to Stream

Controlled direct access is another way to limit livestock access to riparian areas. Livestock can either drink at a stream access point or a stream crossing (Davis et. al, 2022). This can be done in a couple of ways. One way is to have a gate somewhere along streambank fencing. Another way is to have a floating fence and maybe a ramp at the access point. The floating fence can be three walls creating an indent in the water way or it be a two-wall stream crossing. Although limiting livestock access to certain points, is a good way to reduce the negative environmental impacts, there is still erosion and pollutant deposition happening at these points. Therefore, it is important to stabilize these areas to reduce the damage (Davis et. al, 2022).

### Other Watering Alternatives

Other watering alternatives for livestock include: a pipeline, a pond, or a well. A combination of these practices may be and are often used. Having different sources of water on a pasture, especially ones that move around, can help any one area from being overgrazed (Gould, 2012). This decreases erosion which can cause excessive sediment and nutrients from entering the waterways. In addition, this strategy helps spread urine and manure out, decreasing mud and mudholes. This helps limit the livestock contact with harmful pathogens (Gould, 2012). Overall, alternative water sources are a beneficial management practice for the environment and the livestock.

### Associated Costs

There will be costs to implement alternative watering structures (“California Practice”, 2023). Since water must be transported from either a well or another source, such as the stream, there will also be the cost of water transportation. This might be from a pipeline. One example of a pipeline that may be used is one made of PVC, which would cost about $3.96/ foot. If difficult to install, PVC pipe could cost about $6.47/ foot. Water containers may be necessary. A tire trough costs about $3.00/ gallon. A frost-free trough costs about $40.57/ gallon. An above ground storage tank costs about $2.36/ gallon. A below ground storage tank costs about $3.21/ gallon. A stock trough costs about $8.52/ gallon. Fence costs for stream access vary, but barbed or smooth wire can be used and costs about $5.94/ foot. All these estimates include cost of materials and labor (“California Practice”, 2023).

## Heavy Use Protection Areas

***Table B-3 Heavy Use Protection Areas Benefits and Costs***

| Environmental Benefits | Livestock Benefits | Potential Challenges | Estimated Costs |
|---|---|---|---|
| -reduce erosion<br>-decrease sediment deposition in waterways<br>-decreased nutrients to waterways | -livestock exposed to less pathogen heavy mud<br>-livestock tend to be more comfortable meaning they gain more weight<br>-dairy cattle are also more comfortable and produce more milk | -materials<br>-labor<br>-maintenance cost | -reinforced concrete: $11.22/ sq ft<br>-non-reinforced concrete with sand or gravel foundation: $6.49/ sq ft<br>-rock/gravel: $1.81/ sq ft<br>-rock/ gravel on geotextile: $1.98/ sq ft<br>-rock/ gravel-geocell on geotextile: $4.89/ sq ft<br>-sand-topped rock/ gravel on geotextile: $2.58/ sq ft |

The NRCS defines heavy use protection areas as infrastructure, such as concrete, that is “used to stabilize a ground surface that is frequently and intensively used by people, animals, or vehicles” (United States, 2014). Areas frequently used by livestock tend to have very high levels of erosion that can make its way down into the waterway (United States, 2014). Heavy Use Protection areas reduce that erosion, thereby adding to the improvement of overall water quality. Also, urine and manure can make its way to pollute waterways (Briggs & Lemenager, 2020). A study, using heavy use protection pad in heavy use areas of poultry farms, found that heavy use protection pads prevented most nutrients from entering the waterways (Ozbay et al., 2021). Heavy use protection areas are a good way of protecting water quality.

In addition to protecting waterways, heavy use protection areas help keep livestock healthy. Areas frequented by livestock tend to turn into mud or “a combination of soil, manure, and urine” (Briggs & Lemenager, 2020). This mud has a higher concentration of pathogens, which can make livestock sick. This uncomfortable, potentially dangerous environment can lead to lower productivity in livestock. For example, cows tend to have lower body weight and produce less milk when exposed to a muddy environment (Briggs & Lemenager, 2020).

