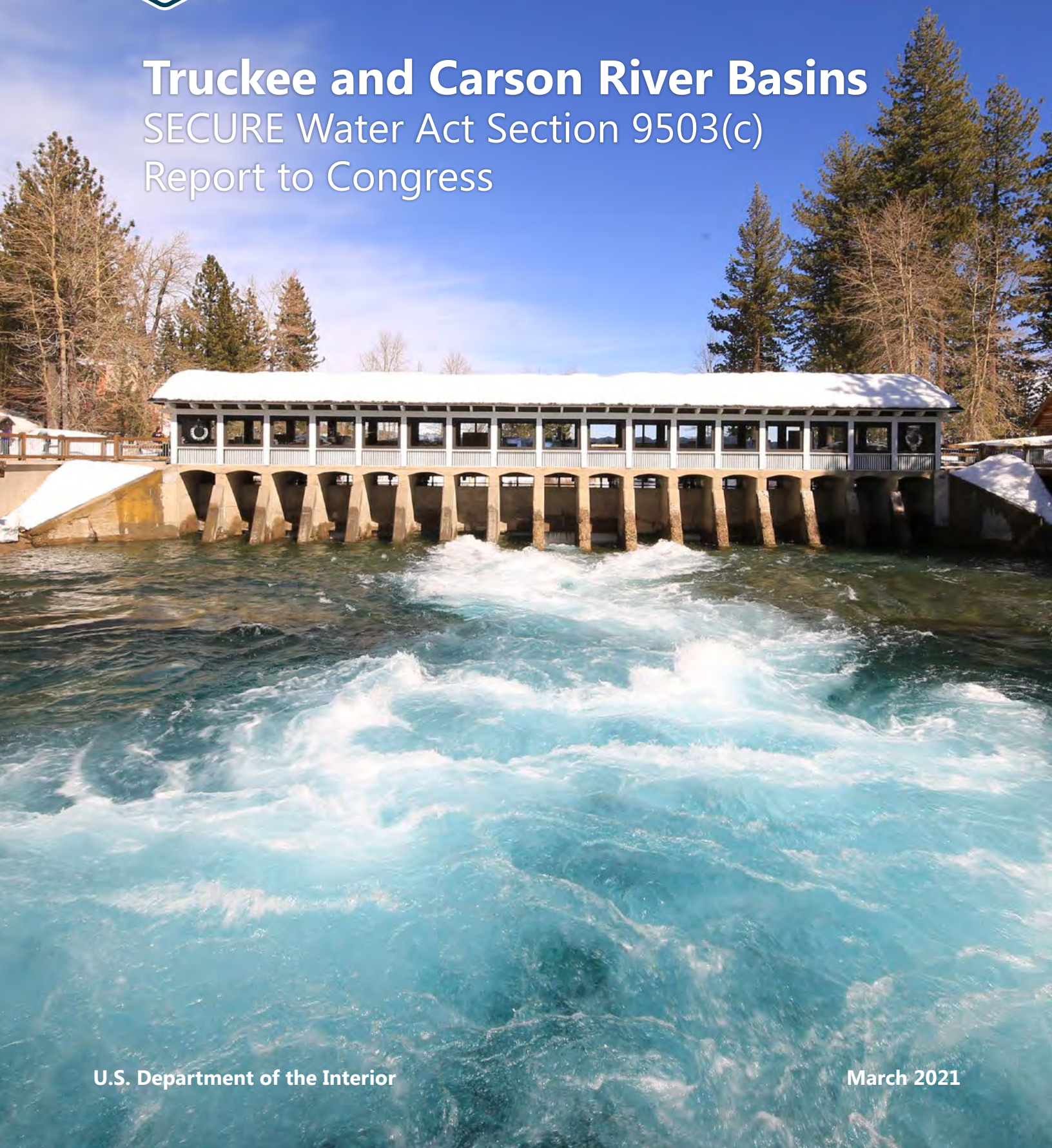
BUREAU OF
RECLAMATION

Truckee and Carson River Basins

SECURE Water Act Section 9503(c)
Report to Congress



U.S. Department of the Interior

March 2021

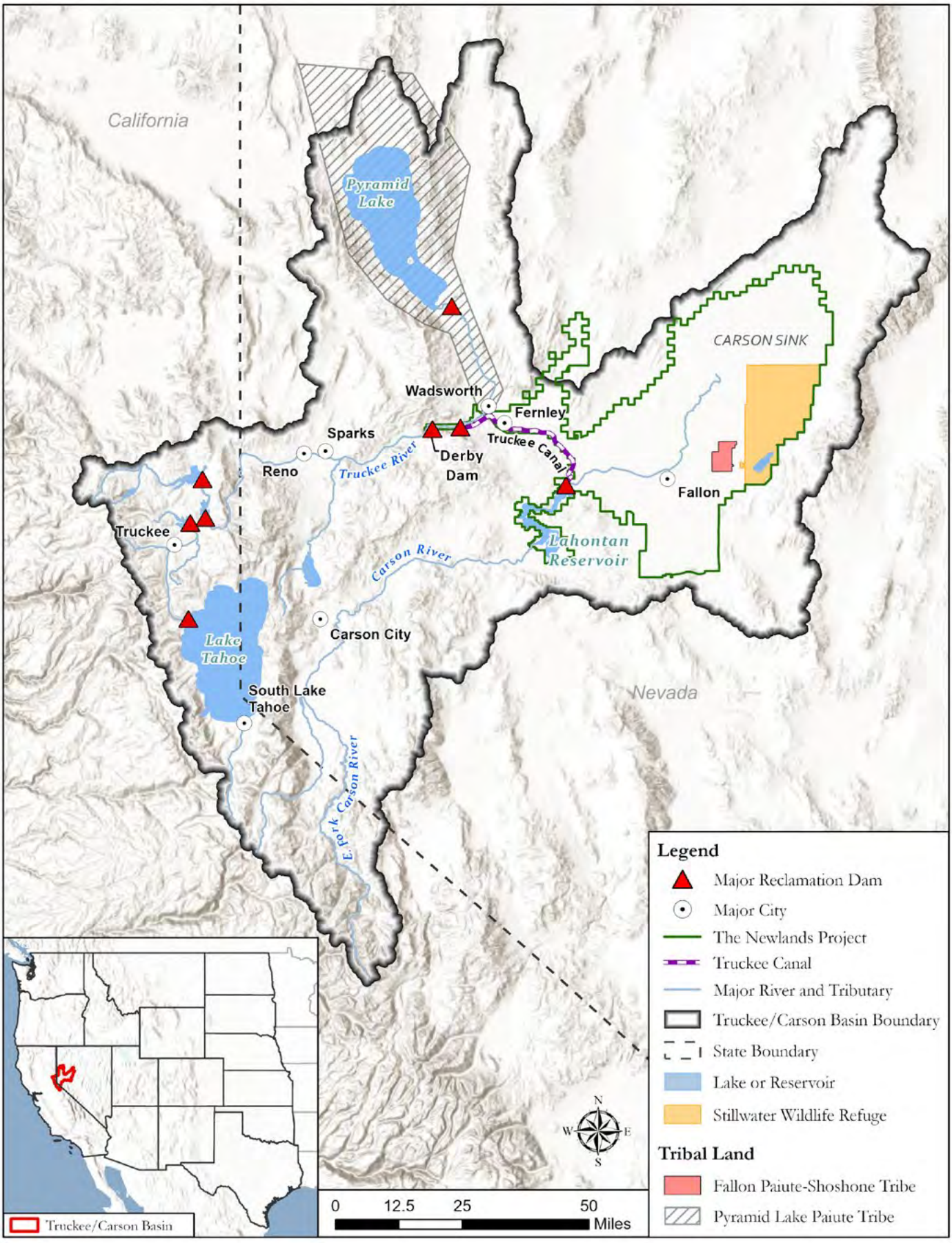
Mission Statements

The Department of the Interior conserves and manages the Nation's natural resources and cultural heritage for the benefit and enjoyment of the American people, provides scientific and other information about natural resources and natural hazards to address societal challenges and create opportunities for the American people, and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities to help them prosper.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Acronyms and Abbreviations

°F	degrees Fahrenheit
Basin Study	Truckee River Basin Study
Carson Basin	Carson River Basin
CRLE	Complementary Relationship Lake Evaporation
DEIS	Draft Environmental Impact Statement
ET	evapotranspiration
INSAR	interferometric synthetic aperture radar
MOA	Memorandum of Agreement
NPCW	Newlands Project Credit Water
PRMS	Precipitation-Runoff Modeling System
Reclamation	Bureau of Reclamation
SAR	Synthetic Aperture Radar
SECURE Water Act	Science and Engineering to Comprehensively Understand and Responsibly Enhance (SECURE) Water Act
TCID	Truckee-Carson Irrigation District
TMWA	Truckee Meadows Water Authority
TRFMA	Truckee River Flood Management Authority
TROA	Truckee River Operating Agreement
TRPA	Tahoe Regional Planning Agency
Truckee Basin	Truckee River Basin
Truckee-Carson Basins	Truckee and Carson River Basins
TSC	Technical Service Center
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UV	ultraviolet-c


California
Nevada
Pyramid Lake
CARSON SINK
Wadsworth
Fernley
Sparks
Reno
Truckee River
Derby Dam
Truckee Canal
Fallon
Truckee
Lahontan Reservoir
Carson River
Lake Tahoe
Carson City
South Lake Tahoe
E. Fork Carson River
Truckee/Carson Basin
0 12.5 25 50 Miles
N
W
E
S
Legend
Major Reclamation Dam
Major City
The Newlands Project
Truckee Canal
Major River and Tributary
Truckee/Carson Basin Boundary
State Boundary
Lake or Reservoir
Stillwater Wildlife Refuge
Tribal Land
Fallon Paiute-Shoshone Tribe
Pyramid Lake Paiute Tribe

Truckee and Carson River Basins Setting

States:

California

Nevada

Major Water Uses:

Agriculture

Municipal

Flood Control

Hydropower

Recreation

Fish and Wildife Habitat

Industrial

River Basin Area: 3,060 square miles

River Length: 119 miles

Major rivers/ tributaries:

- Truckee
- Carson

Notable Reclamation Facilities:

Boca Dam

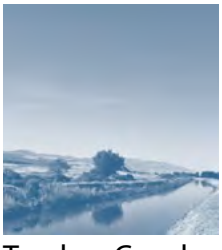
Marble Bluff Dam

Lahontan Reservoir

Lake Tahoe Dam

Stampede Dam

Derby Dam



Truckee Canal

Contents

ABOUT

This basin report is part of the 2021 Science and Engineering to Comprehensively Understand and Responsibly Enhance (SECURE) Water Act Report to Congress, prepared by the Bureau of Reclamation in accordance with Section 9503(c) of the SECURE Water Act of 2009, Public Law 111-11. The 2021 SECURE Water Act Report follows and builds upon the first two SECURE Water Act Reports, submitted to Congress in 2011 and 2016. The report characterizes the impacts of warmer temperatures, changes to precipitation and snowpack, and changes to the timing and quantity of streamflow runoff across the West.

The 17 Western States form one of the fastest growing regions in the Nation, with much of the growth occurring in the driest areas. The report provides information to help water managers address risks associated with changes to water supply, quality, and operations; hydropower; groundwater resources; flood control; recreation; and fish, wildlife, and other ecological resources in the West.

To see all documents included in the 2021 SECURE Water Act Report to Congress, go to: https://www.usbr.gov/climate/secure/

Aerial view of the Truckee River bringing much-needed water to the Nevada desert (Getty Images).

SECTION 1

Water Management Challenges

The Truckee River supports natural ecosystems and is a vital water source for more than 400,000 people. From its origins in the Sierra Nevada Mountains at elevations over 10,000 feet, the Truckee River Basin (Truckee Basin) encompasses an area of approximately 3,060 square miles (1,958,400 acres) in California and Nevada. While the greater portion of the Truckee Basin surface area and the majority of its demands for water resources lie in Nevada, most of the precipitation and virtually all of the water storage for the basin lie in California. The imbalance between water supplies and demands in the Truckee Basin has created conflicts surrounding the rights to, and the uses of, water resources within the basin. The waters of the Truckee River have been fully appropriated; therefore, satisfying competing demands for human, environmental, and other uses of water will likely become increasingly difficult in the future under potential climate change (Reclamation, 2015).

Truckee and Carson River Basins Overview

From tributaries high in the Sierra Nevada Mountains of California, flows into Lake Tahoe of about 180,400 acre-feet are the source of the Truckee River. From its outlet at Lake Tahoe Dam, the Truckee River gains additional flows from several tributaries including Martis Creek, Prosser Creek, and the Little Truckee River in California and Steamboat Creek in Nevada. These flows are important sources of municipal, agricultural, and environmental water for inhabitants of the Truckee Basin, as well as the neighboring Carson River Basin (Carson Basin) where some Truckee River flow is diverted to support the Newlands Project, Stillwater National Wildlife Refuge and the Fallon Paiute-Shoshone Indian Reservation and Community. Remaining flows enter the Pyramid Lake Paiute Indian Reservation and discharge into Pyramid Lake where two endangered endemic fish species, cui-ui *(Chasmistes cujus)* and the Lahontan Cutthroat Trout *(Oncorhynchus clarkii henshawi)*, are found and the Anaho Island National Wildlife Refuge provides breeding habitat for pelicans (**Figure 1**).

- The Truckee Basin straddles the state line between California and Nevada. The Truckee Basin includes Lake Tahoe, Truckee River in California, Truckee Meadows in Nevada, and Pyramid Lake

Figure 1. The Truckee River terminates in Pyramid Lake in Nevada where two endangered endemic fish species—Lahontan Cutthroat Trout (pictured here) and cui-ui—are found.

water user regions. Of the total area of Truckee Basin, approximately 760 square miles (486,400 acres), or almost 25 percent of the Truckee Basin, is located within the State of California—the source of most of the water supply.

