Water Smart Landscapes Rebate Program

($2,000,000)

WaterSMART Grants:
Water and Energy Efficiency Grants FY2022

Notice of Funding Opportunity No. R22AS00023

Funding Group II

November 3, 2021

Applicant:
Southern Nevada Water Authority

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1. Technical Proposal: Executive Summary

Date: November 3, 2021
Applicant: Southern Nevada Water Authority (Category A Applicant)
Location: 1001 South Valley View Boulevard, Las Vegas, Nevada 89153 (Clark County)

Project Summary

As severe and sustained drought conditions in the Colorado River Basin continue to threaten water supplies and delivery systems, water conservation is a critical tool used to ensure a safe and reliable drinking water supply for Southern Nevada. Since 1991, the Southern Nevada Water Authority (SNWA) and its member agencies have implemented one of the most comprehensive water conservation programs in the United States. Conservation initiatives have helped to save billions of gallons of water, extending the availability of Nevada's existing 279,000 acre-feet per year (AFY) Colorado River water allocation under the current federal shortage declaration. In the proposed project, Water Smart Landscape Rebate Program, SNWA will provide funding incentives to property owners who convert lawn to water-efficient landscaping. This project will result in an estimated recurring annual savings of 674.31 AFY by converting 11,985,019 square-feet of lawn during the project period, which translates to 2,022.93 acre-feet (AF) saved during the project period. Over the life of the improvement (50 years), the cumulative impact of this project is estimated to result in a savings of 97,100.64 AF. The project is supported by SNWA's Joint Conservation Plan and Water Resource Plan, both of which prioritize reducing water demands and maximizing the use of available resources through aggressive conservation measures. The project is also bolstered by the passage of Nevada Assembly Bill 356, which was signed into law in June 2021. The law prohibits, with certain exceptions, the use of water from the Colorado River to irrigate non-functional turf in southern Nevada, making it the most aggressive municipal water conservation measure taken the western United States.

Length of Time and Estimated Completion Date

The proposed project encompasses activity from July 2022 through June 2025. Rebates will be issued after the successful completion of each turf conversion. All rebates will be issued by June 2025. Program participation is dependent upon customer demand, which has increased in recent years, and is expected to grow with the passage of Nevada Assembly Bill 356 in the 2021 Legislative Session. The new law prohibits the use of water from the Colorado River to irrigate non-functional turf. Customers must remove non-functional turf on property not zoned exclusively for a single-family residence by December 31, 2026.

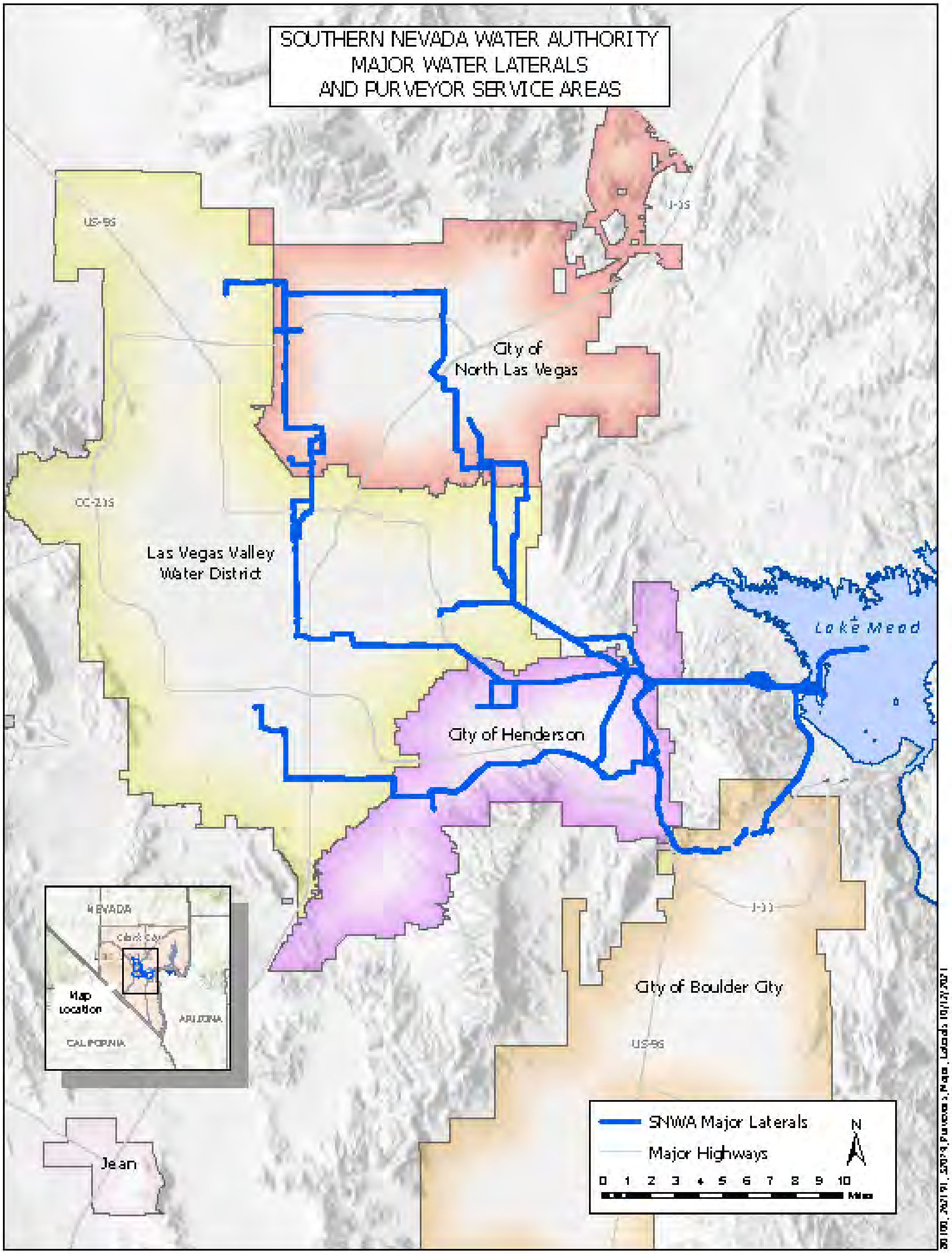
Federal Facilities

The proposed project is not located on a federal facility.

2. Technical Proposal: Project Location

The proposed project will provide incentives for turf conversion on properties located in the SNWA service area in Clark County, Nevada. A map of the SNWA Service Area is included as Figure 1 on the following page.

Figure 1. Map


SOUTHERN NEVADA WATER AUTHORITY
MAJOR WATER LATERALS
AND PURVEYOR SERVICE AREAS
US-95
I-15
City of
North Las Vegas
CC-215
Las Vegas Valley
Water District
Lake Mead
City of Henderson
NEVADA
Clark Co.
Map
Location
ARIZONA
CALIFORNIA
I-11
City of Boulder City
US-95
SNWA Major Laterals
Major Highways
N
0 1 2 3 4 5 6 7 8 9 10
Miles
Jean

3. Technical Proposal: Technical Project Description

In Southern Nevada, nearly all water used indoors is recovered, treated, and returned to the Colorado River system for return-flow credits. The recycling of Colorado River water used in Southern Nevada is accrued according to the 1984 U.S. Bureau of Reclamation "Procedure for Determining Return-Flow Credits to Nevada from Las Vegas Wash" and subsequent administrative updates authorized by the Bureau of Reclamation (Reclamation). This process extends Nevada's Colorado River water supply by nearly 70 percent. As a result, SNWA's conservation efforts emphasize reducing outdoor water use, which cannot be recovered through return-flow credits.

The WSL Program is a key component in SNWA's efforts to meet its conservation goals. The WSL Program encourages property owners to convert unused lawn by providing a financial incentive to offset a portion of the cost associated with the conversion. The program currently rebates $3.00 per square-foot for the first 10,000 square-feet converted per property, and $1.50 per square-foot for each additional square-foot converted.

Based upon a joint Reclamation/SNWA research project conducted from 1995 to 2000, every square-foot of grass replaced with desert landscaping saves an average of 55.8 gallons of water per year (Appendix A Xeriscape Conversion Study). Since 1999, the WSL Program has supported the conversion of more than 200 million square-feet of lawn–resulting in cumulative conservation savings of more than 560,000 AF of water.

Water Smart Landscapes Program Process:

The following details the general process that applicants to the WSL program follow to qualify for and receive landscape conversion rebates:

1. **Application** - Single-family property owners must apply to the WSL Program via mail or internet. Commercial and institutional properties contact a Programs Coordinator directly.

2. **Pre-conversion site inspection –** All properties must meet eligibility requirements. At the pre-conversion site inspection, SNWA staff document the existing landscape, determine eligibility to participate in the program, and explain the program requirements to the property owner or agent.

   (**Step 1-2 Duration: 14 days)**

3. **12-month performance period –** After SNWA deems the property eligible for participation, the property owner is given up to 12 months to complete a landscape conversion. Subject to SNWA approval, participants may be granted up to six additional months.

   (Step 3 Duration: Customer dependent up to 12 months)

4. **Post-conversion site inspection –** Upon notice from the applicant that a conversion is complete, SNWA will inspect the landscape to ensure it meets minimum requirements

and to determine the square footage eligible for rebate. If program requirements are not met, the applicant is given an additional 60 days or the remainder of the 12-month conversion period to take corrective action.

5. **Rebate issuance** – Following a successful post-conversion site inspection, the customer is notified of the rebate amount. The customer acknowledges the amount by signing a form and returning it. A rebate check is then processed and mailed.

   (Step 4-5 Duration: 21 days)

   On average, this entire process takes approximately three to four months from initial customer request.

4. Technical Proposal: Evaluation Criteria

E.1.1. Evaluation Criterion A—Quantifiable Water Savings

Describe the amount of estimated water savings. For projects that conserve water, please state the estimated amount of water expected to be conserved (in acre-feet per year) as a direct result of this project. ***Please include a specific quantifiable water savings estimate; do not include a range of potential water savings.***

During the three-year project period, SNWA expects to convert 11,985,019 square-feet of turf under the requirements of the WSL Program, which when fully complete, will result in a 2,022.93 AF savings. However, it is unlikely that all of the savings will be realized in a single year and accrued over the three-year project window. SNWA estimates the expected life of improvements to be 50 years. Estimated water savings over the 50-year life improvement is calculated below:

Implementation Year (3 years)

$$\frac{55 \text{ gal/sf} \times 3{,}995{,}006\text{sf}}{325{,}851 \text{ gal/AF}} = 674.31 \text{ AF}$$

	Water Saved Per Year (AF)	Cumulative Savings (AF)
Year 1	674.31	674.31
Year 2	Additional 674.31	1,348.62
Year 3	Additional 674.31	2022.93
Years 4-50	2022.93 x 46 Years	93,054.78
TOTAL WATER SAVINGS OVER 50 YEAR IMPROVEMENT		**97,100.64**

Describe current losses: Please explain where the water that will be conserved is currently going and how it is being used.
According to the joint study conducted by Reclamation and SNWA, irrigating turfgrass consumes 73 gallons of water per square foot per year, all of which is consumptive use. The same study found that landscape conversions meeting the program requirements consume 17.2 gallons per square foot per year. The program reduces consumptive landscape use by approximately 76 percent while sustaining or improving the aesthetic and environmental benefits of urban landscape. In a hot desert climate like Las Vegas, live turf grass is not an efficient use of water, where a portion of the water used to irrigate is lost to evaporation and cannot be recycled. The proposed project reduces the consumptive use of Colorado River resources and provides a permanent water savings, increasing availability and reliability.

Describe the support/documentation of estimated water savings: Please provide sufficient detail supporting how the estimate was determined, including all supporting calculations.
SNWA's 2005 Xeriscape Conversion Study (Appendix A) was supported by Reclamation through grant funding and peer review. The study found that conversions from turfgrass to xeriscapes resulted in a water usage drop from 73 to 17.2 gallons per square foot. This study involved hundreds of participants that were divided into three groups: Xeric Study, Turf Study, and control groups. Water use data were collected from utility meters serving each household as well as irrigation submeters. Submeters were installed to determine per-unit area water application for both xeric- and turf grass-dominated landscapes. The per-unit area savings of xeric- versus turf dominated landscapes as revealed by the submeter data was found to be 55.8 gallons per square-foot per year. This results in a significant savings of 76.4 percent when considered in the context of all available residential water conservation measures. Subsequently, SNWA has conducted several analyses that have validated the results of the original study. Several independent studies of SNWA data have concluded the program yields similar or greater savings than SNWA’s estimates.

Please address the following questions according to the type of infrastructure improvement you are proposing for funding.

Turf Removal: Applicants proposing turf removal projects should address the following:

a. How have average annual water savings estimates been determined? Please provide all relevant calculations, assumptions, and supporting data.
Based on the data gathered from the Xeriscape Conversion Study, SNWA can determine the water savings realized from turf conversion projects completed through the WSL Program. 11,985,019 square-feet of turf converted under the requirements of the WSL Program will determine the number of gallons of water saved.

Using a savings of 55 gallons per square-foot, this project will result in a 2,022.93 AF savings over the term of the project.

$$\textbf{Total AF Saved} \quad \frac{55 \text{ gal/sf} \times 11{,}985{,}019 \text{ sf}}{325{,}851 \text{ gal/AF}} = 2{,}022.93 \text{ AF}$$

$$\textbf{Year One AF Saved} \quad \frac{55 \text{ gal/sf} \times 3{,}995{,}006\text{sf}}{325{,}851 \text{ gal/AF}} = 674.31 \text{ AF}$$

$$\textbf{Year Two AF Saved} \quad \frac{55 \text{ gal/sf} \times 3{,}995{,}006 \text{ sf}}{325{,}851 \text{ gal/AF}} = 674.31 \text{ AF}$$

$$\textbf{Year Three Total AF Saved} \quad \frac{55 \text{ gal/sf} \times 3{,}995{,}007 \text{ sf}}{325{,}851 \text{ gal/AF}} = 674.31 \text{ AF}$$

$$\textbf{Total Project Savings} \quad \begin{matrix} Y1 + Y2 + Y3 \\ 674.31 \text{ AF} + 674.31 \text{ AF} + 674.31 \text{ AF} \end{matrix} = 2{,}022.93 \text{ AF}$$

b. What is the total surface area of turf to be removed and what is the estimated average annual turf consumptive use rate per unit area?
The total surface area of natural grass to be removed and replaced is 11,985,019 square-feet.