### Potential Costs

There are extra initial costs that go into constructing heavy use protection areas. In addition, their efficacy was found to decrease with age (Ozbay et al., 2021). This means maintenance is necessary and could add to the cost. A reinforced concrete heavy use protection area costs about $11.22/ square foot (“California Practice”, 2023). Non-reinforced concrete with sand or gravel foundation costs about $6.49/ square foot. Rock and gravel costs about $1.81/ square foot. Rock and gravel on geotextile cost about $4.89/ square foot. Sand-topped rock/ gravel on geotextile costs about $2.58/ square foot ("California Practice", 2023). Although there could be large initial costs with heavy use protection areas, farmers found that they spent less time cleaning livestock after heavy use protection areas were implemented (VanDevender & Pennington, n.d.). All these estimates include cost of materials and labor ("California Practice", 2023).

## Manure Management

***Table B-4 Manure Management Benefits and Costs***

| Environmental Benefits | Livestock Benefits | Potential Challenges | Estimated Costs |
|---|---|---|---|
| -less fecal matter in waterways<br>-less nutrient pollution in waterways<br>-manure applied in appropriate matter can be beneficial pasture | -minimizes livestock exposure to mud and harmful pathogens<br>-improved forage from manure that has been appropriately used as compost | -materials and labor of containers<br>-labor of storing and applying manure at appropriate times<br>-potential cost for collection of excess manure | -earthen facility: $0.30/ cu ft<br>-above ground concrete tank: $1.49/ cu ft<br>-composted bedding pack, concrete floor, concrete walls: $19.30/ sq ft<br>-concrete tank with lid: $16.55/ cu ft |

Although animal waste can be beneficial to crops and pasture, it can also harm waterways and the animals themselves. Often, the level of manure is higher than what the land itself can absorb. This includes an increased concentration of nitrogen and harmful pathogens that can make their way into waterways and harm animal health (Briggs & Lemenager, 2020). Good livestock waste management is essential to protecting waterways.

Manure storage facilities can help prevent runoff of the manure, that can harm animals and waterways. Waste storage allows farms to wait until an appropriate time to apply manure to land (Bollwahn, 2014). Manure may be stored in containers below or above ground that prevent nitrates from leaching into the soil and making their way into waterways. In addition, this also limits livestock exposure to harmful pathogens that can make them sick. If there is more manure than can be used, the manure can be taken away easier when it has been stored. If the manure is to be used, it can be applied at the appropriate time to avoid excess runoff (Bollwahn, 2014). Overall, manure storage is an effective addition to a best management practice plan.

### Associated Costs

The cost of a waste storage facility can vary depending on the materials used ("California Practice", 2023). For example, an earthen facility costs about $0.30/ cubic foot. Above the ground concrete tank costs about $1.49/ cubic foot. A composted bedding pack, concrete floor, and concrete walls costs about $19.30/ square foot. A concrete tank with lid costs about $16.55/ cubic foot. All these estimates include cost of materials and labor ("California Practice", 2023).

## Rotational Grazing

***Table B-5 Rotational Grazing Benefits and Costs***

| Environmental Benefits | Livestock Benefits | Potential Challenges | Estimated Costs |
|---|---|---|---|
| -improved forage production and soil health<br>- increased soil infiltration<br>-decreased erosion<br>-decreased nutrient runoff | -more forage mass available<br>-more of the forage species that livestock prefer available | -fencing<br>-watering systems<br>-added labor of moving livestock | -Barbed or Smooth Wire: $5.94/ft<br>-Barbed or Smooth Wire (Difficult Installation): $8.20/ft<br>-Woven Wire: $7.43/ft<br>-Electric: $3.31/ft<br>-Safety or Heavy Use: $10.33/ft<br>-Organic Fence: $6.48/ft |

Rotational grazing is another strategy that benefits both livestock and the environment. Rotational Grazing is defined as "a system where a large pasture is divided into smaller paddocks allowing livestock to be moved from one paddock to the other easily" (Smith et al., n.d.). This allows areas of the pasture to recover, thereby improving forage production and soil health. Rotational Grazing can increase forage production by up to 70% (Morgan, 2018). This includes plants growing larger roots which can lead to decreased erosion and nutrient runoff. In addition, rotationally grazed areas need less water which is important to drought prone areas (Morgan, 2018). Another environmental benefit is the potential to direct grazing animals to control invasive species. Overall, rotational grazing provides many environmental benefits.