The remaining 2,300 square miles (1,472,000 acres), or 75 percent of the Truckee Basin, is located within the State of Nevada, where most of the urban, agricultural and environmental water demands exist.

- The Carson River is also an important source of water to the Newlands Project, Stillwater National Wildlife Refuge and the Fallon Paiute-Shoshone Indian Reservation and Community (**Figure 2**). Its drainage area is approximately 3,930 square miles (2,515,200 acres). Although the Carson River was not comprehensively studied in the Truckee River Basin Study (Basin Study) (Reclamation, 2015), it is discussed in this document because its flow into the Bureau of Reclamation's (Reclamation) Lahontan Reservoir affects diversions from the Truckee River at Derby Dam. Like the Truckee River, its headwaters are high in the Sierra Nevada Mountains of California. From these sources, its east and west forks have a confluence in Nevada upstream of Carson City. Its average annual discharge into Lahontan Reservoir is about 276,000 acre-feet per year (Reclamation, 2015). After releases from Lahontan Reservoir are made for irrigation and wildlife habitat, it terminates in the Carson Sink, east of Fallon, Nevada.

The primary source of information used in this document is the Basin Study (Reclamation, 2015). It was conducted by Reclamation in partnership with four non-Federal cost-share partners including the Placer County Water Agency, Tahoe Regional Planning Agency, Truckee Meadows Water Authority (TMWA), and Truckee River Flood Management Authority (TRFMA).

Figure 2. Severe drought at the Carson River Diversion Dam in Nevada in April 2013.

The Basin Study focuses on five distinct "water use communities" to represent the primary geographical variations in water uses in the Truckee Basin. These water use communities include:

- **Lake Tahoe Basin** – This area is located between the Sierra Mountains on the west and the Carson Range on the east. It contains Lake Tahoe and its surrounding drainage area. Major communities include Tahoe City and South Lake Tahoe in California.
- **Truckee River in California** – This area is located downstream from Lake Tahoe Dam and includes the Truckee River drainage contributing inflows upstream of the Farad gage near the California-Nevada state line. Major communities include the city of Truckee in California.
- **Truckee Meadows** – This area is located downstream of the Farad gage and includes the Truckee River drainage areas contributing inflows upstream of the Derby Dam. Major communities include the cities of Reno and Sparks in Nevada.
- **Pyramid Lake** – This area is located within the Pyramid Lake Paiute Tribe Reservation in the north central part of the Truckee Basin. The tribal members reside in the communities of Nixon, Sutcliffe, and Wadsworth.
- **Newlands Project** – This area is located on irrigated and wildlife habitat lands in the west-central part of the Truckee-Carson Basins in Churchill, Lyon, Storey, and Washoe counties in Nevada. Major communities include the cities of Fallon and Fernley in Nevada.

In each of these regions, there are a variety of water use types including agricultural uses primarily for irrigation of crops and livestock watering (**Figure 3**).

Figure 3.
One of the many uses of Truckee River water is for irrigation of crops and livestock watering.

Municipal and industrial uses include residential (indoor and outdoor), (hotels, casinos, manufacturing) and recreation (golf courses, boating, fishing) (**Figure 4**). Environmental uses include support for the habitats of aquatic, avian and terrestrial species.

Figure 4. Angler fishing in the Truckee River. The river provides camping, boating, and other recreation.

Table 1 presents recent water demands in acre-feet by sector for each of the water use communities in the Truckee-Carson Basins as estimated by the Basin Study.

There is also some non-consumptive use of Truckee Basin water for hydropower generation, including both Federal and locally-owned and -operated facilities. Located on the Little Truckee River, Stampede Powerplant is operated by Reclamation and produces an average of about 12 million kilowatt-hours annually. TMWA owns three hydroelectric powerplants along the Truckee River—Fleish, Verdi, and Washoe. Combined, they produce 50 million kilowatt hours annually. In the Carson Basin, power is generated by the Truckee-Carson Irrigation District (TCID) at Old Lahontan, New Lahontan, and 26-Foot Drop (V-Line Canal) powerplants. In recent years, these powerplants have produced a combined total of an average of 180 million kilowatt hours annually.

User Community	Agriculture (acre-feet)	Environment (acre-feet)	Municipal and Industrial (acre-feet)	Total User Community (acre-feet)
Truckee River Basin				
Lake Tahoe Basin	--	--	22,111	22,111
Truckee River Basin	--	--	10,937	10,937
Truckee Meadows	21,450	--	83,140	104,590
Pyramid Lake	4,288	27,934	146*	32,368
Newlands Project	9,450	--	3,732	13,182
Total Truckee River Basin User Communities	35,188	27,934	120,066	183,188
Carson River Basin				
Newlands Project	152,798	8,110	--	160,908
Total Combined Truckee and Carson River Basins				
--	187,986	36,044	120,066	344,096

*Note: * = Estimated based on the Pyramid Lake Paiute Tribe estimated population in February of 2017 (Pyramid Lake Paiute Tribe, 2020) assuming 100 gallons per day per capita municipal and industrial water use.*

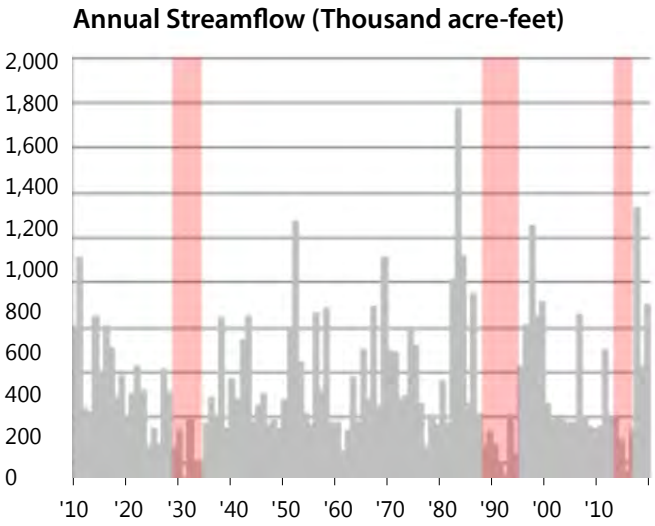
Table 1. Estimated recent water demands of water user communities by sector type in the Truckee and Carson River Basins (in acre-feet).

The Truckee Basin has historically experienced periods of drought and flooding events. **Figure 5** illustrates the variability and extremes of the historic climate as characterized by Truckee River flows at the Farad gage.

In high flow years, winter floods have occurred many times since Reno and Sparks were founded with storms generally occurring between November and April. The primary cause of winter flooding is warm storms falling on the Sierra Nevada snowpack (**Figure 6**). The Truckee River has flooded 23 times in the past 112 years. The largest floods occurred in 1956, 1951, 1963, and 1997. The famous New Year's flood of 1997 caused more than $450 million (unadjusted) in damage. However, consecutive years of low precipitation in the Lake Tahoe basin and Truckee River upstream from Farad produced dry conditions and drought cycles for the entire Truckee Basin. As illustrated on Figure 1, major droughts occurred from 1928 to 1935, 1987 to 1994, and 2014 to 2016. The most intense period of drought occurred in February 2015 with the driest year on-record in terms of runoff. Ultimately, drought and flooding on the Truckee River system are becoming more commonplace.

In the Basin Study, the partners, along with other interested stakeholders, were asked to identify the relative importance of various future social, economic, and environmental factors affecting future water management. Among these factors identified as more important were changes in population including seasonal visitation, conservation of high-quality scenic and recreational environments, and the effects of water availability on municipal, commercial, and industrial activities. In general, land use changes were not considered to be a major factor as existing planning and regulations would likely address these challenges.

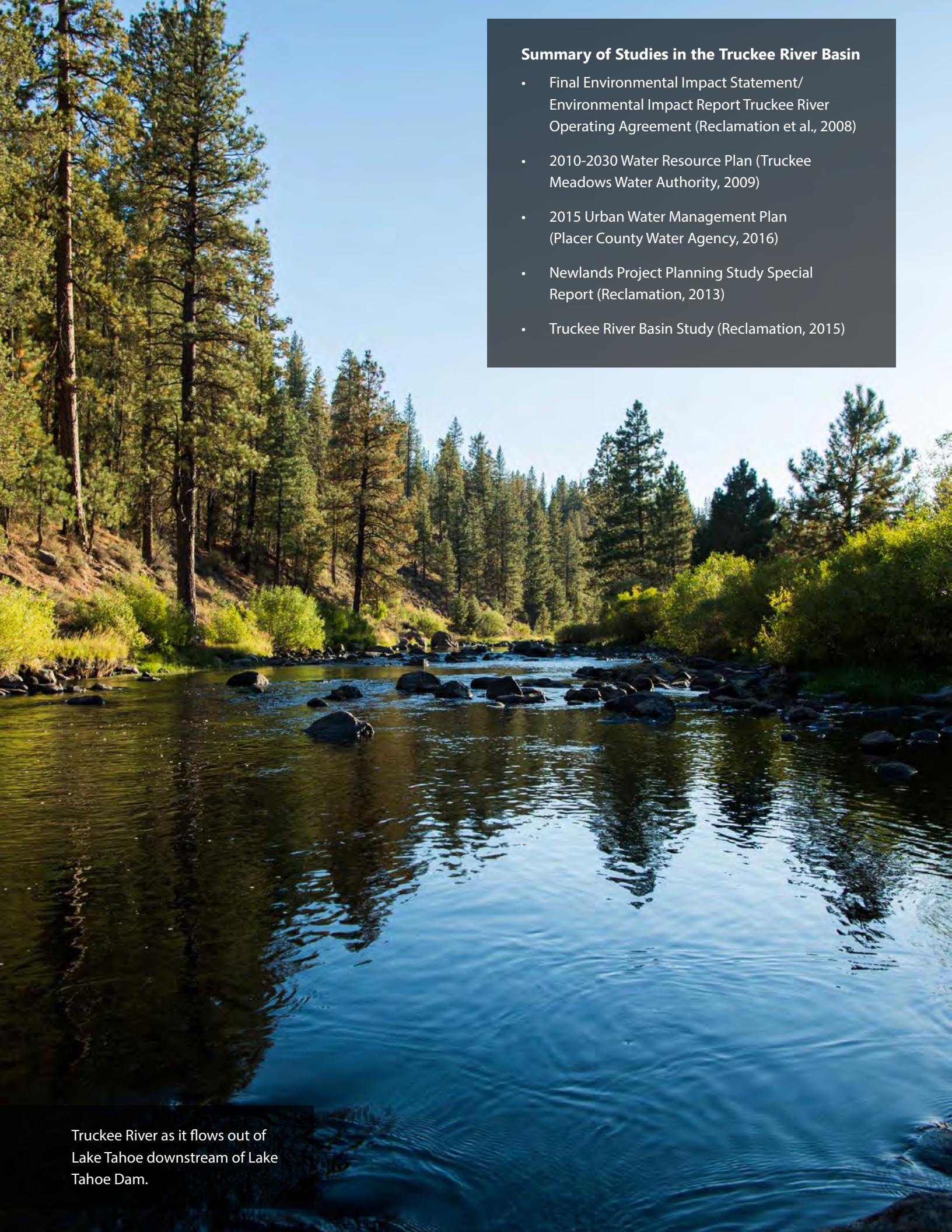
There have been years of legal entanglements in the Truckee-Carson Basins due to the gradual nature of water rights adjudications, and flows needed for the endangered Pyramid Lake fish. However, the 1980 Alpine Decree and more recently the Truckee River Operating Agreement (see the *Truckee River Operating Agreement* section below for details) have decreased water rights uncertainties and increased the flexibility of operations to meet competing needs.



Note: Red shaded bar indicates the most severe recorded drought periods in the Truckee River Basin.

Figure 5. Annual Truckee River Flow at the Farad Gage (1910-2019).

Figure 6. The Little Truckee River is a tributary that flows to Stampede Reservoir, then Boca Reservoir, and terminates at its confluence with the Truckee River. This image shows flooding along the Little Truckee River.



Summary of Studies in the Truckee River Basin

- Final Environmental Impact Statement/ Environmental Impact Report Truckee River Operating Agreement (Reclamation et al., 2008)
- 2010-2030 Water Resource Plan (Truckee Meadows Water Authority, 2009)
- 2015 Urban Water Management Plan (Placer County Water Agency, 2016)
- Newlands Project Planning Study Special Report (Reclamation, 2013)
- Truckee River Basin Study (Reclamation, 2015)

Truckee River as it flows out of Lake Tahoe downstream of Lake Tahoe Dam.

SECTION 2

Analysis of Impacts to Water Resources

Impacts to water and related resources in the Truckee Basin were evaluated in various reports with focused analyses in the Basin Study by developing scenarios characterizing a wide range of potential changes in climatic and socioeconomic conditions in the 21st century. The Basin Study uses 112 climate projections from a dataset that combines projections from sixteen different Global Climate Models. To simplify the use of all 112 climate projections, yet still capture a meaningful range of future climate uncertainty, the Basin Study developed five representative future climate scenarios relative to the median of the 112 climate projections including a Warmer-Drier, Hotter-Drier, Hotter-Wetter, Warmer-Wetter, and a Central Tendency. A reference scenario was developed to represent recent climate, water supply, and demand conditions. These six scenarios were not intended to predict future conditions, but rather to characterize future uncertainties in order to improve the analysis of impacts, development of adaptation strategies, evaluation of performance, and characterization of tradeoffs intended to address the SECURE Water Act water use categories. For a detailed explanation of climate projections relied on by Reclamation, please refer to Reclamation's 2021 West-Wide Climate and Hydrology Assessment, Section 2.1, and for a discussion of associated uncertainties, please refer to Section 9.1.

Temperature

In the Truckee Basin, average annual temperatures vary widely from 58 to 80 degrees Fahrenheit (°F). Temperatures are generally cooler in the high elevation areas of the Sierra Nevada Mountains in the western part of the basin and generally warmer in the lower elevation areas of the eastern part of the basin **(Figure 7)**.