The WSL rebate is $3.00 per square-foot for the first 10,000 square-feet of turf removed and $1.50 per square-foot thereafter. The current average rebate is $2.67 per square-foot. Applying this average rebate rate to the total project cost of $32,000,000, SNWA estimates that 11,985,019 square-feet of turf grass will be removed during the grant performance period.

$$\textbf{Total Square Feet Converted} \quad \frac{\$32{,}000{,}000}{\$2.67\text{/square-foot}} = 11{,}985{,}019 \text{ square-feet}$$

The estimated annual turf consumptive water use rate is 73 gallons per square foot. As previously stated, SNWA's 2005 Xeriscape Conversion Study (Appendix A) found that conversions from turfgrass to xeriscapes resulted in a water usage drop from 73 to 17.2 gallons per square foot.

c. Was historical water consumption data evaluated to estimate average annual turf consumptive use per unit area? If so, did the evaluation include a weather adjustment component?
In the Xeriscape Conversion Study, SNWA performed discrete submetering of xeric and turf areas, respectively. Due to having simultaneous measures of per unit area usage for each landscape type, weather variance was not considered. That is, pre- and post-measures were not used; however, averages for each of those data sets of the life of each study site were included.

In five follow-up studies that utilized pre- and post-measures, the average consumption was at or only slightly off 55 gallons per square foot with data at least five years pre and five years post data.

d. Will site audits be performed before applicants are accepted into the program?
SNWA will complete pre- and post-site audits. Site audits will be documented with photos. The actual converted areas will be documented using GIS and archived by SNWA.

e. How will actual water savings be verified upon completion of the project?
Conservation progress is measured by annually comparing the community's actual water use to the expected water use without conservation measures in effect. To measure conservation, SNWA uses an explanatory regression model to determine the variables that influenced southern Nevada's water use during the preceding year. Although the model has identified a substantial number of relevant variables, the most significant are related to population, weather, and economic indicators. This data is obtained from other agencies on an annual basis.

To track and monitor the effectiveness of the WSL Program, SNWA developed the Conservation Incentive Archive and Database (CiCADA). Developed in-house and launched in 2017, the CiCADA database tracks all participants, processes, and results related to the WSL Program. Important features include individual participant tracking, Clark County Assessor property record information, rebate application information, site assessment information, converted square footage, and rebate amounts. Other functions include the ability to run various reports on program participation, to track quality assurance performed on staff work, and to run queries on numerous tracking and enrollment options. All these functions allow the database to serve as the primary method for tracking performance measures. Information regarding results of the program can be made available to Reclamation as needed, or quarterly through progress reporting processes. At project completion, Reclamation will be provided with a report summarizing the number of square feet converted, rebates issued, acre-feet per year saved, and other relevant program information.

E.1.2. Evaluation Criterion B—Renewable Energy

E1.2.1. Subcriterion No. B.1: Implementing Renewable Energy Projects Related to Water Management and Delivery

This subcriterion is not applicable to the proposed project.

E1.2.1. Subcriterion No. B.2: Increasing Energy Efficiency in Water Management

Describe any energy efficiencies that are expected to result from implementation of the water conservation or water efficiency project (e.g., reduced pumping). If quantifiable energy savings is expected to result from the project, please provide sufficient details and supporting calculations. If quantifying energy savings, please state the estimated amount in kilowatt hours per year.
The proposed project does increase energy efficiency in water management. Water treatment and delivery is energy intensive. It takes 6.67 kilowatt-hours (kWh) to move 1,000 gallons of water. The proposed project will save an estimated 674.21 AFY or 219,724,549 gallons of water annually, which translates into 1,465,514 kWh avoided each year.

$$\textbf{kWh Avoided Annually} \qquad \frac{219{,}724{,}549 \text{ gallons}}{(1000 \text{ gal}/6.67 \text{ kWh})} = 1{,}465{,}514 \text{ kWh}$$

How will the energy efficiency improvement combat/offset the impacts of climate change, including an expected reduction in greenhouse gas emissions.

Consider the amount of carbon that would have been emitted by producing the power to treat and deliver the saved water. Per the U.S. Environmental Protection Agency's (EPA) Power Profiler, the AZNM (Western Electrical Coordinating Council (WECC) Southwest), which is the Emissions & Generation Resource Integrated Database (eGRID) subregion in which SNWA predominantly receives electricity, produces about 0.9523 pounds (lbs.) of carbon dioxide (CO2) emissions per kWh. (https://www.epa.gov/egrid/power-profiler#/AZNM) The proposed project avoids 1,395,608.98 lbs., or 633.04 metric tons (MT), per year. Avoiding 633.04 metric tons of CO2 emissions is akin to removing 137 cars from the road. The car equivalent was calculated using the EPA's Greenhouse Gas Equivalencies Calculator (https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator). These savings compound annually as the non-functional turf is removed permanently.

Lbs. CO2 Avoided Annually	1,465,514 kWh x 0.9523 lbs./kWh	= 1,395,608.98 lbs.
MT Avoided Annually	$\frac{1,395,608.98 \text{ lbs.}}{2204.6 \text{ lbs./MT}}$	= 633.04 MT
Car Equivalent	633.04 MT x .217 cars/MT	= 137.36 cars

If the project will result in reduced pumping, please describe the current pumping requirements and the types of pumps (e.g., size) currently being used. How would the proposed project impact the current pumping requirements and energy usage?

Generally, a reduction in water need has a direct correlation to the amount of time used to run a pump or the number of pumps needed to run, so reduction in water demand correlates to a reduction in pumping and energy usage. In the SNWA service area, 90 percent of water is received from Lake Mead and pumped throughout the Las Vegas Valley (Valley). Moreover, water traverses more than 1,500 feet in elevation through the valley. More than 50 pumping stations are located in the Valley of varying sizes and it is anticipated that a reduction in water use will reduce current pumping requirements and energy usage as there would be less water needed to pump.

Please indicate whether your energy savings estimate originates from the point of diversion, or whether the estimate is based upon an alternate site of origin.

The energy savings estimate originates from the point of diversion. As stated previously, most of the water treated and delivered in the Valley comes from Lake Mead. Reducing consumptive water use saves energy no matter where the water is delivered, but it is of note that water from

Lake Mead is pumped to higher elevations throughout the Valley. Lake Mead's elevation is 1,167 feet above sea level. Where SNWA member agency Las Vegas Valley Water District's Valley View Campus is located near the center of the city, the elevation is 2,208 feet above sea level and some developments in Summerlin (west Las Vegas) are at elevations nearly 4,600 feet above sea level.

Does the calculation include any energy required to treat the water, if applicable?
The calculation does include energy required to treat the water.

Will the project result in reduced vehicle miles driven, in turn reducing greenhouse gas emissions? Please provide supporting details and calculations.
Turf-based landscapes require weekly maintenance, whereas xeric landscapes can be effectively maintained on a longer interval. The Xeriscape Conversion Study documented a 30 percent reduction in maintenance inputs for properties that had 40 percent or less of the completed landscape as turfgrass. Since most of the acreage is professionally maintained, landscape conversions are anticipated to reduce the frequency with which commercial crews are dispatched to the site following conversion. Furthermore, conversions reduce fuel use for small equipment, as well as fertilizer and pesticide use.

Describe any renewable energy components that will result in minimal energy savings/production (e.g., installing small-scale solar as part of a SCADA system).
Not applicable to the proposed project.

E.1.3. Evaluation Criterion C—Sustainability Benefits

Enhancing drought resiliency. *In addition to the separate WaterSMART Environmental Water Resources Projects NOFO, this NOFO places a priority on projects that enhance drought resiliency, through this section and other sections above, consistent with the SECURE Water Act. Please provide information regarding how the project will enhance drought resilience by benefitting the water supply and ecosystem, including the following:*

Does the project seek to improve ecological resiliency to climate change?
The proposed project seeks to improve ecological resiliency to climate change through aggressive conservation of resources. The WSL Program incentivizes property owners in southern Nevada to reduce the consumptive use of water by removing thirsty grass and installing water-efficient landscaping, providing permanent water savings from the limited resources in Lake Mead. SNWA is actively encouraging use of plants predicted to be capable of enduring future climate change and urban heat island effects. Reductions of turf consistently result in higher diversity of plant life. Through these conversions, SNWA anticipates increased adoption of tree species that are more resilient to enduring periods without irrigation, as well as capable of enduring future heat conditions that may threaten more "traditional" plant species which were predominant through the 1980s and 1990s.

Will water remain in the system for longer periods of time? If so, provide details on current/future durations and any expected resulting benefits (e.g., maintaining water temperatures or water levels).

This conservation effort will allow SNWA to save Colorado River water that under the Lower Basin Drought Contingency Plan (DCP) that SNWA is able to store in Lake Mead. These water savings will allow for maintenance of water levels in Lake Mead. SNWA has completed modeling studies, including "The potential effects of climate change and drawdown on a newly constructed drinking water intake: Study case in Las Vegas, NV, USA," that demonstrate that low Lake Mead elevations result in warm water temperatures at SNWA intakes, even more so than warming air temperatures, therefore the ability to keep conserved water in Lake Mead longer will help maintain cooler water temperatures, and better water quality. This study was published in the European Water Resources Association's *Water Utility Journal* and is attached as Appendix B. The project is not anticipated to result in water aging issues within municipal systems that cannot be managed or abated.

Will the project benefit species (e.g., federally threatened or endangered, a federally recognized candidate species, a state listed species, or a species of particular recreational, or economic importance)? Please describe the relationship of the species to the water supply, and whether the species is adversely affected by a Reclamation project or is subject to a recovery plan or conservation plan under the Endangered Species Act (ESA).

The conversion of 11,985,019 square-feet of natural grass to artificial turf resulting in total annual water savings of approximately 2,022.93 AF saves Colorado River water that under DCP we can store in Lake Mead thereby indirectly benefiting those species that rely on the reservoir and river. Whereas turfgrass provides little or no habitat benefit to wild species, many studies have verified that the multi-storied canopy and diversity of plantings in xeric gardens can improve habitat for a broad variety of birds, reptiles, and pollinators.

Federally endangered fish species at Lake Mead include the bonytail chub (Gila elegans) and razorback sucker (Xyrauchen texanus). The Lower Colorado River Multi-Species Conservation Program (LCR MSCP) was created to provide Endangered Species Act (ESA) compliance for the use of Colorado River water resources while conserving native species and their habitats. This 50-year program provides regulatory coverage for water diversions and power production, including the water supply to nearly 40 million people across seven states. Reclamation is the implementing agency for the LCR MSCP, in partnership with 57 entities including state and federal agencies, water and power users, municipalities, Native American tribes, conservation organizations, and other interested parties. SNWA and the Nevada Department of Wildlife (NDOW) are active participants in the implementation of the program. A key component of the LCR MSCP is the production of over 1.2 million native fish to augment existing populations.

NDOW operates the Lake Mead Fish Hatchery that produces bonytail chub and razorback sucker and receives water from a historic intake in Lake Mead. The extreme, persistent drought in the West has significantly affected water levels in Lake Mead; aggressive conservation measures, like the proposed project, that reduce consumptive use of Lake Mead supplies help improve conservation efforts for endangered species and support continued ESA compliance.

Please describe any other ecosystem benefits as a direct result of the project.
While water used indoors in southern Nevada is treated and entirely recycled for use again, outdoor use water cannot be recycled because it is either consumed or allowed to runoff a property leading to urban runoff. This runoff is often salty and contains chemicals, such as fertilizer, which can often degrade water quality because runoff often contains fertilizer, which feeds algae and causes algal blooms that impair water quality and the aquatic ecosystem. These blooms reduce oxygen in the water and impair fish habitat.

Finally, permanent reduction in water use keeps water in the river for fish and wildlife. Ecosystem benefits include more water for fish and wildlife, reduced pollutant and nutrient inputs into the Colorado River system, and cleaner water in the Las Vegas Wash for birds, in addition to the decreased CO2 emissions previously discussed.

Will the project directly result in more efficient management of the water supply? For example, will the project provide greater flexibility to water managers, resulting in a more efficient use of water supplies?
Increased water efficiency is critical to the long-term health and economic future of any desert community. Nevada considers water conservation as a resource because of its ability to reduce water demands and extend the availability of existing, temporary, and future water supplies. Permanent savings, such as those that would be incurred in the proposed project, allow water managers greater flexibility with existing resources. The proposed project also addresses water supply reliability by increasing energy efficiency in water management by avoiding 1,465,514 kWh each year.

The resiliency of xeric landscapes affords more opportunities for water management strategies that can improve conservation outcomes while sustaining a verdant urban landscape. For example, drip irrigated, xeric landscapes are capable of longer irrigation intervals. This capability allows more versatility in the development of mandatory watering schedules.

<u>**Addressing a specific water and/or energy sustainability concern(s)**</u>**.** *Will the project address a specific sustainability concern? Please address the following:*

Explain and provide detail of the specific issue(s) in the area that is impacting water sustainability, such as shortages due to drought and/or climate change, increased demand, or reduced deliveries.
SNWA and its member agencies depend on the Colorado River for approximately 90 percent of community water resource needs. SNWA's primary resource is its share of Nevada's consumptive-use apportionment of 300,000 AFY of Colorado River water. The extended drought in the Colorado River Basin has resulted in significant declines at major system reservoirs, including Lake Mead. A consequence of continued water level declines at Lake Mead is the shortage declaration of Colorado River resources for Southern Nevada. As a result of the federally declared shortage, Nevada must reduce its use to 279,000 acre-feet. As Lake Mead continues to decline, future shortages are expected with even further, deeper declines to Nevada’s allocation. The proposed project reduces the consumptive use of Colorado River resources and provides a permanent water savings, increasing availability and reliability.