Besides environmental benefits, rotational grazing can also be beneficial to livestock health and farm productivity. Plants that livestock like to consume can be planted and will last longer than if livestock were continuously grazed (Beck, 2021). In one study, alfalfa that had been planted 3 years ago for livestock remained at 25% compared to the 10% in continuous pastures. This helps increase grazing efficiency. In fact, rotationally grazed pastures were found to be 65% more efficient than continuously grazed pastures and stocking rate increased by as much as double (Beck, 2021). Overall, it's clear that rotational grazing is beneficial to the environment and livestock farms.

### Potential Costs

There are potential costs associated with rotational grazing. These include fencing and watering systems (Beck, 2021). A barbed or smooth wire fence costs about $5.94/foot ("California Practice", 2023). Barbed or smooth wire fence with difficult installation costs about $8.20/foot. Electric fencing costs about $3.31/foot. Woven Wire is about $7.43/foot. Safety or Heavy Use fencing costs about $10.33/foot. Organic Fencing Costs about $6.48/foot. All these estimates include cost of materials and labor ("California Practice", 2023).

## Other Sources of Shade

***Table B-6 Other Sources of Shade Benefits and Costs***

| Environmental Benefits | Livestock Benefits | Potential Challenges | Estimated Costs |
|---|---|---|---|
| -less erosion near waterways or in one area<br>-less fecal matter deposition near waterways or in one area | -less heat-related stress and illness<br>-more forage with appropriate amounts of shade | -materials<br>-labor<br>-loss of forage if too much shade is used | -portable shade structure: $5.74/sq ft<br>-prefabricated portable shade structure: $7.66/sq ft<br>-tree/shrub establishment (Native Seed, Hand Plant): $784.98/ acre<br>-Silvopasture establishment: $89.46/ acre |

Because there is more shade in riparian areas, livestock tends to congregate in these areas when they are hot (Clary et al., 2016). Where livestock tend to congregate, erosion increases. Congregation near riparian areas tend to increase erosion and other negative effects. Alternate shade, either natural or manmade, seeks to lure livestock away from riparian areas or prevent them from spending too much time in any one area. In one study, alternate shade reduced the time livestock spent in riparian areas by 30% (Clary et al., 2016).

Along with mitigating negative environmental effects, providing sources of shade is beneficial to the health of livestock as well. Shade sources have been documented to reduce heat stress in cattle (Edwards-Callaway et al., 2020). In one study, during a heat wave, heat related cattle deaths came in at 0.2% in shaded areas compared to 4.8% in non-shaded areas (Busby & Loy, 1997). Providing sources of shade to livestock is a worthwhile strategy to mitigate environmental impact on waterways and improve livestock health.

### Associated Costs

Whether planting natural shade or installing manmade shade, there will be some initial costs. A portable shade structure costs about $5.74/ square foot ("California Practice", 2023). A prefabricated portable shade structure costs about $7.66/ square foot. Tree and shrub establishment by native seed that is hand planted costs about $784.98/ acre. Silvopasture establishment costs about $89.46/ acre. All these estimates include cost of materials and labor ("California Practice", 2023).

Another potential cost could be the loss of forage if too much shade is utilized. However, moderate amounts of shade were found to increase forage ("What am I giving", 2021).

## Sources of Funding

There are many existing funds that cover a partial or the full cost of best management practices implementation. The Natural Resources Conservation Service of the United States Department of Agricultural employs regional specialists to help ranchers find funds applicable to them (United States, 2022). Through programs such as the Environmental Quality Incentives Program and the Conservation Stewardship Program, both technical and financial support services are provided (United States, 2022). The California Department of Food and Agriculture also has financial assistance for ranchers implementing best management practices, through programs like the Healthy Soils Grant (California State, n.d.). The Food Animal Concern Trust is a nonprofit that supplies the Fund-A-Farmer Grant (Food Animal, n.d.). This grant potentially supplies applicants up to $3,000 for independent livestock farmers in the United States (Food Animal, n.d.). The Sustainable Agriculture Research and Education Program that offers grants to a variety of people, including ranchers, that use their farm for research or educational purposes (Sustainable Agriculture, 2021). There may be other existing funds out there depending on what the goal of the farm is. Employees at the Natural Resources Conservation Service can help with the research, application, and implementation process.