During the recorded historical period of 1900 to 2010, the mean annual temperature in the Truckee-Carson Basins has already risen by about 3°F. By the end of this century, another 5 to 6°F of warming is projected to occur in the Truckee Basin. As illustrated by **Figure 8**, a similar range of temperature changes is projected for the Carson Basin above Fort Churchill, Nevada.

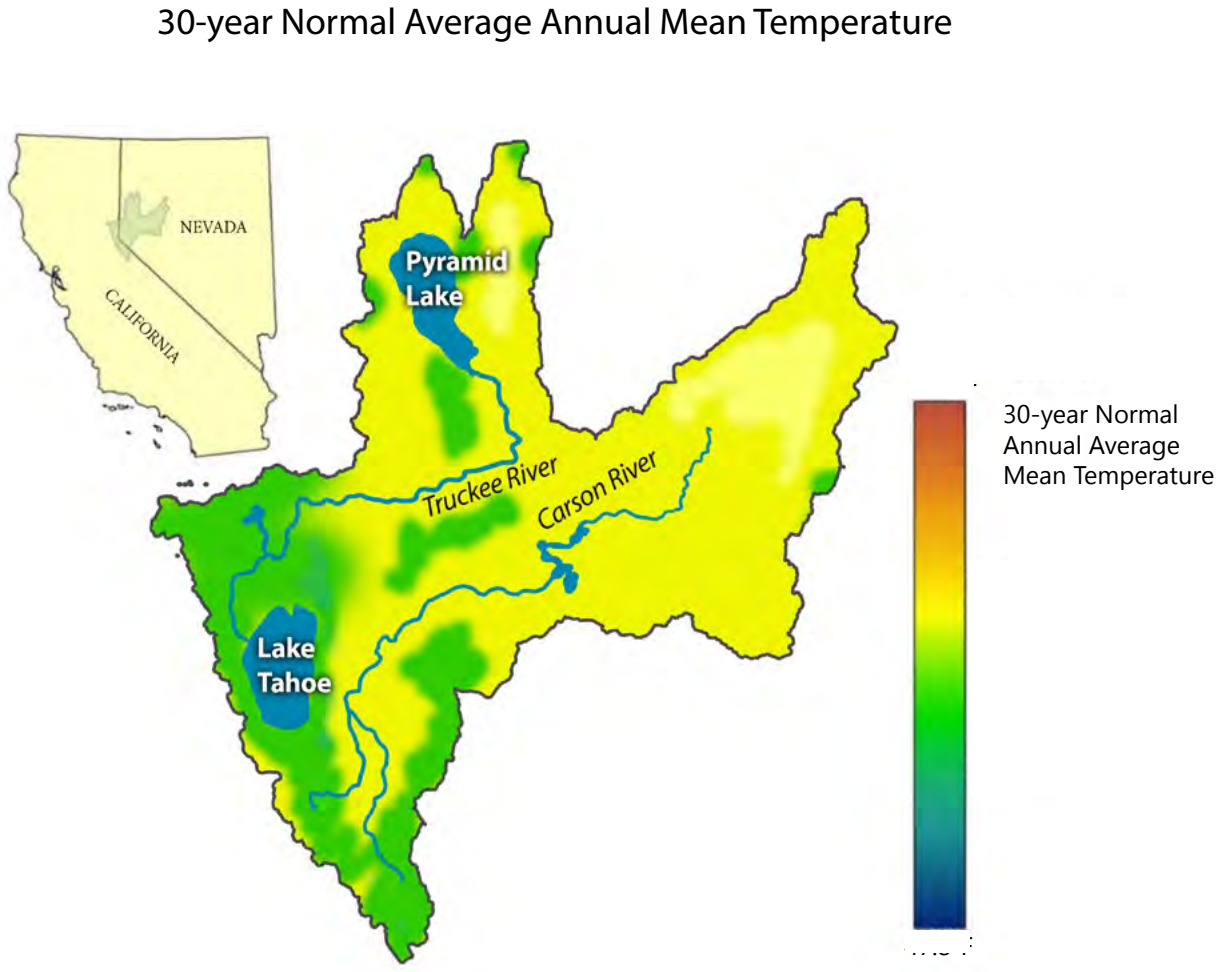
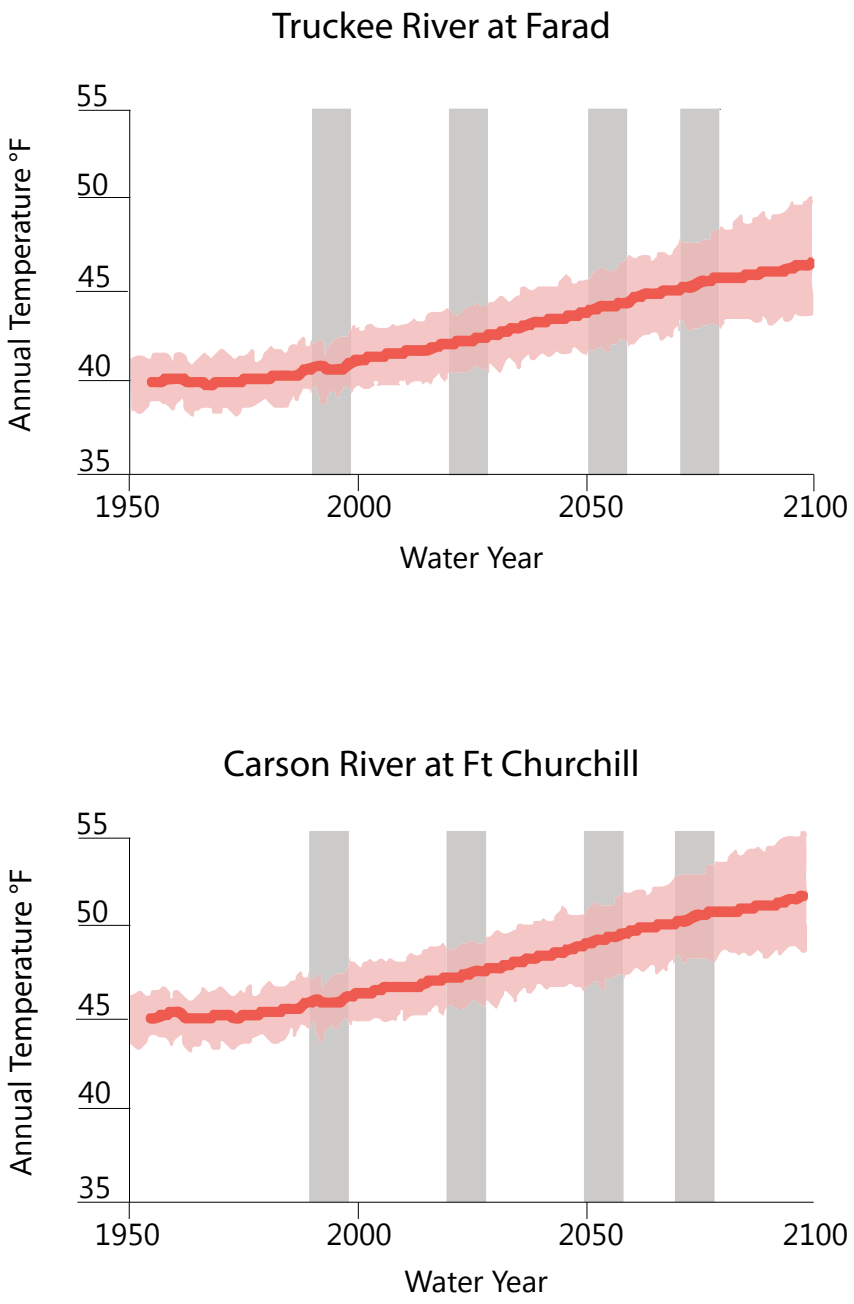


Figure 7. Average annual temperature in the Truckee and Carson River Basins



Note: The darker-colored lines indicate the median-annual condition while the lighter-colored areas represent the time-series range of 10th to 90th percentile annual values.

Figure 8. Average annual temperatures and projections for the Truckee and Carson River Basins (Reclamation, 2011).

Precipitation

Across the Truckee Basin, precipitation also varies widely. The Sierra Nevada Mountains surrounding Lake Tahoe receive well over 70 inches of precipitation per year, which falls almost exclusively as snow from November to April. Summer thunderstorms are common, but produce little rain. The percentage of annual precipitation falling as snow (versus rain) has decreased over the last century. Currently, about 34 percent of precipitation at Tahoe City, California falls as snow, compared with 54 percent at the beginning of the last century. In contrast, lower areas in Nevada typically receive less than an average of 10 inches of precipitation. The lower regions around the Carson River are especially dry, receiving on average less than 5 inches of precipitation each year. Average precipitation for the Truckee-Carson Basins from 1981 to 2010 is shown in **Figure 9**.

Future increases or decreases in average annual precipitation would directly influence the availability of water supplies by changing the amount of water running off into the lakes, rivers, and streams of the Truckee-Carson Basins, as well as the amount recharging groundwater. As illustrated by **Figure 10,** projections of annual precipitation in the Truckee-Carson Basins suggest that annual precipitation may decrease slightly by the end of the 21st century.

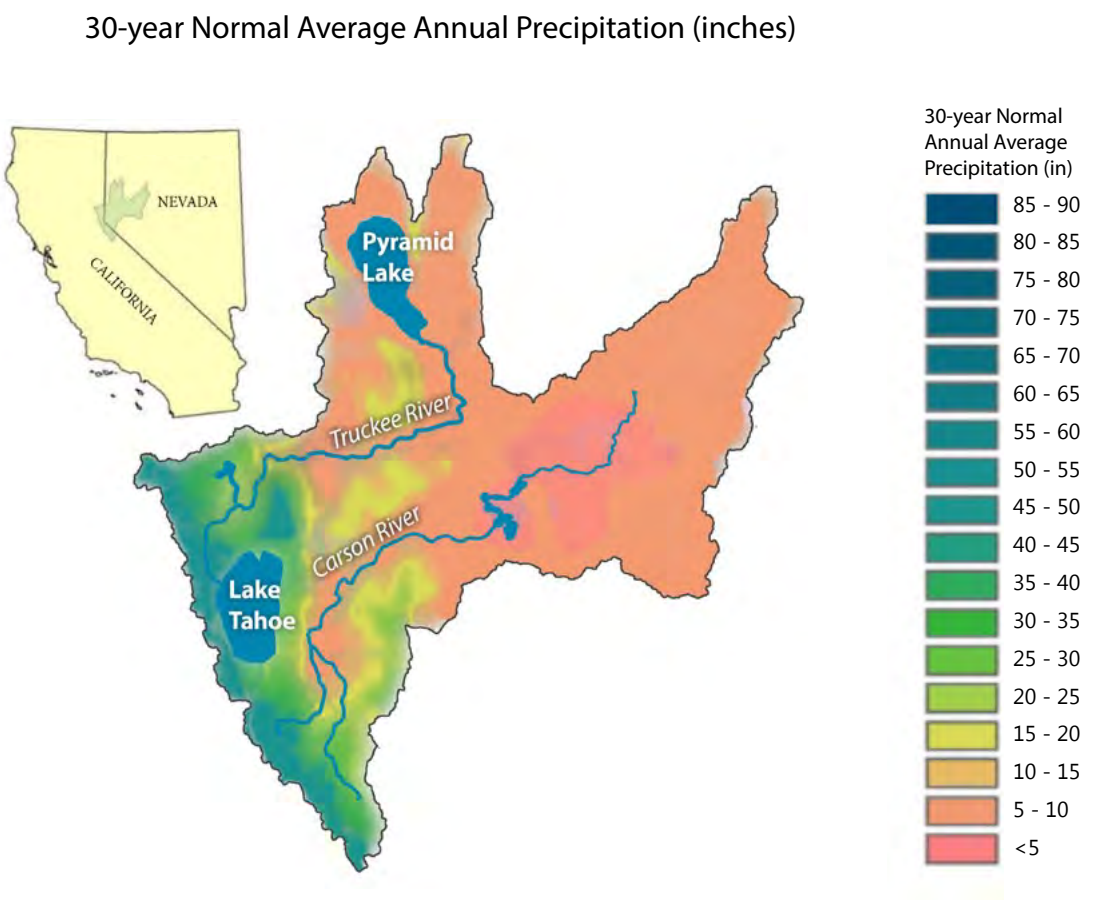
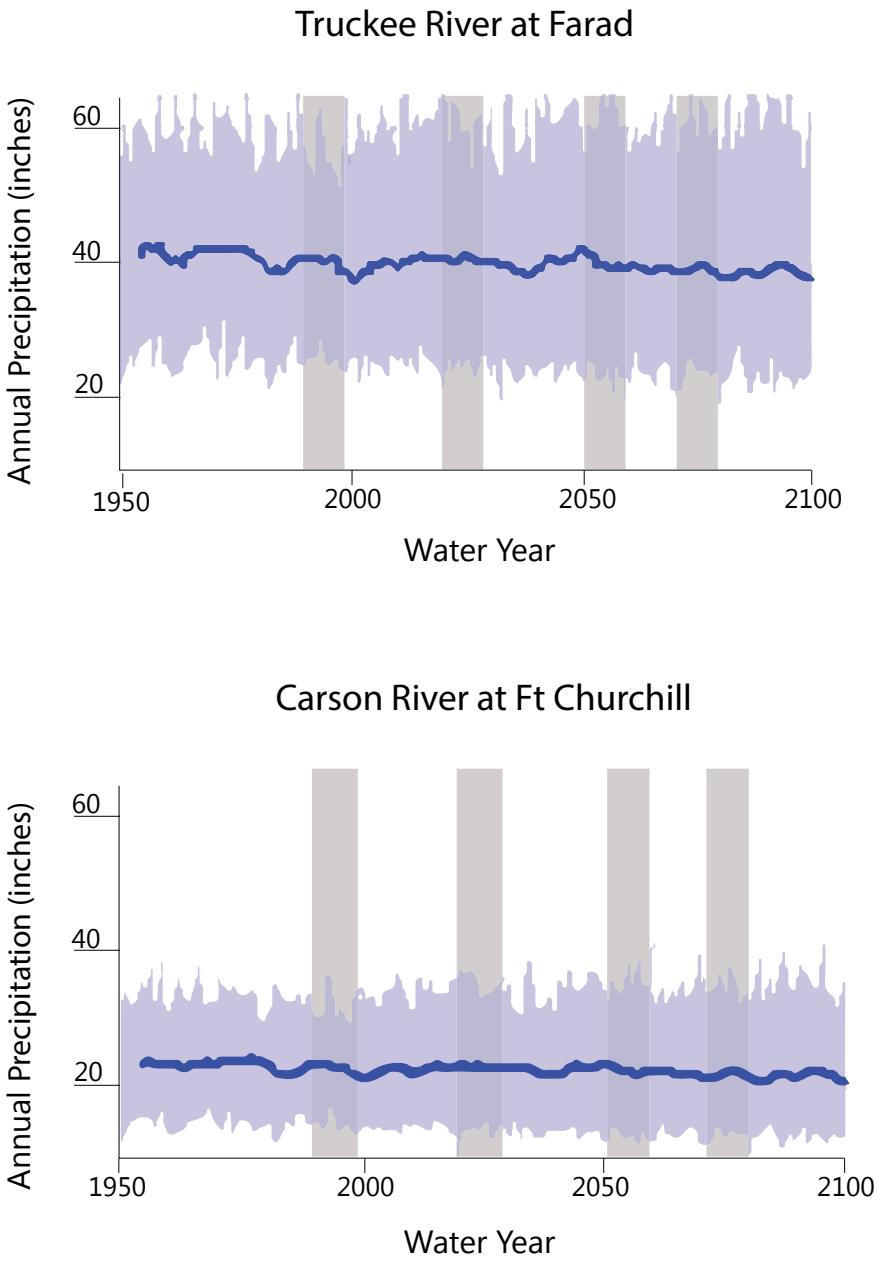


Figure 9. Average annual precipitation in the Truckee and Carson River Basins.