Explain and provide detail of the specific issue(s) in the area that is impacting energy sustainability, such as reliance on fossil fuels, pollution, or interruptions in service.
Energy sustainability is not applicable to the proposed project.

Please describe how the project will directly address the concern(s) stated above. For example, if experiencing shortages due to drought or climate change, how will the project directly address and confront the shortages?
With the federally declared Colorado River shortage, Nevada's allocation is reduced to 279,000 AFY, which represents a 7 percent reduction in total water use. Conservation initiatives, like the proposed project, provide permanent savings of water that would have been otherwise consumptively used.

Please address where any conserved water as a result of the project will go and how it will be used, including whether the conserved water will be used to offset groundwater pumping, used to reduce diversions, used to address shortages that impact diversions or reduce deliveries, made available for transfer, left in the river system, or used to meet another intended use.
Key approaches to SNWA conservation strategies include extending the use of permanent resources and growing temporary resources or banked supplies to increase operational flexibility and reliability. In southern Nevada, SNWA serves as a regional water wholesaler, which eliminates the need for direct marketing between municipalities. Instead, unused Colorado River resources, such as the permanent water savings the proposed project will supply, are stored for future use in water banks located in southern Nevada, California, and Arizona. The Southern Nevada Water Bank (SNWB), established in 1987, has approximately 365,000 AF of credits, including water banked for the Las Vegas Valley Groundwater Management Program. SNWA's California water bank has accumulated approximately 330,000 AF of credits, while Arizona's bank has accumulated 614,000 AF since the inception of Nevada Interstate Banking in 2002. SNWA's water conservation gains have helped further its banking efforts. Since 2002, water-efficiency programs have helped SNWA to contribute approximately 330,000 AF of unused Nevada Colorado River water toward interstate banking efforts. SNWA's conservation efforts also contributed approximately 188,000 AF for storage in Lake Mead.

Provide a description of the mechanism that will be used, if necessary, to put the conserved water to the intended use. Indicate the quantity of conserved water that will be used for the intended purpose(s).
Conserved water will be used to defer withdrawals of banked resources and/or banked in as described above. With Colorado River shortages declared, SNWA intends to utilize banked resources to help offset supply availability. Conservation improves the ability to respond to shortages both by directly reducing demand and by freeing up resources banked for times of emergency. All conserved water is potable.

<u>Other project benefits</u>. *Please provide a detailed explanation of the project benefits and their significance. These benefits may include, but are not limited to, the following:*

(1) Combating the Climate Crisis: E.O. 14008: Tackling the Climate Crisis at Home and Abroad, focuses on increasing resilience to climate change and supporting climate-resilient

development. For additional information on the impacts of climate change throughout the western United States, see: https://www.usbr.gov/climate/secure/docs/2021secure/2021SECUREReport.pdf. Please describe how the project will address climate change, including the following:

Please provide specific details and examples on how the project will address the impacts of climate change and help combat the climate crisis.

Southern Nevada's biggest threat from the climate crisis is reduced water availability due to severe, persistent drought in the Colorado River Basin and throughout the Southwest. Conservation is a key tool in managing our shrinking water supply.

Additionally, climate change is caused by rising manmade greenhouse gas emissions in the atmosphere. Providing reliable quality water requires significant electricity. This project conserves a significant amount of water, thereby reducing the energy used to pump, treat, and convey water. Electricity consumption contributes approximately 99 percent to SNWA's carbon footprint. It is estimated that the proposed project will help save approximately 663.04 metric tons of carbon emissions, or the equivalent of taking 137 cars off the roadway annually each year of the project. This helps us achieve the organization's goal of reducing our operational carbon emissions, directly combating climate change.

SNWA is actively using the WSL Program to help effect succession of the urban canopy to species which are documented to have higher heat tolerance. This succession strategy is vital to helping ensure the community's urban forest is not highly susceptible to environmental collapse due to increasing temperatures.

Does this proposed project strengthen water supply sustainability to increase resilience to climate change?

The proposed project strengthens water supply sustainability to increase resilience to climate change by creating permanent water savings. Sixty percent of SNWA's water supply is used for outdoor irrigation, which represents more than half of the community's water supply unable to be used again. Targeting outdoor irrigation for conservation measures is the best strategy for increasing permanent savings. As property owners replace turf with water-efficient landscaping irrigation, demand for water goes down. Summer temperatures in Nevada's desert climate leads to increased irrigation, especially in the hot summer months. Turf removal through the WSL program reduces peak demands, allowing the community to become more resilient to climate change as water temperatures warm.

Will the proposed project establish and utilize a renewable energy source?

The proposed project will not establish a renewable energy source. SNWA is committed to conserving energy and utilizing renewable resources when possible to ensure energy is available to meet southern Nevada's security and economic needs. SNWA voluntarily committed to meet 50 percent of its energy needs through renewable resources by 2030, which parallels Nevada's recently revised Renewable Energy Portfolio Standards. The savings generated by the proposed project will allow the SNWA to further reduce its non-renewable market purchases, increasing the emphasis on renewable energy.

Will the project result in lower greenhouse gas emissions?
As discussed in Subcriterion No. B.2, less carbon will be emitted due to energy savings. Per the U.S. Environmental Protection Agency's (EPA) Power Profiler, the AZNM (WECC Southwest), which is the eGRID subregion in which SNWA predominantly receives electricity, produces about 0.9523 pounds (lbs.) of carbon dioxide (CO2) emissions per kWh. (https://www.epa.gov/egrid/power-profiler#/AZNM) The proposed project avoids 1,395,608.98 lbs., or 633.04 MT per year.

(2) **Disadvantaged or Underserved Communities: E.O. 14008 and E.O. 13985 support environmental and economic justice by investing in underserved and disadvantaged communities and addressing the climate-related impacts to these communities, including impacts to public health, safety, and economic opportunities. Please describe how the project supports these Executive Orders, including:**

Does the proposed project directly serve and/or benefit a disadvantaged or historically underserved community? Benefits can include, but are not limited to, public health and safety through water quality improvements, new water supplies, new renewable energy sources, or economic growth opportunities.
Although the proposed project does not directly benefit a specific disadvantaged or historically underserved community, it does indirectly benefit these communities due to the benefits to the entire service area, including permanent water savings, better water quality by maintaining water levels in Lake Mead, ecosystem benefits, and reduced CO2 emissions due to reduced electrical use with reduced demand.

The proposed project will support hundreds of jobs for workers in the landscape and nursery industry. These industries are predominantly staffed with workers from lower income and minority households. The rebates offered by SNWA allow low-income property owners to conduct conversions with minimal capital outlay, while reducing their operating costs significantly, thus increasing their disposable income for the long term.

If the proposed project is providing benefits to a disadvantaged community, provide sufficient information to demonstrate that the community meets the disadvantaged community definition in Section 1015 of the Cooperative Watershed Act, which is defined as a community with an annual median household income that is less than 100 percent of the statewide annual median household income for the State, or the applicable state criteria for determining disadvantaged status.
The Nevada median household income is $60,365 in 2019 dollars, per the U.S. Census Bureau (https://www.census.gov/quickfacts/NV). In looking at a breakdown of median household income by race in Las Vegas and surrounding cities or areas of unincorporated Clark County in the SNWA service, it can be surmised that households earning less than 100 percent of the statewide median household income will indirectly benefit from the proposed project.

Table 1. Median Household Income by Race: Cities near Las Vegas

	Las Vegas	Henderson	North Las Vegas	Paradise	Spring Valley	Sunrise Manor
American Indian or Alaska Native	$40,221	$62,500	$54,569	$43,786	No data	$43,177
Asian	$60,836	$76,752	$72,679	$49,527	$66,747	$61,319
Black or African American	$36,464	$51,813	$49,574	$32,528	$45,752	$29,365
Hispanic or Latino	$47,898	$65,313	$54,238	$44,268	$55,279	$47,114
Native Hawaiian or Pacific Islander	$65,859	$82,730	$62,024	$46,433	$79,625	$41,339
White	$62,987	$76,273	$65,430	$54,273	$59,099	$45,643

Groups highlighted in yellow have a median household income below Nevada's state median household income. City median household data from Data Commons, utilizing U.S. Census data (https://datacommons.org/place/geoId/3240000?utm_medium=explore&mprop=income&popt=Person&cpv=age%2CYears15Onwards&hl=en).

If the proposed project is providing benefits to an underserved community, provide sufficient information to demonstrate that the community meets the underserved definition in E.O. 13985, which includes populations sharing a particular characteristic, as well as geographic communities, that have been systematically denied a full opportunity to participate in aspects of economic, social, and civic life.

To see which underserved communities will indirectly benefit from the proposed project, consider a snapshot of population demographics in the county. Table 2 below outlines these demographics. Additionally, 31.6 percent of residents in Clark County identify as Hispanic or Latino. (U.S. Census Bureau Quick Facts, Clark County, Nevada https://www.census.gov/quickfacts/fact/table/clarkcountynevada/RHI225219#RHI225219)

Table 2. Underserved Populations by Race, Percentage of Clark County Population

Black or African American, alone	13.1%
American Indian and Alaska Native, alone	1.2%
Asian, alone	10.4%
Native Hawaiian or Other Pacific Islander, alone	0.9%
Two or More Races	4.9%

(3) Tribal Benefits: The Department of the Interior is committed to strengthening tribal sovereignty and the fulfillment of Federal Tribal trust responsibilities. The President's memorandum "Tribal Consultation and Strengthening Nation-to-Nation Relationships"

asserts the importance of honoring the Federal government's commitments to Tribal Nations. Please address the following, if applicable:

Does the proposed project directly serve and/or benefit a Tribe? Will the project increase water supply sustainability for an Indian Tribe? Will the project provide renewable energy for an Indian Tribe? Does the proposed project directly support tribal resilience to climate change and drought impacts or provide other tribal benefits such as improved public health and safety through water quality improvements, new water supplies, or economic growth opportunities?

The proposed project will not directly serve or benefit a Tribe, nor will it directly increase water supply sustainability, directly provide renewable energy for a Tribe, or directly support resilience to climate change or drought impacts. However, the proposed project will indirectly benefit Indian tribes by reducing the consumptive use on the Colorado River, to which Indian tribes have rights, which include the Fort Mojave Indian Tribe, Colorado River Indian Tribes, Chemehuevi Indian Tribe, Quechan Indian Tribe, and Cocopah Indian Tribe in the Lower Basin. Additionally, the Southern Paiute Tribe will indirectly benefit from the proposed project as their nation is in an SNWA member agency service area.

(4) Other Benefits: Will the project address water and/or energy sustainability in other ways not described above? For example:

Will the project assist States and water users in complying with interstate compacts?

SNWA conservation strategies focus on protecting Lake Mead levels and lessening use of the Colorado River allocation. Projects like the proposed project demonstrate to other stakeholders on the Colorado River that SNWA values the water and is committed to correct use and sustainability as the next round negotiations for the Colorado River operating guidelines begin.

Will the project benefit multiple sectors and/or users (e.g., agriculture, municipal and industrial, environmental, recreation, or others)?

The proposed project will benefit multiple sectors and users throughout the SNWA purveyor service areas, including municipalities in the service area and recreational users at Lake Mead. The proposed project will incentivize turf removal to provide permanent water savings that translate into a more safe, reliable water supply for the community and help maximize return flow credits to the Colorado River. Lessening use of the Colorado River helps maintain Lake Mead levels, which benefits communities in the SNWA service area and the larger region.

Will the project benefit a larger initiative to address sustainability?

SNWA and its member agencies employ environmentally responsible and sustainable practices while complying with federal, state, and local environmental laws and regulations. Conserving water also reduces the energy used to pump, treat, and convey water to customers.

SNWA has identified 5,000 acres of useless grass in southern Nevada to target for turf conversion. It is estimated that removing those 5,000 acres of useless grass will help save approximately 23,000 MT of carbon emissions, or the equivalent of taking 5,000 cars off the roadway. This helps achieve the organization's goal of reducing operational carbon emission and becoming more sustainable.

Will the project help to prevent a water-related crisis or conflict? Is there frequently tension or litigation over water in the basin?
SNWA conservation strategies focus on protecting Lake Mead levels and lessening use of the Colorado River allocation. Projects like the proposed project demonstrate to other stakeholders on the Colorado River that SNWA values the water and is committed to correct use and sustainability as the next round negotiations for the Colorado River operating guidelines begin.

E.1.4. Evaluation Criterion D—Complementing On-Farm Irrigation Improvements

The proposed project does not complement on-farm irrigation improvements.

E.1.5. Evaluation Criterion E—Planning and Implementation

E.1.5. Subcriterion E.1.—Project Planning

Does the applicant have a Water Conservation Plan and/or System Optimization Review (SOR) in place? Please self-certify or provide copies of these plans where appropriate to verify that such a plan is in place. Provide the following information regarding project planning:
To support its water planning and management responsibilities, SNWA develops and maintains a Water Resource Plan and Joint Conservation Plan (Appendix C). The Water Resource Plan projects demand and identifies a portfolio of existing and planned water supply options available to meet demands over time. The Resource Plan prioritizes banking conserved resources and growing temporary supplies to meet demands or offset potential supply reductions. It also outlines several drought response initiatives, including the Colorado River Interim Guidelines, the Colorado River Drought Contingency Plan, adaptive management, and long-term planning with a 50-Year Water Resource Plan.

First developed in 1996, the Water Resource Plan is reviewed annually and updated as needed. As demonstrated in previous revisions, adjustments to the plan are made to account for uncertainties such as drought, conservation achievements, resource availability, and changes in population and demand projections. The 2020 Plan addresses drought through adaptive management strategies employed to meet supply in our region. In addition to strong conservation strategies, the 2020 Plan prioritizes collaboration with interstate and Federal partners, banking resources and growing temporary supplies, preserving access to Colorado River supplies, and protecting the availability of future resources.