## Conclusion

There are many best management practices that are specifically designed for ranchers that help keep the environment, especially the waterways, healthy. Most of these strategies also help keep livestock healthy, improve soil infiltration/moisture retention and forage quality. These strategies do have costs associated with them. However, there are many funds out there to help tackle these costs. Furthermore, the profits that come from having healthy livestock and a healthy pastureland can help mitigate, and in some cases even outweigh the cost of these best management strategies. The right strategies can differ depending on the farm's unique situation, so asking for free assistance at the Natural Resources Conservation Service may be worth considering.

## References for Appendix B


Brackenrich, J., & Duiker, S. W. (2018, June 20). *Avoid overgrazing your pastures*. Penn State Extension. https://extension.psu.edu/avoid-overgrazing-your-pastures#:~:text=the%20weak%2C%20overgrazed%20pasture%20will,overgrazing%20increases%20soil%20compaction.

Briggs, N. G., & Lemenager, R. P. (2020, April 14). *Heavy use area pads for cattle*. Penn State Extension. https://extension.psu.edu/heavy-use-area-pads-for-cattle

Beck, P. (2021, August 4). *Benefits of rotational grazing*. Beef Magazine. https://www.beefmagazine.com/beef/benefits-rotational-grazing

Bollwahn, S. (2014, August 25). *Storing manure on small farms – deciding on a storage option*. MSU Extension. https://www.canr.msu.edu/news/storing_manure_on_small_farms_deciding_on_a_storage_option

Busby, D., & Loy, D. (1996, January 1). *Heat stress in feedlot cattle: Producer survey results*. Iowa State University. https://www.academia.edu/en/24329791/Heat_Stress_In_Feedlot_Cattle_Producer_Survey_Results

*California Practice Scenarios- Fiscal Year 2023*. United States Department of Agriculture: Natural Resource Conservation Service. (2023).

Clary, C. R., Redmon, L., Gentry, T., Wagner, K., & Lyons, R. (2016). Nonriparian Shade as a water quality best management practice for grazing-lands: A case study. *Rangelands*, *38*(3), 129–137. https://doi.org/10.1016/j.rala.2015.12.006

Davis, L., McClure, J., Rourke, D., Garber, L., & Brittingham, M. (2022). *Stream Bank Fencing: Green Banks, Clean Streams*. Pennsylvania Nutrient Management Program. https://extension.psu.edu/programs/nutrient-management/educational/best-management-practices/stream-bank-fencing-green-banks-clean-streams

Dressing, S. A. (2003). *National Management Measures to control nonpoint source pollution from agriculture*. United States Environmental Protection Agency.

Edwards-Callaway, L. N., Cramer, M. C., Cadaret, C. N., Bigler, E. J., Engle, T. E., Wagner, J. J., & Clark, D. L. (2020). Impacts of shade on cattle well-being in the beef supply chain. *Journal of Animal Science*, *99*(2). https://doi.org/10.1093/jas/skaa375

Food Animal Concerns Trust. (n.d.). *Fund-a-farmer grants*. FACT. https://www.foodanimalconcernstrust.org/grants/

California State Government. (n.d.). *Healthy Soils Program*. California Department of Food and Agriculture. https://www.cdfa.ca.gov/oefi/healthysoils/

Galeone, D. G., Low, D. J., & Brightbill, R. A. (2016, November 29). *Effects of streambank fencing of near-stream pasture land on a small watershed in Lancaster County, Pennsylvania*. USGS: A Science for Changing the World. https://pubs.usgs.gov/fs/2006/3112/

Galeone, D.G., 2000, Preliminary effects of streambank fencing of pasture land on the quality of surface water in a small watershed in Lancaster County, Pennsylvania: U.S. Geological Survey Water Resources Investigation Report 2000–4205, 15p., https://pubs.er.usgs.gov/publication/wri004205.