Note: The darker-colored lines indicate the median-annual condition while the lighter-colored areas represent the time-series range of 10th to 90th percentile annual values.

Figure 10. Average annual precipitation and projection for the Truckee and Carson River Basins (Reclamation, 2011).

Snowpack, Runoff, and Streamflow

With increasing temperature, less winter precipitation is projected to occur as snowfall, especially in the lower elevations in the Truckee-Carson Basins. In addition, increased temperatures will cause earlier snowmelt and runoff.

As illustrated by **Figure 11**, these temperature effects, along with potential declines in precipitation, are projected to result in a declining snowpack in the Truckee Basin during the 21st century.

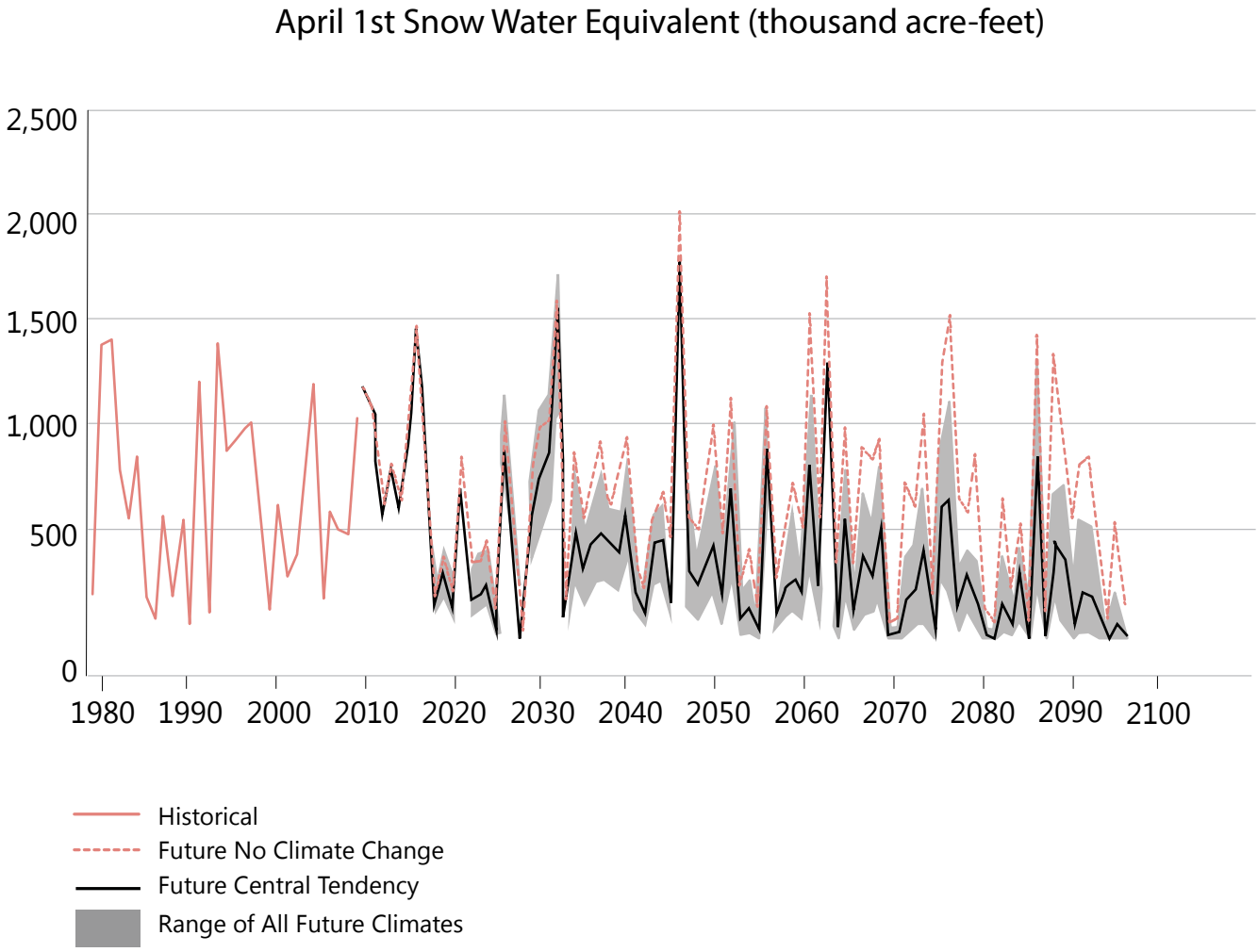


Figure 11. Historical data and projections of April 1st snow water equivalents upstream of the Farad Gage in the Truckee River Basin.

Peak snowmelt runoff in the Lake Tahoe basin has historically occurred in May and June, which is slightly later than other areas in the Truckee Basin because its higher elevations retain snow later into the spring and summer. However, as snowpack and snowmelt patterns change with increasing temperatures through the end of the century, more runoff shifts toward earlier months. **Figure 12** illustrates these changes to the early- (2012 to 2039), mid- (2040 to 2069), and late- (2070 to 2099) century for each of the six climate scenarios. By the mid-century, there is a projected shift to significantly more winter runoff due to warming in the wettest months, but spring runoff is still significant. However, by the end of the century, continued warming has significantly shifted runoff to the winter months in all scenarios except the reference. The Truckee Basin is especially sensitive to climate change because of the unique water balance at Lake Tahoe.

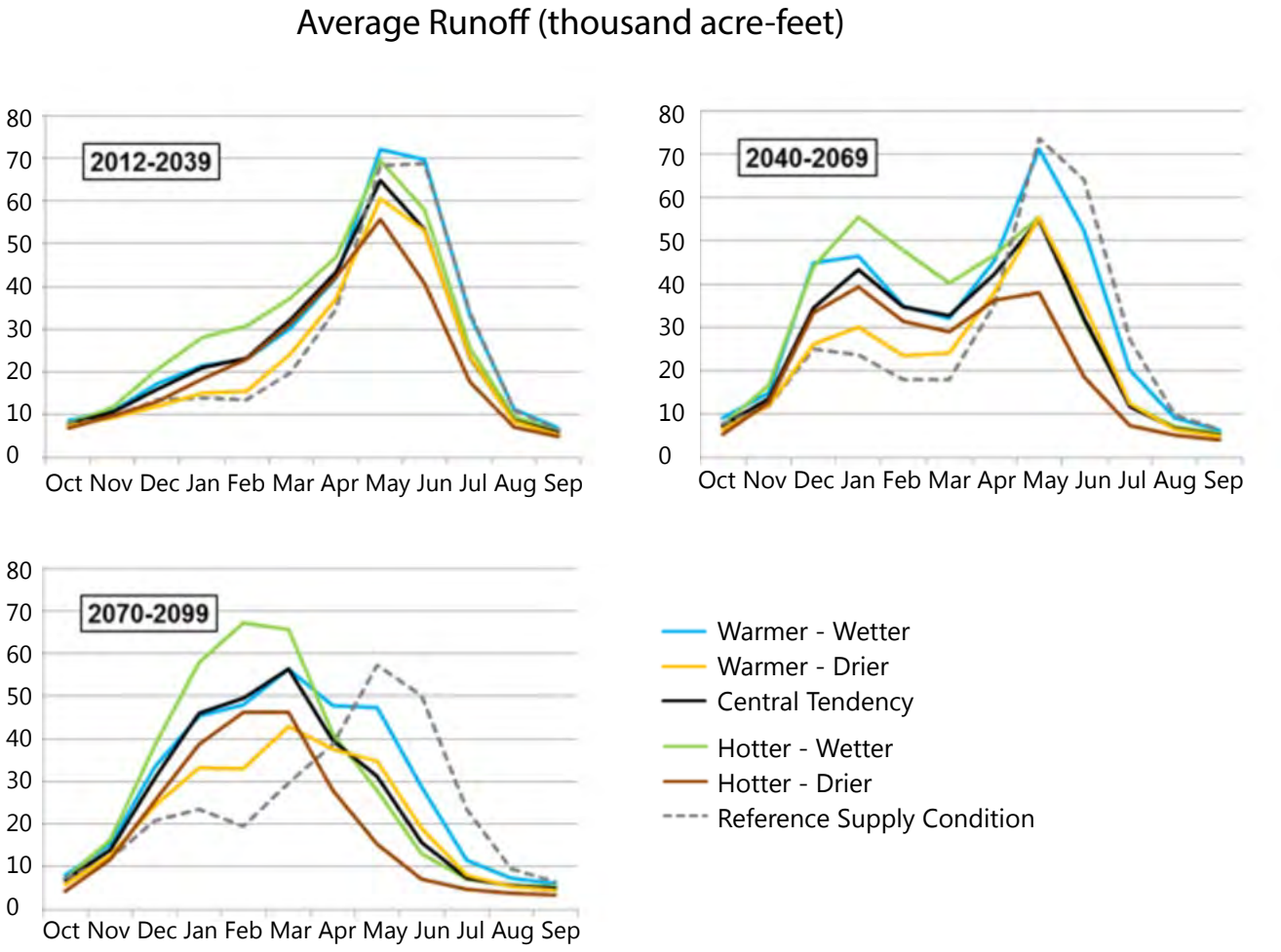


Figure 12. Reference and projections of future monthly average runoff into Lake Tahoe.

Figure 13 provides a time series comparison of future evaporation at Lake Tahoe, along with a statistical summary of the reference supply condition, all future ensembles, and each ensemble separately. Annual evaporation is shown in inches rather than acre-feet because the total volume of evaporation depends on the elevation of the lake and actual surface area. In general, evaporation rates increase over the coming century as the climate of the Truckee Basin warms. Among the future climate scenarios, the Warmer-Wetter scenario shows the least increase in evaporation and the Hotter-Drier scenario shows the most.

For example, Lake Tahoe has a surface area of approximately 120,000 acres. Given this area, the median annual evaporation of 46 inches under the reference supply condition would result in a loss of 460,000 acre-feet of water per year, on average. In comparison, the greatest annual evaporation among the future climate change ensembles is 54 inches. At peak elevation, this would result in a loss of 540,000 acre-feet of water per year (17 percent more water loss). Similar changes in lake evaporation were also estimated for both Lahontan Reservoir and Pyramid Lake.

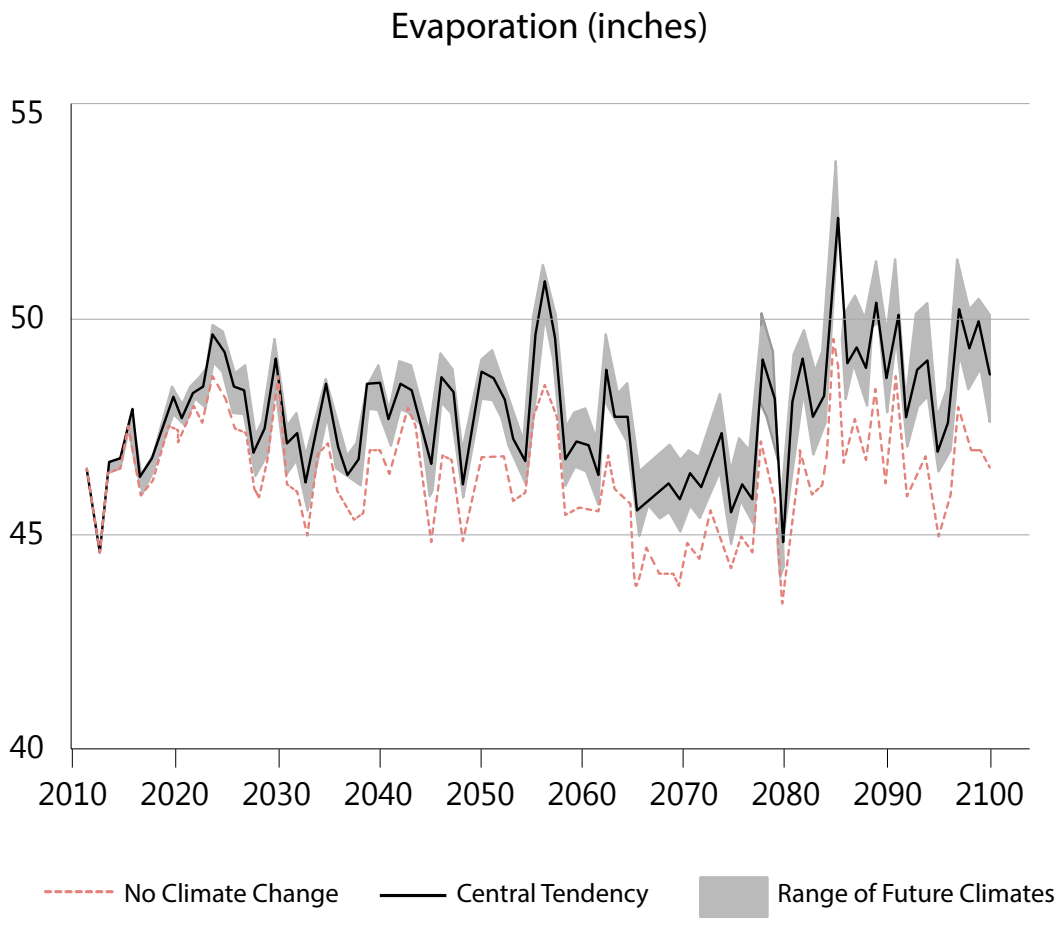


Figure 13. Comparisons of potential future Lake Tahoe evaporation rates.