Conservation plays a critical role in water resource management. For this reason, the SNWA maintains a Joint Conservation Plan (Appendix C). The Joint Conservation Plan was made available to the public for review and comment, reviewed by SNWA's member agencies, and adopted by members that provide potable water services. The Joint Conservation Plan was accepted by the Nevada Division of Water Resources under Nevada Revised Statue (NRS) 540.141 and approved by Reclamation under the Reclamation Reform Act.

Both plans prioritize aggressive conservation measures to reduce water demands and maximize use of available resources. Chapter Three of the Water Resource Plan notes the removal of non-functional turf as a key focus area in water conservation. Non-functional turf exists primarily in streetscapes, common areas, and commercial frontage. Since 2000 SNWA has invested more than $230 million in incentive programs, including, but not limited to the WSL Program.

Chapter Five of the Joint Conservation Plan identifies the WSL Program as a water conservation measure that is projected to remain a major demand-reduction tool in SNWA's work to achieve conservation goals. In addition to the rebate incentive offered, SNWA provides free planning tools and resources to assist property owners with their turf conversions. Chapter Six of the Joint Conservation Plan notes the Water Smart Contractor program, in which free, SNWA-sponsored workshops are provided to participating contractors so their staff members are trained in up-to-date water-efficiency practices.

E.1.6.2. Subcriterion F.2— Readiness to Proceed

Identify and provide a summary description of the major tasks necessary to complete the project.
As a customer rebate program, the WSL Program is dependent upon customer demand. Historically, rebate issuance has remained relatively steady through the fiscal year. If approved, SNWA will be able to proceed as soon as an agreement is entered. The program process for property owners is outlined below. Moreover, with Nevada Assembly Bill 356 enacted, customer demand has increased to levels unseen by the organization.

Water Smart Landscapes Program Process:
The following details the general process that applicants to the WSL program follow to qualify for and receive landscape conversion rebates:

1. **Application** - Single-family property owners must apply to the WSL Program via mail or internet. Commercial and institutional properties contact a Programs Coordinator directly.

2. **Pre-conversion site inspection –** All properties must meet eligibility requirements. At the pre-conversion site inspection, SNWA staff document the existing landscape, determine eligibility to participate in the program, and explain the program requirements to the property owner or agent.

   (**Step 1-2 Duration: 14 days)**

3. **12-month performance period –** After SNWA deems the property eligible for participation, the property owner is given up to 12 months to complete a landscape conversion. Subject to SNWA approval, participants may be granted up to six additional months.

   (Step 3 Duration: Customer dependent up to 12 months)

4. **Post-conversion site inspection –** Upon notice from the applicant that a conversion is complete, SNWA will inspect the landscape to ensure it meets minimum requirements and to determine the square footage eligible for rebate. If program requirements are not met, the applicant is given an additional 60 days or the remainder of the 12-month time period to take corrective action.

5. **Rebate issuance –** Following a successful post-conversion site inspection, the customer is notified of the rebate amount. The customer acknowledges the amount by signing a form and returning it. A rebate check is then processed and mailed.

   (Step 4-5 Duration: 21 days)

   On average, this entire process takes approximately three to four months from initial customer request.

Describe any permits that will be required, along with the process for obtaining such permits.
As a non-construction program, it is not anticipated that the implementation of this rebate project will require the issuance of any permits. Property owners of exceptionally large projects may be required to seek permits depending on the size and scope of work being performed. However, acquisition of such a permit would be the responsibility of the property owner. Such an occurrence is an exception and is not reflective of the standard landscape conversion project.

Identify and describe any engineering or design work performed specifically in support of the proposed project.
Not applicable to the proposed rebate project.

Describe any new policies or administrative actions required to implement the project.
Since the WSL Program is an existing program, this is not applicable to the proposed rebate project.

Please also include an estimated project schedule that shows the stages and duration of the proposed work, including major tasks, milestones, and dates. Milestones may include, but are not limited to, the following: complete environmental and cultural compliance; mobilization; begin construction/installation; construction/installation (50% complete); and construction/installation (100% complete)
By quarter and year, expenditures for this portion of the FY 2022/2023, 2023/2024, and 2024/2025 WSL Program are anticipated to track the following estimated forecast. The charts below depict the estimated amount of landscape converted using the current average rebate of $2.67 per square foot:

Fiscal Year 2022-2023	Percent	Landscape Converted	Rebate Issuance
Q1 - July 1 – September 30	25	998,751.5 square-feet	$2,666,666.50
Q2 - October 1 – December 31	25	998,751.5 square-feet	$2,666,666.50
Q3 – January 1 – March 31	25	998,751.5 square-feet	$2,666,666.50
Q4 - April 1 – June 30	25	998,751.5 square-feet	$2,666,666.50
Total	100	3,995,006 square-feet	$10,666,666

Fiscal Year 2023-2024	Percent	Landscape Converted	Rebate Issuance
Q1 - July 1 – September 30	25	998,751.5 square-feet	$2,666,666.50
Q2 - October 1 – December 31	25	998,751.5 square-feet	$2,666,666.50
Q3 – January 1 – March 31	25	998,751.5 square-feet	$2,666,666.50
Q4 - April 1 – June 30	25	998,751.5 square-feet	$2,666,666.50
Total	100	3,995,006 square-feet	$10,666,666

Fiscal Year 2024-2025	Percent	Landscape Converted	Rebate Issuance
Q1 - July 1 – September 30	25	998,751.75 square-feet	$2,666,667
Q2 - October 1 – December 31	25	998,751.75 square-feet	$2,666,667
Q3 – January 1 – March 31	25	998,751.75 square-feet	$2,666,667
Q4 - April 1 – June 30	25	998,751.75 square-feet	$2,666,667
Total	100	3,995,007 square-feet	$10,666,668

Total Project	**Percent**	**Landscape Converted**	**Rebate Issuance**
Year One (2022-2023)	33.33	3,995,006 square-feet	$10,666,666
Year Two (2023-2024)	33.33	3,995,006 square-feet	$10,666,666
Year Three (2024-2025)	33.33	3,995,007 square-feet	$10,666,668
Total	100	11,985,019 square-feet	$32,000,000

E.1.6. Evaluation Criterion F—Collaboration

Please describe how the project promotes and encourages collaboration. Consider the following:

Is there widespread support for the project? Please provide specific details regarding any support and/or partners involved in the project. What is the extent of their involvement in the process?
The WSL Program has widespread support throughout the SNWA service area. Since 1999, the WSL Program has supported the removal of more than 200 million square-feet of decorative lawn, and participation is expected to grow with the new law prohibiting the use of Colorado River water to irrigate non-functional turf. SNWA was formed in 1991 by a cooperative agreement among the following water and wastewater agencies in southern Nevada:

- Big Bend Water District
- City of Boulder City
- City of Henderson
- City of Las Vegas

- City of North Las Vegas
- Clark County Water Reclamation District
- Las Vegas Valley Water District

Currently, the program is available to municipal water customers or groundwater users within the Las Vegas Valley. Member agencies help promote the program to their customers.

Additional support for turf conversion programs like the WSL Program is evident through the bipartisan support of Assembly Bill 356 in the 2021 Nevada Legislative session. The bill was passed by a 30-12 vote in the Assembly, with the 12 no votes belonging to northern Nevada legislators who felt uncomfortable making decisions about groundcover and water use in areas outside their districts. The bill passed by unanimous vote in the Senate. The passage of this bill demonstrates that Nevada continues to be a leader in conservation in the western United States.

What is the significance of the collaboration/support?

Together, these seven agencies provide water and wastewater service to more than 2.3 million residents in the cities of Boulder City, Henderson, Las Vegas, and North Las Vegas, and areas of unincorporated Clark County (the service area is shown in the map in Figure 1 on page 4). As their wholesale water provider, SNWA is responsible for water treatment and delivery, as well as acquiring and managing the region's short and long-term water resources. Since its inception, SNWA has worked to seek new water resources, manage existing and future water resources, construct and manage regional water facilities, and promote conservation.

The severe and sustained drought conditions on the Colorado River underscores the critical role of conservation in helping to meet current and future demands. SNWA and its member agencies depend on the Colorado River for approximately 90 percent of the community's drinking water needs. As drought conditions continue and with the first federally declared Colorado River shortage, southern Nevada's conservation efforts are even more important. Further declines in Lake Mead's water level could result in additional shortages, which would further stress the ability of water supply facilities to meet water demands. Water conservation helps to mitigate these concerns.

Will this project increase the possibility/likelihood of future water conservation improvements by other water users?

Following passage of Nevada Assembly Bill 356, the City of Henderson established a program to supplement SNWA's WSL Program rebate for non-single family residential customers. Through this program, the City of Henderson provides an additional rebate of $1.50 per square-foot, up to 40,000 square feet. This program has been very valuable for businesses, homeowner associations, apartment and condominium complexes, places of worship, and schools that have large amounts of nonfunctional turf who are looking for a more economical way of complying with the law.

Please attach any relevant supporting documents (e.g., letters of support or memorandum of understanding).
Letters of Support from member agencies, including the City of Boulder City, City of Henderson, City of North Las Vegas, and Clark County Water Reclamation District, are included at the end of this proposal.

E.1.7. Evaluation Criterion G—Additional Non-Federal Funding

This project proposal seeks $2 million from Reclamation's WaterSMART Grants: Water and Energy Efficiency Grants program. Funding will support a portion of SNWA's WSL Rebate Program. SNWA will provide a matching contribution of $30 million for a total project cost of $32 million. If the proposed project is funded by Reclamation, the non-federal share will be 94 percent.

E.1.8. Evaluation Criterion H—Nexus to Reclamation

Does the applicant have a water service, repayment, or O&M contract with Reclamation? If the applicant is not a Reclamation contractor, does the applicant receive Reclamation water through a Reclamation contractor or by any other contractual means?
Reclamation is a critical partner in SNWA's water management and conservation efforts. SNWA diverts 90 percent of its water supply from the Reclamation-managed Colorado River system. SNWA receives delivery of Colorado River water from Reclamation under several contracts held by the SNWA or its member agencies, as listed below:

SNWA Contracts:
- Contract Number 2-07-30-W0266, Amendment Number 1, Amended and Restated Contract with the Southern Nevada Water Authority, for the Delivery of Colorado River Water
- Contract Number 7-07-30-W0004, Amendatory and Supplemental Contract between the United States and the State of Nevada for the Delivery of Water and Construction of Project Works

SNWA Member Agency Contracts:
- Contract Number 14-06-300-978, "Boulder Canyon Project Arizona-California-Nevada Contract for the Delivery of Water," City of Boulder City
- Contract Number 0-07-30-W0246, Contract for Delivery of Water to City of Henderson
- Contract Number 14-06-300-2130, "Boulder Canyon Project Contract for Delivery of Water to Las Vegas Valley Water District"
- Contract Number 2-07-30-W0269, "Boulder Canyon Project Contract with the Big Bend Water District, Nevada, for the Delivery of Colorado River Water"

The water delivered by SNWA under these contracts is diverted at Reclamation-approved diversion points in the Colorado River at Lake Mead and below Hoover Dam. This includes delivery of water through the Robert B. Griffith Water Project (formerly the Southern Nevada Water Project) constructed by Reclamation, as authorized by an Act of the United States Congress.

In addition, SNWA has established long-standing relationships with Reclamation, and has coordinated on a number of initiatives including funding for the Brock Reservoir System Efficiency Project and the Yuma Desalting Plant Pilot Project; development and implementation of interstate water banking agreements with Arizona and California; Colorado River accounting and procedures for return-flow credits; a Xeriscape Conversion Study; and environmental restoration and stabilization initiatives in the Las Vegas Wash and Warm Springs Natural Area.

Will the proposed work benefit a Reclamation project area or activity?
The proposed project will contribute permanent water savings, allowing SNWA to contribute additional unused Colorado River water toward interstate banking efforts.

Is the applicant a Tribe?
The applicant is not a Tribe.

5. Performance Measures-Landscape Irrigation Measures: A.6.a. Turf Removal

Performance measures for this program will be calculated in *rebates issued, turf converted*, and *water saved*. Total program performance measures include the issuance of $32 million in rebates, 11,985,019 square-feet of turf converted, and the recurring annual conservation of 674.31 AFY.

As described in the table below, using the current average rebate of $2.67 per square foot, Reclamation's $2 million contribution to this program will result in the conversion of approximately 719,101 square-feet of lawn and the recurring annual conservation of 121.37 AFY.

Table 3. Federal and Non-Federal Funding Performance Breakdown

Agency	Contribution	Turf Converted (square feet)	Water Conserved (AF)
SNWA	$30,000,000	11,265,917.86	1,901.56
Reclamation	$2,000,000	719,101.14	121.37
Total	$32,000,000	11,985,019	2,002.93

The total number of rebates issued will be available upon project completion.

Performance measures will be based on actual water saved. As described in Section 4 on pages 5 and 21 of this proposal, post-conversion site inspections take place once the applicant notifies SNWA that the conversion is compete. SNWA will inspect the landscape to determine the square footage eligible for rebate and ensure it meets minimum requirements to achieve the 55 gallons per square-foot savings

At the end of the project, SNWA will prepare a closeout package for Reclamation, which will outline the actual project performance results achieved. As an example of the information provided in a closeout package, included below is an excerpt from a letter explaining the final outcomes for Agreement R18AP00167 (Water Smart Landscapes Rebate Program), which was submitted for closeout in November 2019.

In our grant proposal, using an estimated average rebate of $2.60 per square foot, we projected the conversion of 1,269,231 square feet, an annual water savings of 217 afy, and a cumulative recurring savings of 10,850 af. In actuality, the average rebate was $2.51 per square foot, and SNWA was able to accomplish the conversion of 1,314,983 square feet, a recurring annual water savings of 225 afy, and a cumulative recurring impact of 11,250 af.

Conservation progress is measured by annually comparing the community's actual water use to the expected water use without conservation measures in effect. To measure conservation, the SNWA uses an explanatory regression model to determine the variables that influenced southern Nevada's water use during the preceding year. Although the model has identified a substantial number of relevant variables, the most significant are related to population, weather, and economic indicators. This data is obtained from other agencies on an annual basis.