Giuliano, W. M. (2006, February 1). *Should I fence the streams, ponds, and wetlands in my pastures?* repository.arizona.edu. https://repository.arizona.edu/handle/10150/639586

Gould, K. (2012, March 26). *Watering systems for grazing (E3097)*. Agriculture. https://www.canr.msu.edu/resources/watering_systems_for_grazing

Miller, J. J., Chanasyk, D. S., Curtis, T., & Willms, W. D. (2010). Influence of Streambank fencing on the environmental quality of cattle-excluded pastures. *Journal of Environmental Quality*, *39*(3), 991–1000. https://doi.org/10.2134/jeq2009.0233

Morgan, J. (2018, December 14). *Advantages of rotational grazing*. Premier1Supplies. from https://www.premier1supplies.com/sheep-guide/2012/07/a-look-at-the-advantages-of-rotational-grazing/

Muirhead, R. W. (2019). The effectiveness of streambank fencing to improve microbial water quality: A Review. *Agricultural Water Management*, *223*, 105684. https://doi.org/10.1016/j.agwat.2019.105684

Ozbay, G., Khatiwada, R., Smith, S., & Chintapenta, L. K. (2021). Efficacy of Heavy Use Area Protection (HUAP) pads in Poultry Farm. *Agriculture*, *11*(2), 154. https://doi.org/10.3390/agriculture11020154

Paige, C. (2012). *A landowner's guide to fences and wildlife - practical tips to make your fences wildlife friendly*. Land Conservation Assistance Network. https://www.landcan.org/article/A-Landowners-Guide-to-Fences-and-Wildlife--Practical-Tips-to-Make-Your-Fences-Wildlife-Friendly/2716

Smith, R., Amaral-Phillips, D., & Lehmkuhler, J. (n.d.). *Rotational vs. continuous grazing*. Master Grazer. https://grazer.ca.uky.edu/content/rotational-vs-continuous-grazing#:~:text=Rotational%20grazing%20can%20help%20improve,of%20nutrients%20to%20the%20soil.

Sustainable Agriculture Research and Education Program. (2021, April 22). *Grants*. SARE. https://www.sare.org/Grants/

*The benefits of rotational grazing*. Nevada Irrigation District. (2022). https://www.nidwater.com/the-benefits-of-rotational-grazing

United States Department of Agriculture. (2022, August 15). *Nutrient management*. Natural Resources Conservation Service. https://www.nrcs.usda.gov/getting-assistance/other-topics/nutrient-management

United States Department of Agriculture. (2022, November 9). *Environmental Incentives Program*. Natural Resources Conservation Service. https://www.nrcs.usda.gov/programs-initiatives/eqip-environmental-quality-incentives

U.S. Department of Agriculture. (2022, October 28). | *Natural Resources Conservation Service*. Natural Resources Conservation Service. https://www.nrcs.usda.gov/

VanDevender, K., & Pennington, J. (n.d.). *Reducing mud problems in cattle heavy use areas with coal combustion by ...* University of Nebraska Lincoln. http://gpvec.unl.edu/mud/EnviroMudControl-FlyAsh-FSA-1043.pdf

Willms, W. D., Kenzie, O. R., McAllister, T. A., Colwell, D., Veira, D., Wilmhurst, J. F., Entz, T., & Olson, M. E. (2002). Effects of water quality on cattle performance. *Journal of Range Management*, *55*(5). https://doi.org/10.2458/azu_jrm_v55i5_willms

Zeckoski, R., Benham, B., & Lunsford, C. (2007, September). *STREAMSIDE LIVESTOCK EXCLUSION: A tool for increasing farm income and improving water quality*. Virginia Department of Conservation and Recreation. http://lshs.tamu.edu/research/2007/streamside-livestock-exclusion-a-tool-for-increasing-farm-income-and-improving-water-quality/

*What am I giving up? shade and forage production*. Trees for Graziers. (2021, September 15). https://treesforgraziers.com/2021/07/26/what-am-i-giving-up-shade-and-forage-production/