As illustrated by **Figure 14**, Truckee River flows at the Farad gage have shifts in seasonal runoff similar to the Lake Tahoe inflows.

Watershed ET reduces soil moisture which contributes to reduced runoff, streamflow, and groundwater recharge. Actual ET is projected to increase continuously during the 21st century, primarily in higher elevations of the Sierra Nevada mountains. By the end of the century, a 15 percent increase in actual ET may occur in these forested regions because increased warming will increase the length of the growth period, thereby resulting in additional ET. This increased ET during the growing season will also contribute to a decrease in stream baseflows during the summer and early fall seasons.

To assess the impacts of 21st century climate and socioeconomic conditions on the future water demands of the water user communities, the Basin Study developed three storylines to represent current and future water demands. The reference storyline represents current demand as of 2012, when the Basin Study began and thus includes no future growth. The Existing Trends storyline is based on a persistently slow regional economy, such as experienced in the late 2000s. It represents a lower bound for water use and diversions. The Robust Economy storyline is based on a robust and vibrant regional economy like the late 1990s and early 2000s. It represents an upper bound for water use and diversions in the Truckee Basin.

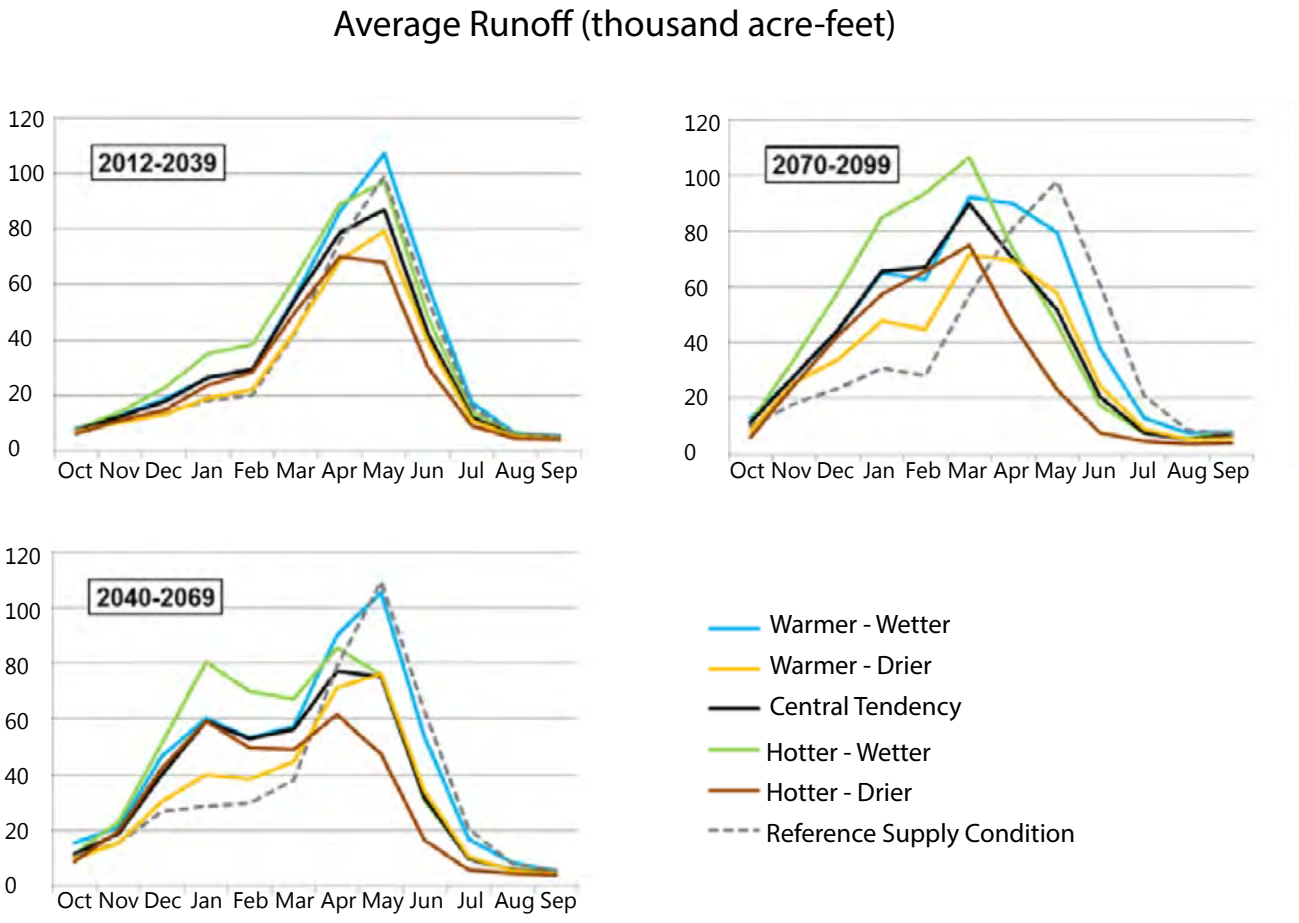


Figure 14. Reference and projections of future monthly average runoff into Truckee River at the Farad gage.

Overall, the water user communities reach their full use of water rights sooner under the Robust Economy storyline than the Existing Trends storyline, but, by the end of the century, total annual water demand in the Truckee-Carson Basins only differs between the storylines by about 25,000 acre-feet. Under both storylines, the majority of Truckee Meadows agricultural water rights are transferred to TMWA to serve growing municipal and industrial needs associated with increased industrial and urban development that also absorbs Truckee Meadows agricultural land. In the Newlands Project, the Robust Economy storyline results in a higher agricultural demand due to increased demand for local agricultural products that leads to currently unused Newlands Project water rights being activated.

Environmental conditions vary widely from year-to-year in the Truckee Basin and have done so for thousands of years. Pyramid Lake fish species and their ecosystems have evolved to respond to years when temperature, streamflow, and water quality conditions are well suited or spawning and propagation. Changes in ambient temperatures and seasonality shifts in streamflow could alter the timing of breeding patterns of aquatic species. Specifically, any impacts on Pyramid Lake elevations have the potential to affect the passage of cui-ui and Lahontan cutthroat trout for spawning, and also the quality of lake habitat for these listed species. In the Basin Study, the range of potential future changes in Pyramid Lake levels was examined. **Figure 15** illustrates the combined effects of change in climate and socioeconomic changes to affect lake levels.

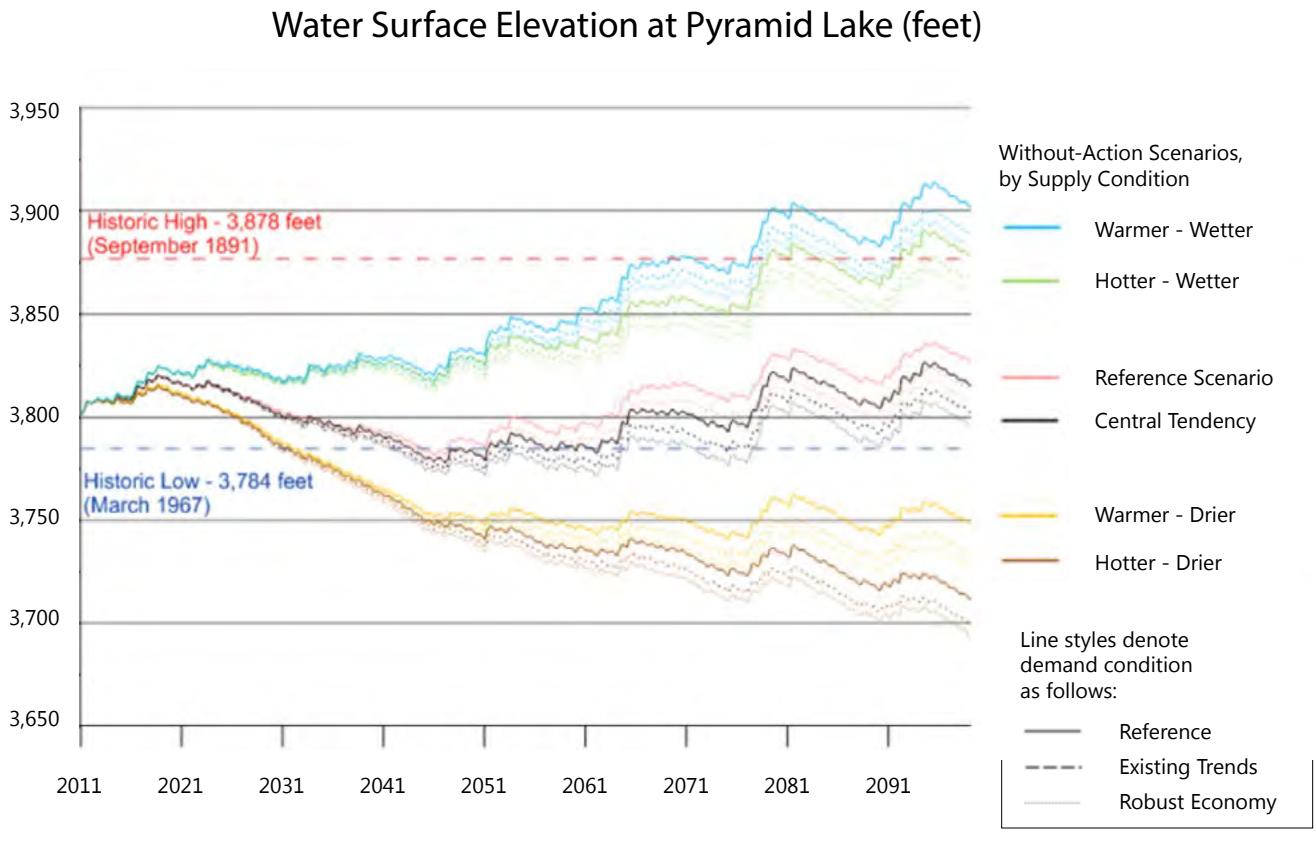


Figure 15. Potential future Pyramid Lake water surface elevations as impacted by climate and socioeconomic scenarios.

As indicated, wetter scenarios result in higher lake levels with hotter scenarios having lower levels. Furthermore, the Robust Economy storyline with greater demands further reduces lake elevations. In contrast, the drier scenarios result in considerably lower levels (up to 200 feet), which is significantly less than the historic low. On the other hand, the Central Tendency scenario indicates lake levels similar to historic conditions.

Similar to agriculture demands, climate changes may also affect water demand for native vegetation that support migratory birds using Lahontan Valley wetlands and other lakes, as well as riparian and meadow areas along the Truckee and Carson Rivers as resting points on the Pacific Flyway. Increased water demands could result from earlier plant growth and greater water needs for each acre of managed wetland. Bird migration patterns may also be affected by global climate changes across the entire migratory flyway, and shifts in arrival at Lahontan Valley wetlands may not match available food supplies.

Lahontan Reservoir in Nevada.

An adaptation strategy evaluated in the Truckee River Basin Study involves managing forest density in the Sierra Nevada watershed. Forest management would increase basin water supplies by reducing evapotranspiration (Getty Images).

SECTION 3

Potential Adaptation Strategies to Address Vulnerabilities

In recent years, numerous activities have taken place to address potential vulnerabilities in the Truckee-Carson Basins. Those activities include, among others, an evaluation of adaptation strategies stemming from the Basin Study; research regarding safety risks of the Truckee Canal; collaboration with stakeholders; and implementation of participatory management.

Basin Study

Truckee River water users and stakeholders have long understood that growing demands, coupled with the potential for reduced supplies due to climate change, may place water users and resources at risk of prolonged water shortages in the future. The Basin Study team obtained input from a large group of interested residents, stakeholders, and a variety of organizations having interest in water management across the entire Truckee Basin. The team engaged the interested parties individually, as well as at community meetings in Reno, Nevada and Lake Tahoe, California, to identify individual actions, or options, for water management under changing climate conditions. This section summarizes some of the key findings from the Basin Study team's evaluation of eight adaptation strategies to address vulnerabilities. The strategies apply the information developed for the Basin Study.

Three water supply augmentation strategies were evaluated as follows:

Additional Truckee Basin Storage – This strategy addresses climate induced changes in seasonal runoff by capturing more water supply to reduce future shortages for all user communities. Implementation would likely involve coordination among Reclamation, the Pyramid Lake Paiute Tribe for fisheries and water rights related concerns, and possibly the U.S. Army Corps of Engineers (USACE) and TRFMA for consideration of flood management operations.

Raise Lahontan Dam – This strategy increases storage of Carson Basin supplies for the Newlands Project, effectively increasing availability of supplies

basinwide. This strategy only reduces diversions from the Truckee River in wetter conditions. It does not change reliability for the Newlands Project, but it does increase flow to Pyramid Lake by up to 5 percent. However, it reduces supply to Lahontan Valley wetlands by up to 9 percent. Implementation would likely involve TCID and the U.S. Fish and Wildlife Service (USFWS).