To track and monitor the effectiveness of the WSL Program, the SNWA developed the Conservation Incentive Archive and Database (CiCADA). Developed in-house and launched in 2017, the CiCADA database tracks all participants, processes and results related to the WSL Program. Important features include individual participant tracking, Clark County Assessor property record information, rebate application information, site assessment information, converted square footage, and rebate amounts. Other functions include the ability to run various reports on program participation, to track quality assurance performed on staff work, and to run queries on numerous tracking and enrollment options. All of these functions allow the database to serve as the primary method for tracking performance measures. Information regarding results of the program can be made available to Reclamation as needed, or quarterly through progress reporting processes. At project completion, Reclamation will be provided with a report summarizing the number of square feet converted, rebates issued, acre-feet per year saved, and other relevant program information.

6. Project Budget: Funding Plan

SNWA as an organization is funded by diverse sources, including a quarter-cent sales tax, connection fees, commodity fees, and reliability charges. These revenue sources provide the organization with a mix of funding sources, which help ensure the financial stability and capacity of the organization. Matching funds for this project will be provided by SNWA.

No in-kind contributions are incorporated into this proposal. No funding will be provided by a source other than the applicant, so no letters of commitment are required.

7. Project Budget: Budget Proposal

Table 4. Total Project Cost Table

SOURCE	AMOUNT
Cost to be reimbursed with the requested Federal funding	$2,000,000
Costs to be paid by the applicant	$30,000,000
Value of third-party contributions	$0
TOTAL PROJECT COST	**$32,000,000**

Table 5. Budget Proposal

BUDGET ITEM DESCRIPTION	$/Unit	Quantity	Quantity Type	TOTAL COST
Salaries and Wages				
	N/A	N/A		
Fringe Benefits				
	N/A	N/A		
Travel				
	N/A	N/A		
Equipment				
	N/A	N/A		
Supplies and Materials				
	N/A	N/A		
Contractual				
	N/A	N/A		
Third-Party Contributions				
	N/A	N/A		
Other (Rebates)				
WSL Rebates	$2.67	11,985,019	Sq. Ft.	$32,000,000
TOTAL DIRECT COSTS				**$32,000,000**
Indirect Costs – 0%				$0
TOTAL ESTIMATED PROJECT COSTS				**$32,000,000**

8. Project Budget: Budget Narrative

All costs included in this proposal are directly related to rebate costs. Program costs for salaries/wages, fringe benefits, travel, equipment, and supplies and materials are not being requested for consideration as either match or reimbursable expenditures. All costs are direct and necessary for program implementation. The non-federal contribution is 94 percent; the federal contribution is 6 percent.

Salaries and Wages: Reclamation funding will not be expended for program administration. In addition to SNWA's matching contribution, SNWA will assume all overhead costs necessary to operate the program, including staffing, administration, marketing, and other duties associated with assuring a successful program.

Fringe Benefits: Not applicable to this project.

Travel: Not applicable to this project.

Equipment: Not applicable to this project.

Supplies and Materials: Not applicable to this project.

Contractual: Not applicable to this project.

Third-Party In-Kind Contributions: Not applicable to this project.

Environmental and Regulatory Compliance Costs: Please review responses in the Environmental and Cultural Resources section. SNWA does not anticipate additional costs associated with environmental compliance. If SNWA receives an award, possible costs will be discussed during the development of the financial agreement.

Other (Rebates): Expenditures totaling $32 million in WSL rebates will result in the estimated conversion of 11,985,019 square-feet of turf. The rebate average is $2.67 per square-foot.

Total Direct Costs: Reclamation is requested to contribute $2 million toward direct costs. SNWA will provide a cash match of $30 million.

Indirect Costs: Not applicable. All direct costs align with eligible categories. SNWA does not have a federally negotiated indirect cost rate agreement. No funds are requested for indirect costs.

9. Environmental and Cultural Resources Compliance

Will the proposed project impact the surrounding environment (e.g., soil [dust], air, water [quality and quantity], animal habitat)? Please briefly describe all earth-disturbing work and any work that will affect the air, water, or animal habitat in the project area. Please also explain the impacts of such work on the surrounding environment and any steps that could be taken to minimize the impacts.
The proposed project would convert turf to desert landscaping at single-family residences (SFR) and non-SFRs in the Valley. The proposed project activities would be completed under SNWA's WSL Program that incentivizes private property owners who convert their turf to desert landscaping with rebates.

All proposed turf conversions would be completed by private parties on private land within previously disturbed residential and commercial areas. Minimal earth-disturbing work would be required to remove the grass and install desert landscaping. Small equipment, including sod cutters and compact loaders, and hand tools would be used at the site as appropriate. Impacts to soil and air quality would be minimal and temporary since only the top layer of grass would be removed, which would leave most of the existing soil bed in place, that top would be immediately replaced with desert landscaping.

There would be no impacts to water quality. The proposed turf conversions would reduce annual outdoor water use and result in beneficial impacts to water quantity and a reduction in Nevada's Colorado River consumptive water use. The proposed project area is previously disturbed, comprised entirely of maintained grass and used year-round, and therefore does not provide animal habitat. Proposed project activities would temporarily increase ambient noise levels. No roads would be blocked by the proposed project activities. Following proposed project activities, the SFR and non-SFR private property sites would maintain the same purpose with a desert landscape look and therefore cause minimal visual impacts to the surrounding environment.

Are you aware of any species listed or proposed to be listed as a Federal threatened or endangered species, or designated critical habitat in the project area? If so, would they be affected by any activities associated with the proposed project?
The project area for the proposed action consists entirely of maintained grass areas on property sites in the Valley that are previously disturbed, used year-round, and do not provide or are not designated as critical habitat.

Are there wetlands or other surface waters inside the project boundaries that potentially fall under CWA jurisdiction as "Waters of the United States?" If so, please describe and estimate any impacts the proposed project may have.
There are no wetlands or other surface waters inside the proposed project area boundaries that potentially fall under Clean Water Act jurisdiction as "Waters of the United States."

When was the water delivery system constructed?
The Las Vegas Valley Water District (LVVWD) commenced operations in 1954 and has served as the Southern Nevada region's largest municipal water provider since that time. As the region evolved so too has the LVVWD's water delivery system to meet the region's needs. The exact age of the water delivery system to each turf conversion site is unknown but would range from 1954 to the present.

Will the proposed project result in any modification of or effects to, individual features of an irrigation system (e.g., headgates, canals, or flumes)? If so, state when those features were constructed and describe the nature and timing of any extensive alterations or modifications to those features completed previously.
The proposed project would not result in the modification of an irrigation system.

The project will result in the modification of rebate recipient's irrigation systems. All spray irrigation will be converted to low volume, pressure-regulated drip irrigation.

Are any buildings, structures, or features in the irrigation district listed or eligible for listing on the National Register of Historic Places? A cultural resources specialist at your local Reclamation office or the State Historic Preservation Office can assist in answering this question.
The proposed project area includes private SFR and non-SFR commercial properties throughout the Valley, all of which have been previously disturbed. There are buildings, structures, or features within the Valley that are listed or eligible for listing on the National Register of Historic Places. However, it is not anticipated that any of these properties will apply for the proposed turf conversion.

Are there any known archeological sites in the proposed project area?
The proposed project area includes private SFR and non-SFR commercial properties throughout the Valley, all of which have been previously disturbed. There are several known archaeological sites throughout the Valley. However, it is not anticipated that any of these sites will apply for the proposed turf conversion.

Will the proposed project have a disproportionately high and adverse effect on low income and minority populations?

The proposed project would not have a disproportionately high and adverse effect on low income and minority populations. The WSL Program is open to all private property owners and the turf conversions would save water for the entire service area.

Will the proposed project limit access to and ceremonial use of Indian sacred sites or result in other impacts to tribal lands?

There would be no direct benefits or adverse effects to Indian tribes by the proposed project. There are no Indian sacred sites or tribal lands within the proposed project area. The proposed project would not limit access to and ceremonial use of Indian sacred sites and would not result in any impacts on tribal lands.

Will the proposed project contribute to the introduction, continued existence, or spread of noxious weeds or non-native invasive species known to occur in the area?

The proposed project area consists entirely of maintained grass areas on privately owned SFR and non-SFR properties in the Valley. Since the properties are maintained, it is unlikely noxious weeds or non-native invasive species occur within their boundaries. Further, Nevada state law requires noxious weed control on all lands, including private property. Therefore, the proposed project would not contribute to the introduction, continued existence, or spread of noxious weeds or non-native invasive species.

10. Required Permits or Approvals

As a non-construction program, it is not anticipated that the implementation of this rebate project will require the issuance of any permits. Property owners of exceptionally large projects may be required to seek permits applicated to the size and scope of work being performed. However, acquisition of such a permit would be the responsibility of the property owner. Such an occurrence is an exception and is not reflective of the standard landscape conversion project.

11. Letters of Support

Attached at the end of this proposal, pages 31 through 36.

12. Official Resolution

An official resolution authorizing the submission of this proposal and confirming the subject matching requirements will go before the SNWA Board of Directors at its November 18, 2021 meeting. A copy will be forwarded to Reclamation at that time.

13. Unique Entity Identifier

SNWA maintains an active registration in SAM.gov. Its Cage Code is 3NRT9. SNWA’s unique entity identifier, or DUNS No., is 135965650, and SNWA’s SAM Unique Identifier is SM1CPB4X7E88.

14. Supporting Documents: Appendices A - C

All appendices are included as attachments via grants.gov.

CITY OF BOULDER CITY
Mayor Kiernan J. McManus
401 California Avenue
Boulder City, NV 89005
(702) 466-0785
kmcmanus@bcnv.org

October 14, 2021

Bureau of Reclamation
WaterSMART Grants: Water and Energy Efficiency Grants
Attn: Mr. Josh German, Program Coordinator
P.O. Box 25007
Denver, CO 80225

Re: Letter of Support, Bureau of Reclamation Notice of Funding Opportunity R22AS00023

Mr. German,

Boulder City is a unique community of 16,000 residents overlooking Lake Mead and one of the most amazing technological advances from the past century – Hoover Dam. We are the "Home of Hoover Dam" being built to house the workers who constructed the dam. Our community has been a leader in Clean Energy for more than eight decades. Lake Mead is more than drinking water for our residents; it also supplies a majority of our hydroelectric power. As we, the residents who can literally see the effects of the drought on the Colorado River and Lake Mead, watch and wonder, we also call on our residents, business owners and community leaders to take action – locally, regionally and federally.

The recent Federal water shortage declaration on the Colorado River means that Nevada's annual allotment will be reduced by seven percent, or 21,000 acre-feet, so conservation measures for Southern Nevada Water Authority (SNWA) member agencies are more critical than ever. As Mayor, I am working with SNWA to put our wastewater to better use. We are currently negotiating a plan to replace potable water with treated effluent to irrigate our two community golf courses.

Over the past 10 years, residents and businesses in Boulder City have received nearly 300 rebates for elimination of non-functional turf (grass that is not used for any purpose beyond mowing). That's more than one football field in grass annually: 589,609 square-feet of turf conversions in the Boulder City service area to date.

With the support of the Bureau of Reclamation's WaterSMART Water and Energy Efficiency Grants program, I believe we can be even more effective through the Water Smart Landscapes Rebate program. The Water Smart Landscapes Rebate program has already been effective at saving billions of gallons of water in southern Nevada.

Since inception, the program has helped property owners upgrade more than 197 million square-feet of lawn to water efficient landscaping.

Please feel free to reach out to me if you would like more details on programs we have started or are investigating. Together, we can help save our precious resource and keep Lake Mead healthy. The WaterSMART Water and Energy Efficiency Grants program is a critical component in these efforts.

Thank you,

Kiernan J. McManus
Mayor
City of Boulder City, Nevada

CITY OF BOULDER CITY
401 California Avenue
Boulder City, NV 89005
www.bcnv.org

Bureau of Reclamation
WaterSMART Grants: Water and Energy Efficiency Grants
Attn: Mr. Josh German, Program Coordinator
P.O. Box 25007
Denver, CO 80225

Re: Letter of Support, Bureau of Reclamation Notice of Funding Opportunity R22AS00023

Mr. German,

In the short three months that I have been the City Manager for Boulder City, I've come to recognize one issue in our community that has a dramatic impact on us all – water levels on Lake Mead. Our entire region is facing challenges as more than 20 years of drought continues to take its toll on the Colorado River and Lake Mead, the source of 90 percent of our water supply. These bodies of water are also the primary source for hydroelectric power that we receive in our city.

Internally, Boulder City Staff members are looking at ways to conserve water, while preserving the natural beauty of trees, shrubs, plants and flowers. For example, Boulder City Code provides requirements for new development landscaping. The current code is more than twenty years old. The city is working with a landscape architect consultant to develop new landscape requirements for new development and guidance for parkway landscaping. The changes focus on installation of desert landscaping and drought-resistant plants.

As a City, we are also contemplating elimination of non-functional grass beyond what AB 356 requires. (Passed in the 2021 Nevada Legislative session, AB 356 prohibits Colorado River water to be used to irrigate non-functional turf in southern Nevada on most commercial and public property starting in 2027.) Programs like Water Smart Landscaping Rebates incentivize property owners to convert non-functional turf now to save water and protect the health and economic future of the region.

I urge the Bureau of Reclamation's WaterSMART Water and Energy Efficiency Grants program to support the Southern Nevada Water Authority/Las Vegas Valley Water District's Water Smart Landscapes Rebate program. The Water Smart Landscapes Rebate program has already been effective at saving billions of gallons of water in southern Nevada. Since inception, the program has helped property owners upgrade more than 197 million square-feet of lawn to water efficient landscaping.

In closing, I believe every opportunity to save water should be considered in the coming years. It will not only help us retain our water and power supplies, but also ensure the health of Lake Mead, one of the most beautiful tourist attractions in Southern Nevada.