Forest Management – This strategy increases water supply by reducing ET through management of forest density in the Sierra Nevada watershed. The strategy has the potential to effectively increase basinwide water supplies. Implementation would likely involve coordination with U.S. Forest Service, other public or private landowners, and the Tahoe Regional Planning Agency.

The Basin Study also evaluated the potential for demand reduction by the following strategy:

Truckee Canal Rehabilitation – This strategy addresses seasonality shifts and reductions in precipitation by restoring Truckee Canal diversion and conveyance capacity. As a result, it would reduce the frequency of annual crop demand shortages for the Newlands Project by 4 to 12 percent, increasing spills to Lahontan Valley wetlands by 6 percent and reducing long-term shortages to wetlands by up to 3 years, as well as increasing TCID hydropower generation by 4 to 14 percent. Implementation would likely be needed among the Pyramid Lake Paiute Tribe, TCID, and the City of Fernley. Also, to achieve the increased canal capacity created by the new Derby Dam Fish Screen, TCID would need to line the sections of Truckee Canal deemed to be the most at risk as prescribed by the Truckee Canal Extraordinary Maintenance Project environmental impact statement (Reclamation, 2020 [DEIS Truckee Canal]).

The Basin Study also evaluated a variety of potential institutional changes to address system vulnerabilities including the following:

Adapt Flood Management Operations – This strategy mitigates for shifts in the timing of precipitation and snowpack runoff by capturing it in Truckee Basin reservoirs. However, the limited availability of storage for this strategy only reduces shortages for agricultural and municipal

Figure 16. Lahontan Dam in Nevada, completed in 1915, is a zoned earthfill structure. The reservoir has a storage capacity of 289,700 acre-feet. Old Lahontan Powerplant, immediately below Lahontan Dam, has a capacity of 42,000 kilowatts.

and industrial uses by 3 to 9 percent. Pyramid Lake spawning flows are increased by up to 15 percent, but adult passage flows are reduced by up to 13 percent in drier scenarios. Reclamation is actively working to implement this strategy through a water management operations pilot (see the *Water Management Operations Pilot* section below). Reclamation is coordinating with USACE, TMWA, TRFMA, Pyramid Lake Paiute Tribe, and numerous other supporting stakeholders to develop acceptable flood management strategies, fisheries, and water right-related concerns.

Adapt Newlands Project Storage Targets – This strategy adjusts Newlands Project operations and end-of-month storage targets at Lahontan Dam to capture additional storage by diverting Truckee River water when suitable changes in hydrology occur (**Figure 16 and 17**). This strategy would require close coordination with the Pyramid Lake Paiute Tribe and TCID to ensure the intended balance in Truckee River water supplies would not be disrupted. This would also require a revision to 43 CFR 418 Operating Criteria and Procedures for the Newlands Reclamation Project, Nevada.

Consolidate Agricultural Water Rights – This strategy responds to increased crop water demands by reducing acreages under cultivation. It reduces the frequency of shortages in the Newlands Project by up to 28 percent without significantly affecting any other water users in the Truckee Basin. Its implementation would likely involve major changes to water rights and close coordination with parties to the Orr Ditch and Alpine decrees, TCID, and the Nevada State Engineer.

Adapt Fish Flow Regimes – This strategy adapts to changes in the seasonality of flows in the lower Truckee River and Pyramid Lake. It increases adult passage flows by 1 to 10 percent and spawning flows by 10 to 71 percent. However, it does not change duration of years with poor spawning flows. Its implementation would likely involve coordination among the range of agencies who previously developed the existing regime for the Truckee River.

In summary, no singular action was found to sustain the balance between supplies and demands provided under the historical climate or reference scenario.

Figure 17. Lahontan Reservoir in Nevada showing signs of drought in June 2015.

However, each of the options evaluated addresses at least a portion of the affects from future changes in climate. Ultimately, addressing future changes will require a combination of options from among the adaptation strategies identified. However, the precise composition and intentions of these efforts will require additional study, planning, and close coordination among stakeholders of the Truckee-Carson Basins.

Research

Reclamation and its partners have conducted a substantial amount of research in the Truckee-Carson Basins to address vulnerabilities. These studies are described below.

Response to January 5, 2008 Truckee Canal Breach

The Truckee Canal originates at the Derby Diversion Dam on the Truckee River, approximately 20 miles east of Reno, Nevada, and ends at Lahontan Reservoir (**Figure 18**). On January 5, 2008, the north embankment of the canal, approximately 12 miles downstream of the Derby Diversion Dam, breached after a storm. This resulted in an uncontrolled water release that caused flooding and damage to approximately 590 properties in the city of Fernley, Nevada. TCID, which operates and maintains the canal, repaired the breach in February 2008, and the canal reopened in March 2008. Following the January 2008 canal breach, Reclamation completed several studies that identified areas requiring repair and maintenance to address safety concerns. Until long-term repairs are made, the canal is required to be operated at a lower stage (height of water) to reduce risk. The proposed Truckee Canal Extraordinary Maintenance project (see the *Truckee Canal Extraordinary Maintenance Environmental Impact Statement* section below) is designed to make repairs to mitigate a 100-year flood event and improve conveyance efficiency. Ultimately, the improved conveyance efficiency also will help alleviate the impacts of drought. As mentioned in the *Basin Overview* section above, drought and flooding on the Truckee River system are becoming more commonplace.

Truckee Canal Engineering and Economic Feasibility Design Study

In 2019, Reclamation's Technical Service Center (TSC) prepared the Truckee Canal Engineering and Economic Feasibility Design Study (Reclamation, 2019 [Feasibility Design Study]) to evaluate risk reduction measures along the Truckee Canal to reduce the risk of a canal breach for public safety. The aim of the study was to develop feasibility level design risk reduction alternatives and associated construction cost estimates. The study developed an implementation plan to reduce risks and improve the canal to safely convey an operating flow of 600 cubic feet per second (cfs). Of the five alternatives considered, the study recommended the alternative to line the canal, full prism, with geomembrane and concrete for 12.7 miles in two phases (5.99 miles in Phase 1 to reduce the highest risk locations and 6.69 miles in Phase 2 to eliminate hydrologic load risk) within the Derby, Fernley, and Lahontan Reaches. The recommended alternative also armors 5,800 linear feet of the canal to prevent failure from a hydrologic event. As part of the study, TSC staff coordinated the proposed feasible risk reduction alternative plans with the environmental impact statement for Truckee Canal extraordinary maintenance being prepared concurrently by Reclamation's Lahontan Basin Area Office. The draft environmental impact statement (DEIS) was released in February 2020 and the alternative recommended in this study became the recommended alternative for final design in the DEIS.

Figure 18. The Truckee Canal, approximately 20 miles east of Reno, Nevada.

Truckee Canal Extraordinary Maintenance Environmental Impact Statement

Reclamation is proposing to assist the TCID with extraordinary maintenance to address safety needs along the Truckee Canal. In accordance with the 1996 operations and maintenance contract, Reclamation needs to evaluate the TCID's request to improve the structural integrity of the canal to reduce the risk of a canal breach for public safety. The aim is to enable the TCID to complete necessary repairs to restore safe operation of the Truckee Canal so water rights can be served within the Newlands Project under the existing Operating Criteria and Procedures for the Newlands Project (43 CFR 418) and in compliance with decrees, contracts, and other applicable laws, as funding becomes available. Towards this end, Reclamation prepared a DEIS (Reclamation, 2020 [DEIS Truckee Canal]) to analyze the environmental impacts of the proposed extraordinary maintenance. Five alternatives and a no action alternative were considered. While Reclamation has identified a preferred alternative in the DEIS, actual selection of a preferred alternative will not occur until the Record of Decision. The decision on the alternative to implement will consider public comments and the full analysis in the final environmental impact statement.

Collaboration

Reclamation collaborates with partners in the Truckee-Carson Basins to manage the use of credit water and other mechanisms that create flexibility in water use and storage.

Truckee River Operating Agreement

The Truckee River Operating Agreement (TROA), signed in 2008 (Reclamation, 2008) and implemented in December 2015, is an agreement developed by Federal, State, Tribal, and local agencies and organizations, and required by Public Law 101-618, for operation of the Truckee Basin.

TROA creates flexibility in water use and storage while ensuring that existing water rights are served, and flood control and dam safety requirements are met. Principally, TROA provides for more effective coordination of reservoir operations on the Truckee River. As such, TROA allows for more stable water supply for Reno, Sparks, and Washoe County, Nevada; enhances streamflow in the Truckee River below Derby Dam for threatened and endangered fish species; and improves water quality.

Credit Water Operations

TROA provides for the establishment of credit water in the Truckee Basin. Specifically, it prescribes rules and procedures that provide opportunities for signatory parties to retain all or a portion of the water that they would otherwise be entitled to divert as credit water in the Truckee River Reservoirs, Independence Lake, and Donner Lake (**Figure 19 and Figure 20**). TROA establishes multiple categories of credit water (e.g., Municipal and Industrial Use, Fish, Water Quality); priorities for each category of credit water; and accounting procedures relative to its storage, release, spill, evaporation, and exchange. Relative priorities for various types of credit water and credit water operations are important for administration of TROA when concurrent uses or potentially conflicting operations are scheduled or requested.

Trades and Exchanges

TROA provides opportunities for TROA parties to move, exchange, and trade water among Truckee River Reservoirs, Independence Lake, and Donner Lake in accordance with prescribed rules and limitations. The goal of trades and exchanges is to enhance a party's ability to maximize the use of their water for their operational purposes. Exchanges of water between reservoirs can be accomplished in several ways. The provisions for exchanging water greatly enhance and increase the flexibility of system operations. The increased flexibility provided by TROA through the various categories of credit water and opportunities for exchanges facilitates more efficient use of the existing available water supply to more effectively serve the many, and often competing, beneficial uses. Trades take place when two TROA parties agree to move their water between reservoirs on paper, without physical transfer of the water.

Figure 19. Donner Lake in California (Getty Images).

Figure 20. Completed in 1970, Stampede Dam and Reservoir are located on the Little Truckee River.

TROA Monthly Scheduling Meetings

On a monthly basis, TROA parties submit their plan for operations over the next month. The TROA administrator coordinates each parties' plan and inputs it into the Truckee River Operations Model. TROA parties then attend scheduling meetings to discuss upcoming Truckee River operations. Scheduling meetings provide the opportunity for TROA parties to discuss planned operations and ongoing projects, and to identify synergistic efforts, such as water trades or exchanges and operations that may benefit both parties.

Truckee River Operating Agreement Memorandum of Agreement

The TROA Memorandum of Agreement (MOA) (Section 11, Appendix A of TROA) was signed in 1999 to optimize endangered species management in the Truckee River. The MOA delineated the roles and responsibilities of the USFWS, Pyramid Lake Paiute Tribe, Reclamation, and Bureau of Indian Affairs in the management of Truckee River water designated to protect and conserve cui-ui and Lahontan cutthroat trout of Pyramid Lake, which are protected species under the Endangered Species Act and subsequent amendments (16 USC 1531 et. seq.) (**Figure 21 and Figure 22**). In the MOA, the parties agreed to transfer the role of Team Lead for the management of designated waters of the Truckee River from the USFWS to the Tribe. It was agreed that the Tribe, in collaboration with the other parties and in the framework of an Interagency Team, would manage the designated waters in accordance with an Annual Water Management Plan, which is consistent with the terms of an approved Conservation and Management Plan that provides for the protection and conservation of the species protected under the Endangered Species Act. The Interagency Team directs the selection of the monthly flow regime, and any subsequent flow modifications, and scheduling of the Stampede and Prosser Creek Reservoir (USFWS, 2008).

Newlands Project Credit Water Collaboration

The use of Newlands Project Credit Water (NPCW) is a process within TROA that allows for the storage of Newlands Project water in Truckee River reservoirs. The goal of NPCW is to maximize the use of Carson River water and minimize the diversion of Truckee River water in order to benefit threatened and endangered fish species in Pyramid Lake. The Lahontan Basin Area Office is responsible for scheduling and managing Newlands Project Credit Water. To implement Newlands Project Credit Water, the Lahontan Basin Area Office consults with the Pyramid Lake Paiute Tribe and coordinates with the Pyramid Lake Paiute Tribe and coordinates with all TROA parties on operations on a monthly basis. In 2019, the first year of implementation, NPCW saved over 16,000 acre-feet of Truckee River water from being unnecessarily diverted to the Carson Basin.

Truckee River Operating Agreement Modeling

TROA operations is a complex blend of legal requirements and stakeholder input to determine Truckee River operational needs. To aid in the process, the Truckee River Operations Model was collaboratively built in RiverWare to guide daily operations. The model contains the TROA governing regulations and allows stakeholders to provide input into how they would like to manage their water. The operations model is managed by the TROA administrator and is regularly updated to meet operational needs. Along with the operations model, the Lahontan Basin Area Office manages a collaboratively developed Truckee River Planning Model. The planning model is logic-driven and simulates Truckee River operations over the last 116-year period. The planning model is regularly used by stakeholders to complete long-term studies (e.g., Safety of Dams studies, water supply studies, and drought contingency planning).

Figure 21. View of exit channel for endangered cui-ui fish at Marble Bluff Dam on the Truckee River.

Figure 22. Pyramid Lake located near Wadsworth, Nevada is the terminus for the Truckee River (Getty Images).

Derby Dam is a diversion dam on the Truckee River, located between Reno and Fernley, Nevada. This image shows low water levels due to drought.

SECTION 4

Innovations

Reclamation and water users in the Truckee-Carson Basins have implemented numerous innovations to address challenges and improve water management.

Basin Study

The Basin Study developed a suite of innovative hydrologic modeling tools to evaluate the Truckee Basin. The study relied upon climate and socioeconomic scenarios describing potential future conditions that were developed by the Basin Study partners and interested stakeholders with input from the public and Reclamation. The scenarios were evaluated by creating a new set of modeling tools. The innovative tools were specially designed and developed to address the relatively small geographic size and complex topography of the Truckee Basin. Assessing climate change impacts on small water users and evaluating local options that operate at small spatial scales required a sufficiently fine discretization to adequately simulate hydrologic processes such as precipitation, snowpack, runoff, and streamflow.

This was accomplished by applying additional downscaling to obtain the refined scale necessary to adequately represent the Truckee Basin. These future climate projections were downscaled to local weather stations and used as the basis for mapping climate across the Truckee Basin. This refined climate data was then used as inputs to the U.S. Geological Survey (USGS) Precipitation-Runoff Modeling System (PRMS) software. PRMS is a physical process-based modeling system used to evaluate the response of various combinations of climate and land use on streamflow and general watershed hydrology.

The Basin Study developed three PRMS models to simulate the hydrology above the Farad gage in California, representing 90 percent of the surface runoff in the Truckee Basin. These models used 300 square meter computational grid cells and included a simplified representation of groundwater. Model development included the application of spatial data and analysis (i.e., GIS information) to delineate and define a network of hydrologic response units based on characteristics, such as drainage boundaries; elevation, slope, and aspect; plant type and cover; land use; distribution of precipitation, temperature, and solar radiation; soil morphology and geology; and flow direction. A robust, multi-step approach was used to both calibrate each PRMS model to hydrology and to evaluate model performance relative to observed historic streamflows, snow-covered area and measured snow-water equivalent from 1980 to 2010. **Figure 23** illustrates the locations of the three PRMS models, climate data, and streamflow locations.

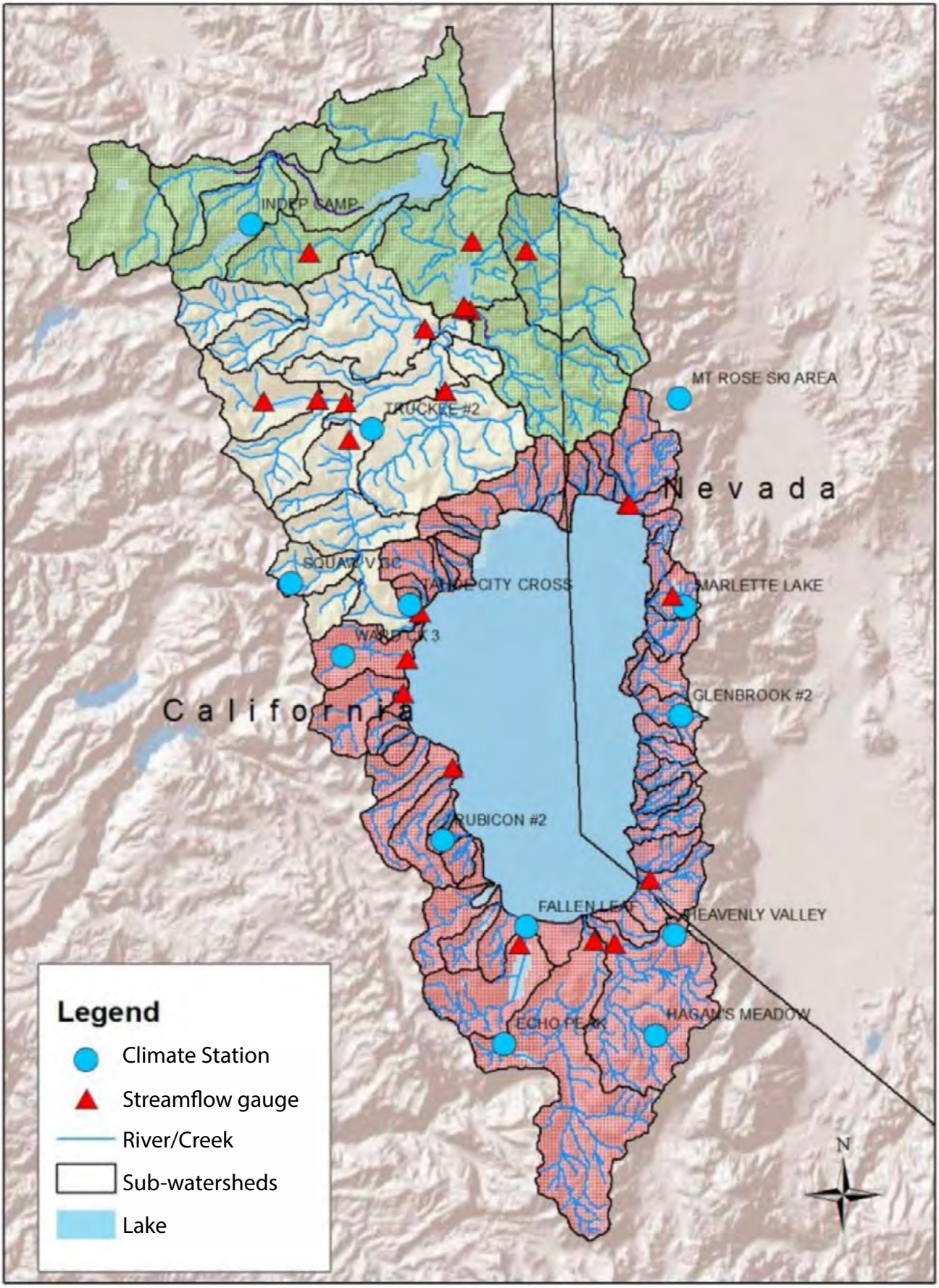


Figure 23. Precipitation-Runoff Modeling System models in the Truckee River Basin.

For lower portions of the Truckee Basin, numerical hydrology models such as PRMS were not available. The Basin Study relied on regression relationships embedded in an early version of the TROA Planning Model to describe stream and aquifer interactions at 11 locations on the Truckee River between the Farad gage and Pyramid Lake, and for inflows to Lahontan Reservoir at the Fort Churchill gage station on the Carson River. Lake evaporation is also an important component of the water budget affecting the water supply in the Truckee Basin. To address lake evaporation, Reclamation applied the Complementary Relationship Lake Evaporation (CRLE) model (Morton, 1986). The application of the CRLE model required estimates of future solar radiation, dewpoint, and average daily temperature for each of the six climate scenarios in order to simulate evaporation from Truckee Basin lakes. Ultimately, the state-of-the art analysis conducted in the Basin Study produced valuable data on the projected effects of climate change in the Truckee Basin. The results of this study are being used to refine water management in the Truckee Basin moving forward.

Canal Seepage Research on the Truckee Canal

Reclamation's Science and Technology program sponsored three grants to study innovative methods of assessing, detecting, characterizing and/or quantifying seepage in the Truckee Canal (**Figure 24**). This research provides enhanced seepage detection and characterization approaches to Reclamation and other agencies; directly helps Reclamation manage water resources more efficiently; and is potentially applicable to other earthen embankment sites and structures in order to identify and prioritize potential repair locations to promote healthy water conveyance and storage infrastructure. Technological innovations like those studied in this research will become increasingly important as Reclamation's conveyance infrastructure continues to deteriorate with age.

Figure 24.
The Truckee Canal.

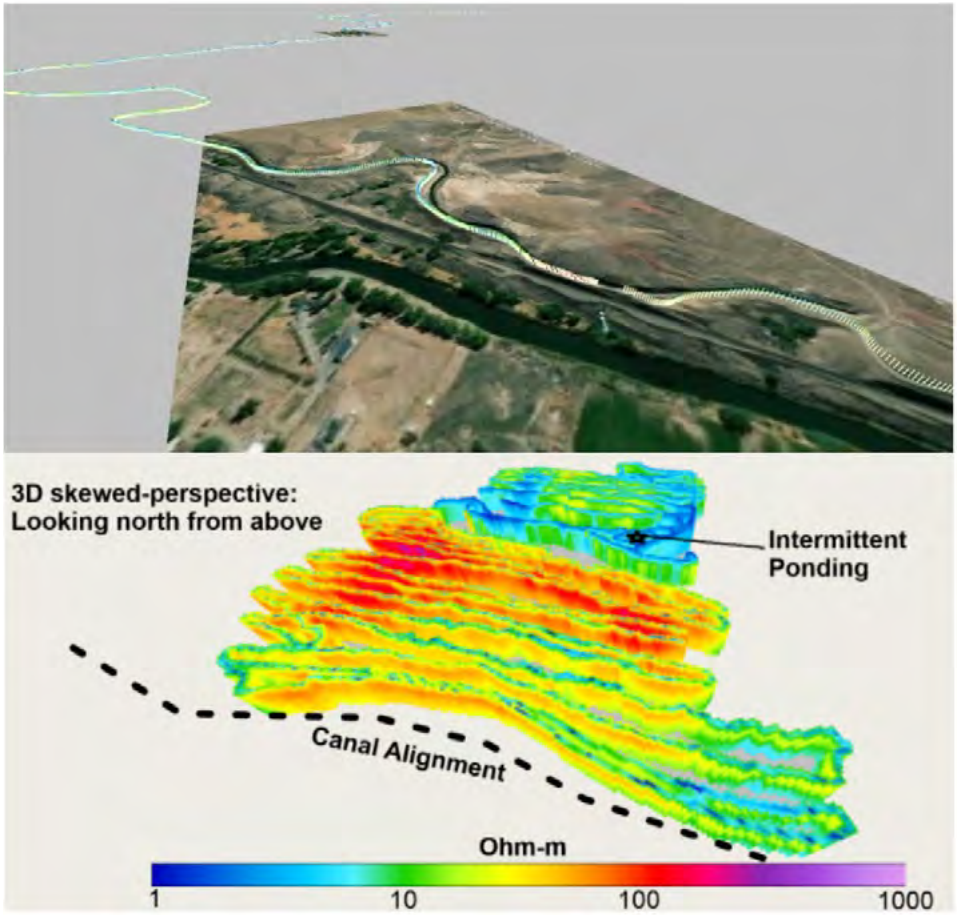


Figure 25. Examples of modeled subsurface conductivity from frequency-domain electromagnetic data: A continuous two-dimensional "ribbon" conductivity model reveals subsurface geology and seepage along the length of the Truckee Canal (top), and a three-dimensional model showing complex subsurface patterns beneath a gridded survey at a specific seepage area of interest.

Note: Ohm-m = Ohm-Meter; used to measure electrical resistivity.

Detecting Seepage in Canals using Satellite Remote Sensing

This study researched an innovative way to detect and characterize seepage in canals using C- and L-band Synthetic Aperture Radar (SAR) satellite remote sensing technology. Truckee Canal was used as a pilot study for the new technology and a year-long time-series of Sentinel SAR data was obtained for 2017. The data was analyzed to evaluate the feasibility and value of using SAR satellite remote sensing technology to detect soil moisture content and time-lapse fluctuations related to seepage phenomena at the Truckee Canal. This initial proof-of-concept effort showed that the SAR approach is feasible for detecting seepage. The new enhanced seepage detection approach will provide a technique to quantify potential seepage losses for more rapid and global management of canal embankments (Reclamation, 2020 [Remote Sensing]).

Rapid Geophysical Profiling for Canal Embankment and Levee Health Assessment and Seepage Detection

Canals and levees pose several practical and technical challenges to adequately assess health, performance, and maintenance needs. A promising new approach for rapid characterization and monitoring of canal health combines satellite-based remote sensing imagery data and rapid surface-based geophysical profiling data (a suite of non-destructive testing and subsurface imaging techniques) with a semi-automated data fusion, analysis, and data interpretation workflow **(Figure 25)**.

The new seepage detection workflow is currently being used to inform a related Reclamation Science and Technology project being conducted along a reach of the Truckee Canal. Reclamation staff, in partnership with NASA and USGS, are investigating the use of interferometric synthetic aperture radar (INSAR) satellite remote sensing data as an additional tool for seepage detection and time-lapse condition monitoring of seeps along canals and levees. The seepage detection workflow is being used to help verify seepage conditions along the Truckee Canal. In addition to the results of this new workflow, known seepage and non-seepage segments will be used as ground truthing to help evaluate the effectiveness and limitations of INSAR for seepage characterization. Frequency-domain electromagnetic data is being used to estimate depth to seepage and geologic layers of interest. The end goal is to use this screening-level information to help evaluate if INSAR analysis can be used not only to detect seepage, but to go as far as estimating average hydraulic conductivity of materials between the canal and a given seepage area. Future efforts will focus on continuation and development of new partnerships for further implementation and improvement of this developed seepage detection workflow (Reclamation, 2020 [Geophysical Profiling]).

Using Heat as a Tracer to Estimate Seepage Losses and Improve Water Operations in Canals

In this study Reclamation worked with USGS to quantify seepage from the Truckee Canal using heat as a tracer **(Figure 26)**. This technique involves monitoring sediment temperatures at multiple depths below the canal and at variations in canal stage. Data was recorded at 0.5-hour intervals from March to November during the 2018 to 2019 irrigation seasons. Data collected during the 2018 irrigation season was used for model calibration and data from 2019 was used as model verification.

Figure 26. Installing temperature rods in the Truckee Canal for measuring diffuse seepage using the heat as a tracer approach.

Stage-seepage regressions were calculated for all transects in the Truckee Canal. As a result of this research, Reclamation will have improved knowledge of how seepage rates vary over time and space (Reclamation, 2020 [Heat as a Tracer]).

Project Improvements

Reclamation is continuously improving its facilities in the Truckee-Carson Basins, as necessary.

Derby Dam Fish Screen

In September 2020, Reclamation completed construction of the Nation's largest horizontal fish screen at Derby Dam near Reno, Nevada (**Figure 27**). Derby Dam is 110 years old and is the first irrigation structure designed by Reclamation. The dam is part of a system that provides water to 57,000 acres of cropland. The fish screen is a critical investment to modernize Reclamation's infrastructure to provide reliable water supplies for irrigation customers in an environmentally sound manner. The project is an important partnership with the USFWS, the Pyramid Lake Paiute Tribe, and Reclamation's irrigation partners.