Thank you,

Taylour Tedder, CEcD
City Manager, Boulder City

CITY OF
NORTH LAS VEGAS
Your Community of Choice

Utilities Department
2250 Las Vegas Blvd. N., Suite 250 • North Las Vegas, Nevada 89030
Telephone: (702) 633-1275 • Fax: (702) 649-2594 • TDD (800) 326-6868
www.cityofnorthlasvegas.com

October 13, 2021

Bureau of Reclamation
WaterSMART Grants: Water and Energy Efficiency Grants
Attn: Mr. Josh German, Program Coordinator
P.O. Box 25007
Denver, CO 80225

Re: Letter of Support, Bureau of Reclamation Notice of Funding Opportunity R22AS00023

Dear Mr. German,

On behalf of the City of North Las Vegas, I am pleased to provide this letter of support for the Southern Nevada Water Authority's (SNWA) application for the above-referenced funding opportunity.

As an SNWA member agency, the City of North Las Vegas supports SNWA's vigorous conservation efforts, which are more important than ever, given the severe drought conditions in the region and the recent Colorado River shortage declaration. A keystone of the conservation program is the Water Smart Landscapes Rebate program, has helped upgrade more than 3.8 million square-feet of turf to water-efficient landscaping, translating into to billions of gallons of water saved. Funding for this critical program is vital to incentivize property owners to make the switch to water-efficient landscaping, providing permanent water savings for southern Nevada.

If you have questions, please contact the conservation program supervisor, Amanda Dillard, at (702) 633-1877 or at DillardA@cityofnorthlasvegas.com.

Sincerely,

Tom Brady, P.E., LEED AP
Director of Utilities

Cc: Amanda Dillard, Special Assistant to the Utilities Director (conservation program supervisor)

CITY OF HENDERSON
240 Water Street
P.O. Box 95050
Henderson, NV 89009

October 27, 2021

Bureau of Reclamation
WaterSMART Grants: Water and Energy Efficiency Grants
Attn: Mr. Josh German, Program Coordinator
P.O. Box 25007
Denver, CO 80225

Re: Letter of Support, Bureau of Reclamation Notice of Funding Opportunity R22AS00023 Water and Energy Efficiency Grant (WEEG) – Southern Nevada Water Authority

Dear Mr. German:

On behalf of the City of Henderson, I would like to indicate our strong support for the Southern Nevada Water Authority's (SNWA) 2022 WaterSMART Water and Energy Efficiency Grant (WEEG) application. As a member agency of the Southern Nevada Water Authority, we utilize water from the Colorado River to meet our community's needs and member collaboration is critical in effectively adapting to address the impacts of drought and climate change on the water supply we depend upon.

The Water Smart Landscaping Program has proven to be an extremely effective means in southern Nevada to encourage and realize water use reductions in residential and commercial settings. To date, this program has helped convert over 197 million square feet of lawn to water-efficient landscaping and saved billions of gallons of water. WEEG funding will enable the SNWA to continue its Water Smart Landscaping program and accommodate the increasing number of applications for assistance resulting from increased public awareness of the water challenges our community faces.

A WaterSmart WEEG grant will expand our multi-agency partnership in southern Nevada to improve drought and climate change resiliency and support our progress towards water sustainability. I thank you in advance for your positive consideration of the SNWA's application. Please contact me at 702-267-2085 should you require further information.

Sincerely,

Debra March
Mayor

Clark County
Water Reclamation
DISTRICT

October 18, 2021

John Entsminger
Southern Nevada Water Authority
1001 South Valley View Boulevard
Las Vegas, NV 89153

RE: Reclamation WaterSMART Water and Energy Efficiency Grants (WEEG) Application for SNWA Water Smart Landscaping Program

John:

The Clark County Water Reclamation District submits this letter in strong support of the Southern Nevada Water Authority (SNWA) grant application for continued funding of its Water Smart Landscaping Program. We believe the Program provides a valuable benefit to our community – conservation of our most valuable resource, water.

As the largest wastewater treatment facility in the state, collecting, treating, and returning over 110 million gallons of wastewater daily, we understand the critical role of water as a resource for our community. Unlike water that goes down a drain, water used in irrigation systems cannot be captured, treated, or returned to the environment – it is lost. The SNWA has already been proactive in addressing this lost water resource and the Water Smart Landscaping Program demonstrates their ongoing commitment to this cause.

We have a long history of working together to ensure water integrity remains a priority amid challenging environmental dynamics. As water levels continue to decrease in Lake Mead, preserving our water resources is even more paramount to the continued growth and health of our Southern Nevada community. The SNWA is a key partner in both providing water and developing innovative solutions to preserve our region's water resources.

Specifically, the Water Smart Landscaping Program has been effective in our service area. To date, the Program has saved billions of gallons of water by helping covert over 197 million square feet of lawn to water-efficient landscaping. We believe continued Program efforts will benefit our community by equipping residents and business owners with incentives to actively take their own steps toward water conservation.

Regards,

-Tom

Tom Minwegen
General Manager
Clark County Water Reclamation District

5857 East Flamingo Road • Las Vegas, Nevada 89122 • (702) 668-8888 • (800) 782-4324
cleanwaterteam.com

Appendix A

Xeriscape Conversion Study

Southern Nevada Water Authority
Water Smart Landscapes Rebate Program

Xeriscape Conversion Study

Final Report

SOUTHERN NEVADA
WATER AUTHORITY

SNWA Member Agencies

- *Big Bend Water*
- *City of Boulder City*
- *City of Las Vegas*
- *City of Henderson*
- *City of North Las Vegas*
- *Clark County Water Reclamation District*
- *Las Vegas Valley Water District*

2005

By

Kent A. Sovocool
Senior Conservation Programs Analyst
Southern Nevada Water Authority

With data processing assistance from

Mitchell Morgan
Assistant Management Analyst
Southern Nevada Water Authority

Funded in part by a grant from
Bureau of Reclamation
U.S. Department of Interior

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Abstract

The authors present a manuscript covering the Southern Nevada Water Authority's (SNWA) multi-year Xeriscape Conversion Study, which was funded in part by the Bureau of Reclamation - Lower Colorado Regional Area[1].

Xeriscape (low-water-use landscaping) has held the promise of significant water savings for a number of years, but how much exactly it can save, especially as a practical residential landscape concept has been a point of debate and conjecture. Lacking to date has been a truly experimental quantitative study in which per-unit area application data has been gathered to quantify savings estimates (for a variety of reasons, most research has been limited to the total household level, with comparisons involving homes that are mostly xeriscape or traditional landscaping). Recognizing the need for more exacting (and locally applicable) savings estimates, SNWA conducted a study that could yield quantitative savings estimates of what a xeriscape conversion facilitation program could yield under real world conditions.

The experimental study involved recruiting hundreds of participants into treatment groups (a Xeric Study and a Turf Study Group and control groups), as well as the installation of submeters to collect per unit area application data. Data on both household consumption and consumption through the submeters was collected, as well as a wealth of other data. In most cases, people in the xeric study group converted from turf to xeriscape, though in some cases recruitment for this group was enhanced by permitting new landscapes with xeric areas suitable for study to be monitored. Portions of xeric areas were then submetered to determine per-unit area water application for xeric landscapes. The TS Group was composed of more traditional turfgrass-dominated landscapes, and submeters were installed to determine per-unit area application to these areas as well. Submeter installation, data collection, and analysis for a small side-study of multi-family/commercial properties also took place.

Results show a significant average savings of 30% (96,000 gallons) in total annual residential consumption for those who converted from turf to xeriscape. The per-unit area savings as revealed by the submeter data was found to be 55.8 gallons per square foot (89.6 inches precipitation equivalents) each year. Results showed that savings yielded by xeriscapes were most pronounced in summer. A host of other analyses covering everything from the stability of the savings to important factors influencing consumption, to cost effectiveness of a xeriscape conversion program are contained within the report.

An abbreviated summary of the report's findings appears as the *Executive Summary and Conclusions* section (pg. 60).

[1]This report with written and electronic appendices satisfies a deliverables requirement pursuant the applicable funding agreement with the Bureau of Reclamation (Cooperative Agreement #5-FC-30-00440). SNWA gratefully acknowledges BOR for its funding assistance with this project.

Keywords: *water conservation, xeriscape, xeric, landscape conversion, desert landscape low-water-use, plants, landscape, irrigation, residential water consumption, outdoor water use, submeter, irrigation controller, resource conservation, incentive programs, utility, water resources.*

Acknowledgements

There have over the course of this study been so many contributors to this research that thanking each of them individually is an impossibility; however. the authors would like to express their gratitude to individuals in the following groups and organizations without whom this research would not have been possible.

- The study participants without whom no data could have been collected.
- The Southern Nevada Water Authority (SNWA) and the numerous personnel who have supported and promoted this research. The authors especially thank members of the Conservation Division, present and past, which have supported this research over the years.
- The member agencies of the SNWA listed on the cover. Special thanks go to Boulder City, the cities of Henderson and North Las Vegas, and the Las Vegas Valley Water District for the reading of meters and submeters related to the study.
- The SNWA Xeriscape Conversion Study Team and all those who have contributed to study recruitment, data collection, and data processing.
- Aquacraft, Inc. for preliminary analyses and collection of trace flow data.
- The Bureau of Reclamation Lower Colorado River Office and members of this office who helped facilitate funding for the research.
- Those whom have reviewed and commented on the Xeriscape Conversion Study and the results. The authors graciously acknowledge the contributions of reviewers of the final manuscript. Final manuscript reviewers included SNWA personnel in the Conservation and Resources Divisions, members of the Las Vegas Valley Water District's Resources Division, a contractor to the SNWA, and outside reviewers at the City of Austin, Texas. The Bureau of Reclamation also had the opportunity to comment on a draft prelude to final submission.
- Those organizations that have acted as a forum for exhibiting this research.
- Those who have worked for the study in the past and have gone on to other things.
- Those who have supported the research and the research personnel in other capacities.

Introduction and Background

XERISCAPE AND WHAT IT MAY MEAN FOR WATER CONSERVATION

In the Mojave Desert of the southwestern United States, typically 60 to 90% of potable water drawn by single-family residences in municipalities is used for outdoor irrigation. Thus, in this region, and indeed most of the entire Southwest, the most effective conservation measures are oriented towards reducing outdoor water consumption. A commonly considered method for accomplishing water conservation is to use xeriscape (low-water-use landscaping) in place of traditional turf. Xeriscape is based on seven principles:

- Sound Landscape Planning and Design
- Limitation of Turf to Appropriate Areas
- Use of Water-efficient Plants
- Efficient Irrigation
- Soil Amendments
- Use of Mulches
- Appropriate Landscape Maintenance

The term “xeriscape” was invented by Nancy Leavitt, of Denver Water (a public utility) in the early 1980s as a fusion of the Greek word “xeros” (meaning dry or arid) and landscape. Denver Water trademarked the term shortly thereafter though it has entered the English vernacular over the last 20 years as the concept has spread globally.

So promising was xeriscape, that water purveyors and others interested in conservation began actively promoting xeriscape in place of traditional landscape as early as the mid-80s as part of water conservation strategies. The need to better understand its true effectiveness as a conservation tool led to a host of studies being conducted in the 1990s, which have generally pegged savings associated with xeriscape at between 25% and 42% for the residential sector (Bent[1] 1992, Testa and Newton[2] 1993, Nelson[3] 1994, Gregg[4] et al. 1994). The variation in savings estimates is due to a large number of factors ranging from the different climates of each study locality, different local definitions of xeriscape, and different study methodologies employed.

The work done to this point has greatly advanced the water conservation community’s ability to evaluate, modify, and justify programs to encourage the use of xeriscaping as an integral component of water conservation plans. Utilities, water districts, cities, counties, and states are beginning to promote xeriscape as a cost-effective, mutually beneficial alternative to traditional turfgrass-dominated landscapes. Recently, this interest has increased at the national level, and this study is part of that evolution. Interest is further enhanced at the time of publication of this report due to a significant drought impacting the Colorado River Basin and much of the western United States.

NEVADA'S COLORADO RIVER RESOURCES AND THE SPECIAL IMPORTANCE OF OUTDOOR WATER CONSERVATION

The Colorado River serves as the lifeblood for many of the communities of the southwestern United States, permitting society to flourish, despite the harsh, arid conditions that often define it. It serves the needs of millions within the region and its yearly volume is entirely divided up by the Colorado River Compact[5] and subsequent legislation and legal decisions, known as the "Law of the River" that specify allocations for each of the states (and Mexico) through which it flows. Among other things, the Bureau of Reclamation – Lower Colorado Region (BOR-LCR) is charged with maintaining an adequate and established allocation of water for each of the states in the arid Lower Basin. Since water demand management is ultimately accomplished at local levels, BOR-LCR actively partners with entities that divert Colorado River water to encourage conservation. In southern Nevada, the major regional organization meeting this criterion is the Southern Nevada Water Authority (SNWA).

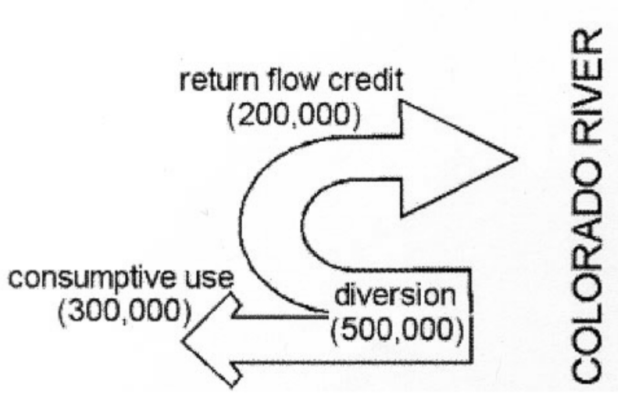
In 1991 the SNWA was established to address water on a cooperative local basis, rather than an individual water purveyor basis. The SNWA is committed to managing the region's water resources and developing solutions that ensure adequate future water supplies for southern Nevada. The member agencies are the cities of Boulder City, Henderson, Las Vegas, North Las Vegas, the Big Bend Water District, the Clark County Water Reclamation District, and the Las Vegas Valley Water District. As southern Nevada has grown into a metropolitan area and a world-famous vacation destination, so too have its water needs. The SNWA was created to plan and provide for the present and future water needs of the area.

Five different water purveyors provide potable water to most of Clark County. Big Bend Water District provides water to the community of Laughlin; the cities of Boulder City and Henderson provide water to their respective communities. The Las Vegas Valley Water District provides water to the City of Las Vegas and portions of unincorporated Clark County; the City of North Las Vegas provides water within its boundaries and to adjacent portions of unincorporated Clark County and the City of Las Vegas. The SNWA member agencies serve approximately 96% of the County's population.

Southern Nevada's climate is harsh. The Las Vegas Valley receives only 4.5 inches of precipitation annually on average, has a yearly evapotranspirational (ET) water requirement of nearly 90 inches, and it is one of the fastest growing metropolitan areas in the United States. Clark County, the southernmost county in Nevada, has a population in excess of 1.6 million people and has been experiencing extremely strong economic growth in recent years with correspondent annual population growth averaging in excess of 5% percent. The primary economic driver of Clark County's economy is the tourism and gaming industry, with an annual visitor volume in excess of 30 million people per year. Today more than 7 out of every 10 Nevadans call Clark County home.

Consumptive use (use where Colorado River water does not return to the Colorado River) is of paramount interest to SNWA (specifically, consumptive use is defined by SNWA as the summation of yearly diversions minus the sum of return flows to the River). A 1964 Supreme Court Decree in Arizona v. California verified the Lower Basin apportionment of 7.5 million acre feet (MAF) among Arizona, California, and Nevada, including Nevada's consumptive use apportionment of 300,000 acre feet per year (AFY) of Colorado River water as specified initially in the Colorado River Compact[5] and Boulder Canyon Project Act[6]. Return flows in Nevada consist mainly of highly treated Colorado River wastewater that is returned to Lake Mead and to the Colorado River at Laughlin, Nevada. With return flow credits, Nevada can actually divert more than 300,000 AFY, as long as the consumptive use is no more than 300,000 AFY (see diagram below). Since Colorado River water makes up roughly 90% of SNWA's current water-delivering resource portfolio, it means that in terms of demand management, reduction of water used outdoors (i.e., water unavailable for accounting as return flow) is much more important in terms of extending water resources than reduction of indoor consumption at this point in time.

Diagram Showing Dynamic of Diversions, Return Flow Credits (from indoor uses) and Consumptive Use



Since most of the SNWA (Authority) service area contains relatively scarce local reserves (there are little surface or groundwater resources) and since, as explained above, its Colorado River apportionment is limited, the organization has an aggressive conservation program that began in the 1990s. The Authority has been committed to achieving a 25% level of conservation (versus what consumption would have been without conservation) by the year 2010 (note though that soon this goal will be revised to probably be even more aggressive in the immediate future due to the drought). In 1995, the SNWA member agencies entered into a Memorandum of Understanding (MOU) regarding a regional water conservation plan. The MOU, updated in 1999, identifies specific management practices, timeline, and criteria the member agencies agree to follow in order to implement water conservation and efficiency measures.

The programs or Best Management Practices (BMPs) listed in the MOU include water measurement and accounting systems; incentive pricing and billing; water conservation coordinators; information and education programs; distribution system audit programs; customer audit and incentive programs; commercial and industrial audit and incentive programs; landscape audit programs; landscape ordinances; landscape retrofit incentive programs; waste-water management and recycling programs; fixture replacement programs; plumbing regulations, and water shortage contingency plans. The BMPs provide the framework for implementing the water conservation plan and guidance as to the methods to be employed to achieve the desired savings.

THE RESEARCH STUDY

The potentially large water savings attainable with the broad-scale use of xeriscaping and the fact that associated reductions are in consumptive-use water makes xeriscape of paramount interest for both BOR and SNWA. For this reason, a partnership between BOR and SNWA was formed to investigate the savings that could be obtained with a program to encourage converting traditional turfgrass landscape to xeriscape. This was formally implemented as a Cooperative Agreement[7] in 1995. With its signing, a multi-year study of xeriscape was born, which has come to be known as the SNWA Xeriscape Conversion Study (XCS). As delineated in the most recent version of the Scope (Appendix 1) for this agreement, the objectives of the Study are to:

- Objective 1: Identify candidates for participation in the Study and monitor their water use.
- Objective 2: Measure the average reduction in water use among Study participants.
- Objective 3: Measure the variability of water savings over time and across seasons.
- Objective 4: Assess the variability of water use among participants and to identify what factors contribute to that variability.
- Objective 5: Measure the capital costs and maintenance costs of landscaping among participants.
- Objective 6: Estimate incentive levels necessary to induce a desired change in landscaping.

SNWA assembled a team to support the XCS, and field data was collected through 2001 with the draft final report finished in 2004 (intermediate reports outlined some of the major conclusions). By agreement, the SNWA agreed to provide the raw data collected for possible use in national research efforts by BOR (data was included with the final version of this manuscript submitted to BOR).

Methodology

STUDY GROUPS AND MONITORING

The study team recruited participants who live in single-family residences within the following entities' water jurisdictions: The Las Vegas Valley Water District (77% of the participants in the entire study group), Henderson (12%), North Las Vegas (9%), and Boulder City (2%).

There are a total of three groups in the XCS, the Xeriscape Study (XS) Group, the Turf Study (TS) Group, and a non-contacted Comparison Group. The XS Group is composed of residents who converted at least 500 square feet (sqft) of traditional turfgrass to xeric landscape as well as residents who installed new xeric landscaping. To clarify, in this region, xeric landscaping is principally composed of a combination of desert-adapted shrubs, trees, some ornamental grasses, and mulch (often rock). A $0.45 per square foot incentive helped the property owner by absorbing some, but not the majority, of the cost of the conversion. Homeowners were required to plant sufficient vegetation so that the xeric landscape would at a minimum have 50% canopy coverage at maturity. This avoided the creation of unattractive "zeroscapes" composed exclusively of rocks, which could potentially act as urban heat islands. The incentive was capped for each residence at $900 for 2,000 sqft; however, many residents converted more landscape than that which qualified for the incentive with the cap. Indeed, the average area converted in this study group was 2,162 sqft. A total of 472 properties were enrolled in the Study as XS Group participants. Aerial photographs, supported by ground measures, were used for recording areas. As a supplement to the main experimental group, 26 multi-family and commercial properties were submetered as well.

In return for the incentive, XS Group residents agreed to ongoing monitoring of their water consumption. This was accomplished in two ways. First, mainmeter data was taken from standard monthly meter reading activity (this was for assessing water use at the entire single-family residence level). Second, residents agreed to installation of a submeter that monitored irrigation consumption on a portion of the xeric landscape. Submeters were typically read monthly, as with mainmeters and were used to study per-unit area application of water comparatively. The area monitored by the submeter was called the Xeric Study Area. Study areas were tied to irrigation zones and stations. Virtually all study properties have in-ground irrigation systems and controllers to avoid the presence or absence of these as a major confounding factor. This experimental control is important because it has been noted that the presence of automated irrigation is highly associated with increased water usage for residential properties (Mayer and DeOreo[8] et al. 1999) apparently because such systems make irrigation more likely to occur regularly versus hand-watering. Having participants in both groups possess automated systems also avoids the potential bias of more heavily turf-covered properties being more likely to be fully automated, thus having higher consumption as was the case for Bent[1] 1992 (as identified in Gregg[4] et al. 1994). All areas of each property were broken down into landscape categories. For example, a XS Group property might have monitored (via the submeter) xeric landscape and unmonitored xeric, turf, garden, and other (non-landscaped) areas. Square footages were recorded for each of these respective area types.

In addition to water-consumption monitoring, residents agreed to a yearly site visit for data-collection purposes. During site visits, information was collected on the xeric species present, plant canopy coverage at the site, components of the irrigation system, and per-station flow rates.

Staff trained in the identification of locally used landscape plants collected data on plant size and species present.

Plant canopy coverage was calculated by first taking the observed plant diameters, dividing this number by two to get radius, then applying the formula for getting the area of a circle ($A=\pi r^2$). This area result was then multiplied by the quantity of those species of plants observed to be at that size. The summation of all areas of all plants of all size classes in the study area is the total canopy coverage for that area.

Data on the components of irrigation systems was collected by staff trained in the different types of irrigation emitters available (ex. drip, microsprays, bubblers, etc.). Staff then ran individual stations and watched meter movement to get the per-station flow rates.

The Turf Study (TS) Group is composed of properties of more traditional landscape design, where an average 2,462 sqft of the landscaped area was of traditional turfgrass (most commonly Fescue). Mainmeter data was collected in the same manner as for the XS Group. Due to design challenges, the submeter was more commonly hooked to monitor a mixed type of landscape rather than just turf, though many did exclusively monitor turf (only “exclusively turf” monitoring configurations were used in per-unit area landscape analyses). TS participants enrolled voluntarily, without an incentive and agreed to yearly site visits as above. Other data on irrigation systems was collected in a manner similar to that for the XS Group properties. A total of 253 residences were recruited into the TS Group.

The enrollment of participant residences into the XS and TS Groups was directly dependent on homeowners’ willingness to participate in this study. For this reason, sampling bias was of reasonable concern to SNWA. To address this, a third subset of non-contacted Comparison Groups was created to evaluate potential biases. Comparison properties were properties with similar landscape footprints and of similar composition to the TS group and pre-conversion XS Group and were in the same neighborhoods as these treatment properties. This control group was also subject to the same water rates, weather, and conservation messaging as the treatment groups. Having this group also permitted SNWA to evaluate the combined effects of submetering and site visits on the treatment groups.

GENERAL DATA METHODS, STRATEGIES, AND STATISTICS

Several different data analysis methods were applied in the course of the study. Details of each can be found in the corresponding subsections below. Broadly, analysis methods fell into the categories of pre- vs. post-treatment evaluations, comparative analyses of different treatment groups, analyses to determine variables associated with consumption, and assorted cost-benefit analyses. Statistical methods employed include descriptive statistics (ex. means, medians, etc.), tests for differences in means assuming both normally distributed data (*t*-tests) and non-normally distributed (i.e., non-parametric) data (*Mann-Whitney U*-tests), as well as techniques employing established economic principles and multivariate regression (some details of regression models are included in Appendix 2). In means comparisons, statistical significance was determined to occur when the probability of a Type I error was less than 5% (α=0.05). Presentation of data involving calculations of differences in values (for example, means differences) may not appear to add up in all cases, due to rounding. Types of data analyzed include mainmeter consumption data, submeter consumption data combined with area data (i.e., application per unit area data), flow-rate data, cost data, survey responses, and assorted demographic and Clark County Assessor's Office data. Consumption data was gathered by the aforementioned purveyor entities and assembled by SNWA. Most other data was collected by SNWA (Aquacraft Inc. also performed some analyses on consumption and data logger collected data under contract to SNWA). In many analyses, data was scatterplotted and objective or subjective outlier removal done as deemed appropriate. Finally, in some cases, data analysis was expanded upon to include attempts at modeling. These endeavors are elaborated on in other parts of the manuscript.

PRE/POST ANALYSES

For each property and year where complete monthly consumption records were available, these were summed to provide yearly consumption. Data for each XS Group property was assembled from the five years before conversion (or as many records as were available; only properties having converted from turf to xeriscape were in this analysis sample) and as many years post-conversion as records permitted up through 2001. These data sets permitted comparison of total yearly consumption before and after the landscape conversion. The impact of submetering and site visits could also be evaluated by comparing mainmeter records for the TS Group pre- and post-installation of landscape submeters. Differences could be further confirmed by comparing the change in total household consumption following the conversion or submetering event for the XS and TS groups respectively against the change in consumption for non-contacted, non-retrofitted properties of similar landscape composition. The general analysis strategy for Objective 2 of the approved Scope (Appendix 1) is summarized in the following tables (Tables 1 and 2):

TABLE 1: Planned Pre-/Post-Retrofit Analyses for XS Group

	Pre-retrofit (kgal/yr)	Post-retrofit (kgal/yr)	Difference in Means (kgal/yr)
Xeriscape Treatment			
Comparison			
Difference in Means (kgal/yr)			

TABLE 2: Planned Pre-/Post-Retrofit Analyses for TS Group

	Pre-retrofit (kgal/yr)	Post-retrofit (kgal/yr)	Difference in Means (kgal/yr)
Submetered Conventionally Landscaped Treatment			
Comparison			
Difference in Means (kgal/yr)			

ANALYSES OF SAVINGS OVER TIME AND SEASONS

Objective 3 directs SNWA to measure the variability of water savings over time and across seasons. In the approved Scope, this was anticipated to involve comparing the XS, TS, and Comparison Groups to derive savings estimates in the manner specified in the tables that follow (Tables 3 and 4):

TABLE 3: Planned Post-Retrofit Analyses for XS Group Across Time

	First Year's Consumption (Y1)	Third Year's Consumption (Y3)	Difference in Means (kgal/yr)
Xeriscape Treatment			
Comparison			
Difference in Means (kgal/yr)			

TABLE 4: Planned Post-Retrofit Analyses for TS Group Across Time

	First Year's Consumption (Y1)	Third Year's Consumption (Y3)	Difference in Means (kgal/yr)
Submetered Conventionally Landscaped Treatment			
Comparison			
Difference in Means (kgal/yr)			

Since in most cases, meters were read monthly or at least bimonthly, SNWA is able to provide an analysis exceeding the level of detail originally specified in the Scope. Specifically, the longevity of savings from conversions for *each* year following the conversion could be evaluated, thus the following new table specifies the more in-depth level for the "over time" analyses called for in Objective 3:

TABLE 5: Enhanced Post-Retrofit Analyses for XS Group Across Time

Mean Post-retrofit Consumption	First Year Post-retrofit (Y1)	Second Year Post-retrofit (Y2)	Third Year Post-retrofit (Y3)	Fourth Year Post-retrofit (Y4)	Fifth Year Post-retrofit (Y5)
Xeriscape Treatment (kgal/year)					
Comparison Group (kgal/year)					
Difference in Means (kgal/year)					

TABLE 6: Enhanced Post-Retrofit Analyses for TS Group Across Time

Mean Post-retrofit Consumption	First Year Post-retrofit (Y1)	Second Year Post-retrofit (Y2)	Third Year Post-retrofit (Y3)	Fourth Year Post-retrofit (Y4)	Fifth Year Post-retrofit (Y5)
Submetered Conventionally Landscaped Treatment (kgal/year)					
Comparison Group (kgal/year)					
Difference in Means (kgal/year)					

Recruitment of properties for the XCS spanned a couple of years. For this reason, in order to evaluate true changes over time, the first year after each conversion was designated as Y1, the second as Y2, and so forth. As such, consumption data for a property starting in, for example, 1995, was designated as belonging to Y1, but for a different property starting in 1996, 1996 was Y1. In this way, the impact of different start years was corrected for and multiyear analyses could be considered on a more common basis. This permits inferences to be made about how landscape water consumption and savings change over time as plants in the xeric areas mature. It is also the reason the sample size appears to diminish for the XS Groups from Y1 to Y5. It is not that there was heavy loss of sample sites, rather that fewer sites were in existence for a total of five years owing to early enrollment. A similar effect is seen in the TS Group. There is no data for Y5 for the TS Group because enrollment for that Group started later than for the XS Group.