The new fish screen will prohibit fish from entering into the Truckee Canal. In particular, the project promises to greatly improve passage for Lahontan cutthroat trout journeying to upstream rearing and spawning habitat for the first time in a century. As such, it will significantly aid in the recovery of the federally threatened trout.

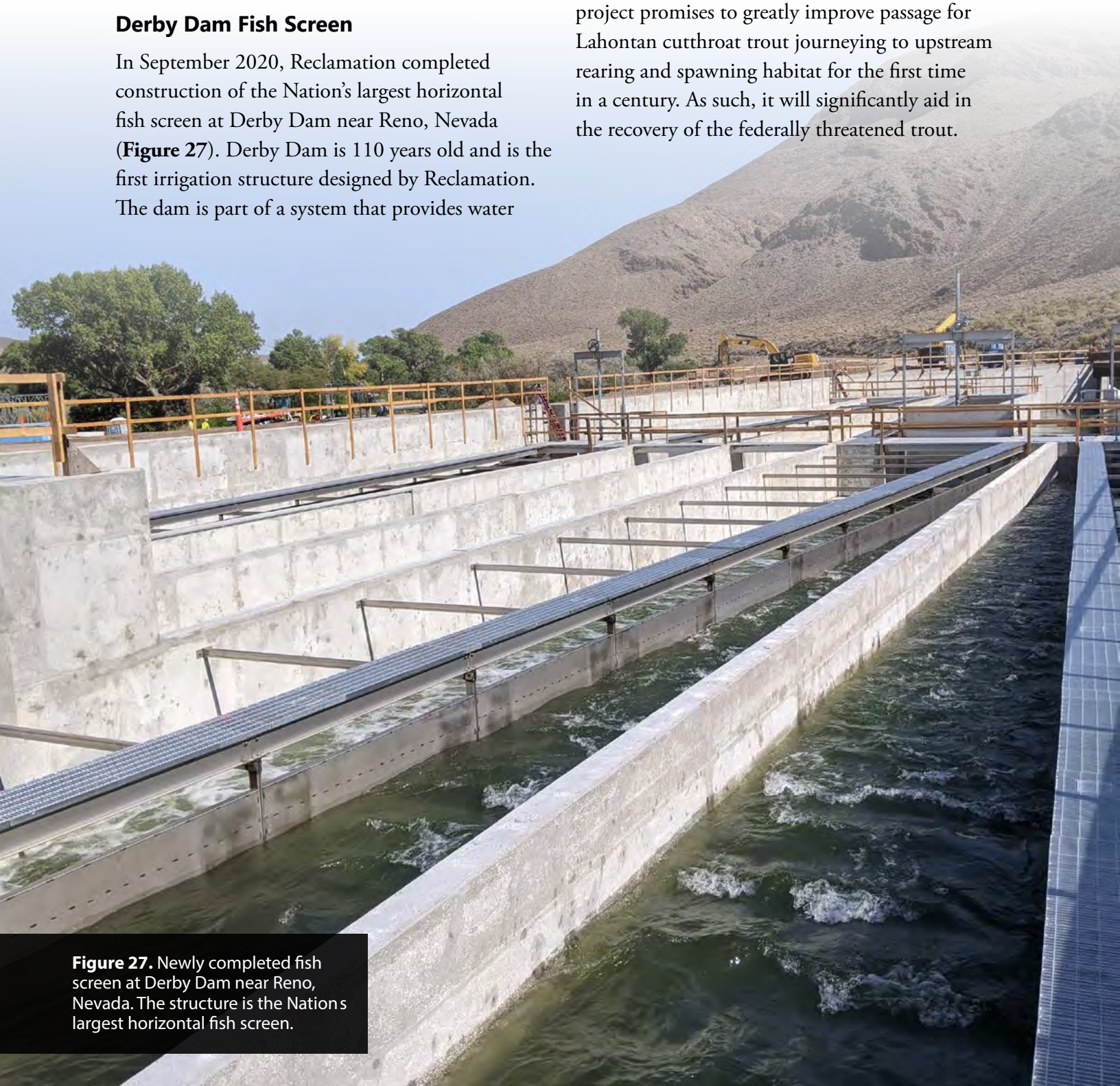


Figure 27. Newly completed fish screen at Derby Dam near Reno, Nevada. The structure is the Nation s largest horizontal fish screen.

Figure 28. Downstream face of Stampede Dam, California, showing construction of the 11.5-foot-high crest raise.

Stampede and Boca Dams Safety Modification Projects

In 2018, Reclamation completed raising Stampede Dam upstream of Reno, Nevada by 11.5 feet to address dam safety concerns that could cause large flood events. Investigations indicated that Stampede Dam safety modifications were needed to prevent potential overtopping of the dam (**Figure 28**). These modifications will protect both Stampede Dam and Boca Dam (6 miles downstream of Stampede Dam) and downstream populations from loss of life, property damage and environmental impacts. Reclamation is also constructing an earthen buttress on the downstream face of Boca Dam to stabilize the dam and modifying the spillway crest structure.

V-Line Wasteway

The V-Line Wasteway near Fallon, Nevada was built as a rapid response to runoff about three times higher than normal in water year 2017. The Lahontan Basin Area Office and TCID had to move quickly to minimize the impact of flooding. The Carson River winds through Fallon, Nevada and, if flood water was released from Lahontan Dam, it would flood the city. In a coordinated effort, the Lahontan Basin Area Office and TCID made a plan to install an innovative wasteway on the V-Line, an irrigation canal that circumvents the city. The wasteway would act as a pressure relief valve and would spill water into the desert, thereby preventing the city from flooding. Only 17 days after the initial project concept, the wasteway was designed, reviewed, and construction was complete.

In addition to construction of the V-Line Wasteway, from February through July 2017 an Emergency Operation Command was established to prevent flooding. The Lahontan Basin Area Office, City of Fallon, local emergency response, State of Nevada, Churchill County, and other parties dedicated resources towards the protection of life and property. Due to these coordinated efforts, no homes were flooded in the Lahontan Valley.

Truckee River Basin Study partners have started a pilot project to evaluate the use of weather forecasts to inform reservoir operations in the Truckee Basin, and to devise and test new, more flexible flood control criteria (Getty Images).

SECTION 5

Next Steps

Reclamation continues to make advancements in water management of the Truckee-Carson Basins through research and collaboration with partners.

Ultraviolet Aquatic Vegetation Control in Canals – Truckee Canal Test Case

Reclamation's Science and Technology Program is supporting research on the use of ultraviolet aquatic vegetation control in canals (**Figure 29**). The research will be completed in 2022. Many of the over 8,000 miles of Reclamation's canals are located in or around urban and residential areas. Aquatic macrophyte (plant) populations are growing within these canals and place communities near Reclamation facilities at risk by increasing the water surface elevation within canals to potentially unsafe levels.

Numerous irrigation districts across Reclamation are forced to manage aquatic plants by using chemical treatments, which can harm crops, or mechanical harvesting, which further spreads aquatic species. Pilot studies in concrete lined canal, Lake Tahoe, and laboratory settings have found the use of ultraviolet-c (UV) light as an effective and environmentally friendly alternative to chemical and mechanical methods of eradicating aquatic plants. This research will test the efficacy of UV treatment as an environmentally safe alternative to treat aquatic vegetation in an unlined canal. The Truckee Canal will be used as a test case to determine the efficacy of UV treatment for the management of aquatic plants. This research will quantify the changes in plant density based upon UV treatment exposure time, thereby allowing managers to optimize treatment plans in the future.

Figure 29. Aquatic plants growing in a canal (Getty Images).

Water Management Operations Pilot (Forecast Informed Reservoir Operations)

The Basin Study was the first study in the Truckee-Carson Basins to evaluate long-range sources of future uncertainty in climate and socioeconomics, and their effects on supplies, demands, and a variety of other water related resources. One of the eight key strategies identified in the Basin Study was to adapt the Truckee River flood control management that allows for shifts in the timing of precipitation and snowpack runoff by capturing it in Truckee Basin reservoirs. In response to Reclamation's recent Water Management Options funding opportunity, Basin Study partners including the TMWA and TRFMA, along with the TROA administrator and numerous other supporting stakeholders, proposed and were awarded a pilot project to study the opportunity of flexible, forecast-driven operations.

The objective of the pilot study is to work with the USACE to devise and test new, more flexible flood control criteria and evaluate the use of weather forecasts to inform reservoir operations in the Truckee Basin. The pilot study partners will provide this information to the USACE in the form of a Preliminary Viability Assessment with the goal of updating the Water Control Manual for operations of flood control reservoirs including Prosser Creek, Stampede, and Boca. Potential revisions may include modifications to the rule curves, downstream regulation goals, required flood storage volumes, and downstream flow thresholds in place on the Truckee River (at the Reno Gage). Ultimately, the pilot study will enable a diverse stakeholder group to proactively address the supply and demand imbalance that is occurring in the Truckee Basin and is expected to increase with the changing climate (Reclamation, 2020 [Draft Truckee Basin WMOP MOA] and Reclamation, 2019 [WMOP Truckee Basin Proposal]).

Sunset at Lake Tahoe at Emerald Bay in California (Getty Images).

References

Placer County Water Agency, 2016	Placer County Water Agency, 2016. 2015 Urban Water Management Plan. Adopted June 2, 2016. Prepared by Tully and Young. Available online at https://cdn.cosmicjs.com/8f300fc0-70c5-11e8-a5be-c3d0d175fd82-PCWA%202015%20UWMP%20-%20Final%207.14.16.pdf (last accessed September 16, 2020)
Pyramid Lake Paiute Tribe, 2020	Pyramid Lake Paiute Tribe, 2020. Pyramid Lake Paiute Tribe Homepage. Available online at http://plpt.nsn.us/plpt.html (last accessed August 6, 2020).
Reclamation, 2020 (DEIS Truckee Canal)	Bureau of Reclamation, 2020 (DEIS Truckee Canal). Draft Environmental Impact Statement Truckee Canal Extraordinary Maintenance. Newlands Project, Nevada. February 2020. Interior Region 10, California-Great Basin. Sacramento, California.
Reclamation, 2020 (Draft Truckee Basin WMOP MOA)	Bureau of Reclamation, 2020 (Draft Truckee Basin WMOP MOA). Draft Truckee River Basin Water Management Options Pilot Memorandum of Agreement. Interior Region 10, California-Great Basin. Sacramento, California.
Reclamation, 2020 (Remote Sensing)	Bureau of Reclamation, 2020 (Remote Sensing). Detecting Seepage in Canals Using Satellite Remote Sensing. Knowledge Stream. June 2020. Technical Service Center, Research and Development Office. Denver, Colorado.
Reclamation, 2020 (Geophysical Profiling)	Bureau of Reclamation, 2020 (Geophysical Profiling). Rapid Geophysical Profiling for Canal Embankment and Levee Health Assessment and Seepage Detection. Knowledge Stream. June 2020. Technical Service Center, Research and Development Office. Denver, Colorado.
Reclamation, 2020 (Heat as a Tracer)	Bureau of Reclamation, 2020 (Heat as a Tracer). Using Heat as a Tracer to Estimate Seepage Losses and Improve Water Operations. Knowledge Stream. June 2020. Technical Service Center, Research and Development Office. Denver, Colorado.

Reclamation, 2019 (Feasibility Design Study)

Bureau of Reclamation, 2019 (Feasibility Design Study). Technical Memorandum 29-TRU-8150-FEA-2018-3: Truckee Canal Engineering and Economic Feasibility Design Study. Newlands Project, Nevada. July 2019. Mid-Pacific Region. Sacramento, California.

Reclamation, 2019 (WMOP Truckee Basin Proposal)

Bureau of Reclamation, 2019 (WMOP Truckee Basin Proposal). WaterSMART Water Management Operations Pilot for the Truckee River Basin. Letter Proposal. July 2019.

Reclamation, 2015

Bureau of Reclamation, 2015. Truckee River Basin Study, Basin Study Report. December 2015. Available online at: https://www.usbr.gov/watersmart/bsp/docs/finalreport/truckee/tbsbasinstudy.pdf (last accessed July 1, 2020).

Reclamation, 2013

Reclamation, 2013. Newlands Project Planning Study Special Report. Mid-Pacific Region, Lahontan Basin Area Office. Carson City, Nevada. Available online at https://www.usbr.gov/mp/lbao/docs/lbao-npps-specialreport-ch1-2.pdf (last accessed August 6, 2020).

Reclamation, 2011

Bureau of Reclamation, 2011. SECURE Water Act Section 9503(c) – Reclamation Climate Change and Water, Report to Congress. Policy and Administration Office. Denver, Colorado. Available online at: https://www.usbr.gov/climate/secure/docs/2011secure/2011SECUREWaterReport.pdf (last accessed August 6, 2020).

Reclamation, 2008

Bureau of Reclamation, 2008. Truckee River Operating Agreement, 73 Federal Register 74031 (December 5, 2008), pp. 74031-74039.

Reclamation et al., 2008

Bureau of Reclamation, U.S. Fish and Wildlife Service, Bureau of Indian Affairs, and State of California Department of Water Resources, 2008. Final Environmental Impact Statement/ Environmental Impact Report Truckee River Operating Agreement.

Truckee Meadows Water Authority, 2009

Truckee Meadows Water Authority, 2009. 2010-2030 Water Resource Plan. Available online at https://tmwa.com/wp-content/uploads/docs/your_water/2030WRP/Final/2030_WRP.pdf (last accessed September 10, 2020).

USFWS, 2008

U.S. Fish and Wildlife Service, 2008. Intra-Service Biological Opinion on the Truckee River Water Management Agreement Memorandum of Agreement. April 17, 2008. Nevada Fish and Wildlife Office, Reno, Nevada.

Cover Photo: Reclamation s Lake Tahoe Dam in California controls the top 6 feet of Lake Tahoe. With the surface area of the lake, this creates a reservoir of 744,600 acre-feet capacity and regulates the lake outflow into the Truckee River (Getty Images).