Savings from xeriscape may be greatest in summer when evapotranspirational demand is greatest for all plants, but so to an extreme degree in southern Nevada for turfgrasses (Source: University of Nevada Cooperative Extension). In considering how savings may be different across seasons, the Scope (Appendix 1) directs the SNWA to certain prescribed analyses (Tables 7 and 8):

TABLE 7: Planned Summer Post-Retrofit Analyses for XS Group

	Pre-Retrofit Summer Consumption (kgal/month)	**Post-Retrofit Summer Consumption (kgal/month)**	**Difference in Means (kgal/month)**
Xeriscape Treatment			
Comparison Group			
Difference in Means (kgal/month)			

TABLE 8: Planned Summer Post-Retrofit Analyses for TS Group

	Pre-Retrofit Summer Consumption (kgal/month)	Post-Retrofit Summer Consumption (kgal/month)	Difference in Means (kgal/month)
Submetered Conventionally Landscaped Treatment			
Comparison Group			
Difference in Means (kgal/month)			

Because of the resolution available by submetering, even more detailed data pertaining to application of water to turf and xeriscape through seasons is available in the comparative per-unit area irrigation analyses (see following section and Comparison of Per-Unit Area Water Application between Turfgrass and Xeric Landscape in *Results and Discussion*).

COMPARATIVE PER-UNIT AREA IRRIGATION ANALYSES

Submeter consumption data combined with measurement of the irrigated area permitted calculation of irrigation application on a per-unit area basis (gallons per square foot, which can also be expressed as precipitation inches equivalents) for most study participants. In this way, exacting measures of consumption for irrigation of xeric and turf landscape types could be measured. The sample size (N_s) is the product of the number of months or years of data and the number of valid submeter records analyzed. Sample sizes for specific analyses appear in *Results and Discussion*. Only records for submeters that monitored turf exclusively were included in per-unit area analyses involving the TS Group so that other landscape types would not confound calculation of results.

No prescribed analyses of submeter consumption data appear in the Scope. The two basic sets of analyses selected by SNWA were (i.) a comparative analysis of annual application to xeric and turf areas and (ii.) a comparative analysis of monthly application to xeric and turf areas. The analytical setup of these appears in Tables 9 and 10 respectively. Secondary analyses comparing usage to theoretical reference ET demand projections follow the basic comparisons and appear in *Results and Discussion*.

TABLE 9: Planned Comparative Analysis of Turf and Xeric Per Unit Area Annual Application

	Per Unit Area Application (gallons/square foot/year)
Submetered Turf (TS Group)	
Submetered Xeriscape (XS Group)	
Difference (gallons/square foot/year)	

TABLE 10: Planned Comparative Analysis of Turf and Xeric Per Unit Area Application for Each Month

	Jan Gal/SqFt	Feb Gal/SqFt	Mar Gal/SqFt	Apr Gal/SqFt	May Gal/SqFt	Jun Gal/SqFt	Jul Gal/SqFt	Aug Gal/SqFt	Sep Gal/SqFt	Oct Gal/SqFt	Nov Gal/SqFt	Dec Gal/SqFt
Submetered Turf (TS Group)												
Submetered Xeriscape (XS Group)												
Difference (gallons/square foot/month)												

MULTIVARIATE ANALYSES TO IDENTIFY SIGNIFICANT SOURCES OF VARIABILITY

Objective 4 of the Scope (Appendix 1) directs SNWA to assess variability of water use amongst the study participants and identify what factors contribute to that variability. Potential sources of variability originally specified for investigation in the Scope included the following:

- Number of members in the household
- Age of occupants
- Number of bathrooms
- Income
- Home value
- Percentage of xeriscaping
- Xeriscape density
- Turf type
- Type of irrigation
- Lot size
- Landscapeable area
- Existence of a pool
- Flow rates
- Water use factors

As the XCS developed, additional potential factors were assessed. A complete listing of data recorded is included in Appendix 3 (not all data was collected for all properties in the study).

Preliminary investigations focused on some of the above variables from a principally univariate analysis perspective (DeOreo[9] et al. 2000, Sovocool[10] et al. 2000, Sovocool and Rosales[11] 2001, Sovocool[12] 2002). The advantage of this was that it permitted rapid quantification and association of target variables' influences on participant water use, especially at the per-unit area scale. However, the most sophisticated way to deal with a study of this type where there are a number of potential independent associations of several predictor variables to a dependent variable is by the application of multivariate regression analysis methods. This permits so-called "partial regression" of independent variables to the target dependent one, here water consumption. Multiple regression for estimation can be expressed in the general multiple regression equation as follows:

$$\hat{Y}_i = \hat{a} + \hat{b}_1 * X_{1i} + \hat{b}_2 * X_{2i} + \ldots + \hat{b}_{ni} * X_{ni} + \in$$

Where $\hat{Y}$ is the estimated dependent variable, $\hat{a}$ is the y-axis intercept, $\hat{b}$ is each estimated beta partial regression coefficient representing the independent contribution of each independent variables' influence on $\hat{Y}$, X is each independent variable up to the *nth* variable, *i* is the time period and $\in$ is the error term for the model.

Multicollinearity between X variables violates the underlying assumptions of regression models and can be dealt with by setting limiting tolerance thresholds of similarity in contribution of variability to a regression model. This, in turn, permits identification and possible exclusion of such highly collinear and possibly inappropriate independent variables. The most significant variables can then be quantified and their relative vector and magnitude of association on the dependent variable can be deduced, ultimately yielding an explanatory multivariate model of how such variables may contribute to water consumption. Such variables are explored for association to total household consumption and xeric landscape submeter consumption in the results section in two distinct modeling exercises.

ECONOMIC ANALYSES

Objective 5 of the Scope mandates quantification and measurement of capital costs and maintenance costs of the conversion. In the summer of 2000, data on landscape maintenance economics was obtained via surveys sent to study participants. The survey helped quantify both labor hours and direct costs associated with landscape choices. For details on the survey and methodology, consult Hessling[13] (2001). Three hundred surveys were returned for analysis. Results of these were tabulated and compiled, and analyses proceeded from there.

By the very nature of the study methodology, it was recognized at the outset that a simple comparison of the XS and TS groups would likely fail to demonstrate the economic considerations with respect to maintenance of the whole landscape level as most residents' landscapes were composed of multiple landscape types (at the least, both xeric and turfgrass areas). This led to an analytical method of comparing the costs of landscape maintenance based on the relative percentages residents had of turf and xeric areas respectively.

The water bill savings associated with conversion projects were calculated based on the Las Vegas Valley Water District's water rates as they currently stand (in early 2004). Savings were calculated by modeling bills for a typical fifth decile (midrange in consumption) home where the average yearly consumption is 208,057 gallons and for such a home doing an average (according to data collected for the Water Smart Programs single-family sector in early 2004) 1,615.8-sqft-conversion from turfgrass to xeric landscape (note the difference in this average size conversion relative to that of the XS Study Group; conversion sizes, along with lot sizes, have diminished over time in this area). Bills were modeled on a monthly basis and all charges were applied that actually appear for customers. An example output of this model appears in Appendix 4.

As directed in the Scope (Appendix 1), the financial viability of xeriscape conversions was explored. This necessitated looking at the economics of conversions from the homeowner and SNWA perspectives. Hessling[13] (2001) attempted some of these initially. A follow-up analysis from these same perspectives was performed in the writing of this report and is included in *Results and Discussion*. The homeowner perspective included an estimative Net-Present-Value (NPV)-based modeling approach to determine when return on investment (ROI) was achieved and details on this model appear in Appendix 5. This same model is used to determine the incentive level necessary to induce change (Objective 6) by making some assumptions about what timeframe is acceptable for owners to achieve ROI. The approach used for the SNWA perspective is to consider alternative sources of water and use the cost associated with these to determine the maximum amount SNWA should pay to help convert grass to xeric landscape.

Results and Discussion

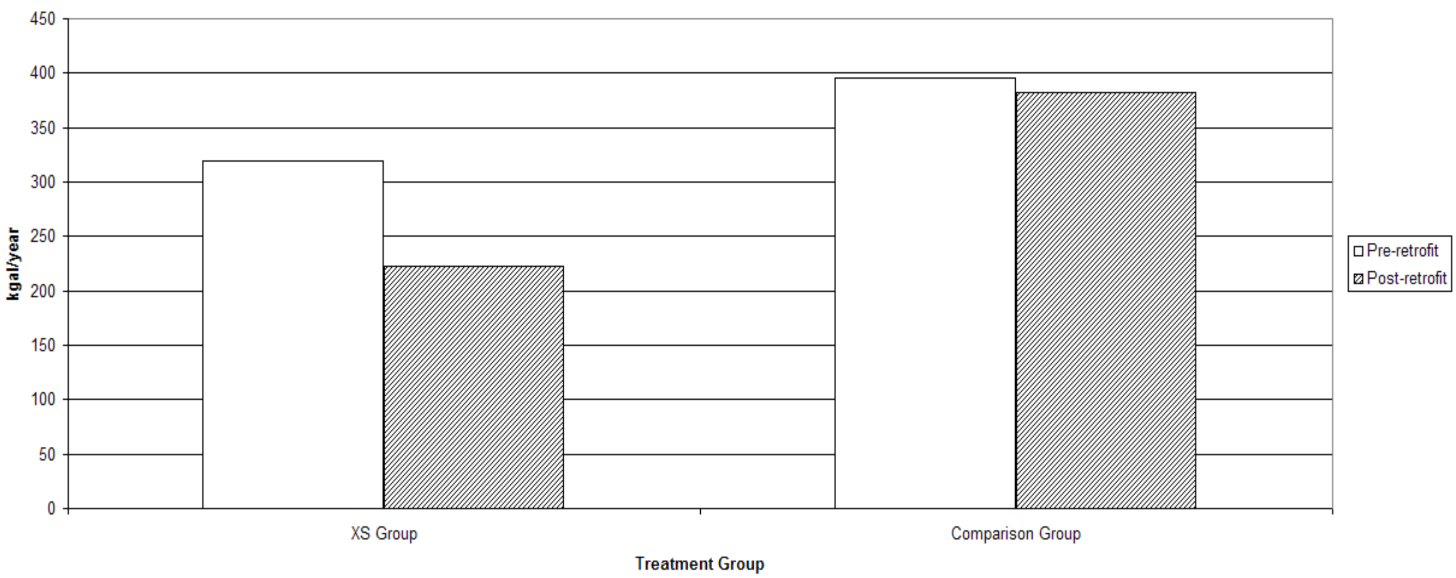
REDUCTION IN TOTAL HOUSEHOLD WATER CONSUMPTION FOLLOWING CONVERSION TO XERISCAPE

Results for the XS Group pre/post-conversion comparisons are shown in Table 11 and Figure 1.

TABLE 11: Pre-/Post-Retrofit Analyses for XS Group

	Pre-retrofit (kgal/yr)	**Post-retrofit (kgal/yr)**	**Difference in Means (kgal/yr)**	**t-tests (* denotes significance)**
Xeriscape Treatment n=321	**Mean=319** Median=271	**Mean=223** Median=174	**96*** (30% reduction from pre-retrofit)	**t=16.8* p<0.01**
Comparison n=288	**Mean=395** Median=315	**Mean=382** Median=301	**13** (3% reduction from pre-submetering)	**t=1.85 p=0.07**
Difference in Means (kgal/yr)	**76***	**159***		
t-tests (* denotes significance)	**t=4.32* p<0.01**	**t=9.69* p<0.01**		

FIGURE 1: Pre-/Post-Retrofit Consumption for XS and Comparison Groups



Mean monthly consumption for the residences dropped an average of 30% following conversion. A dependent *t*-test demonstrates that the reduction in usage is highly significant (*t*=16.8; p<0.01).

Though individual performance may vary greatly, the overwhelming majority of homes in the study saved water following the conversion (285 out of 321 analyzed). This finding of about a third reduction in consumption is nearly identical to findings from a study of residences in Mesa, Arizona (Testa and Newton[2] 1993). It may be that a reduction of about this percentage may be anticipated to occur when the average single-family residence built in the late 20th century does an average-size conversion in the southwestern United States. The large savings are likely in part because the great majority of water consumption goes to outdoor irrigation in this region. In this study, the average savings realized was 96,000 gallons per year per residence.

The difference in consumption of the pre-retrofit homes to the non-contacted comparison homes is shown in Table 11 and Figure 1. As demonstrated, a *t*-test of consumption between these two groups shows there was significant difference in initial consumption between the two groups (t=4.32; p<0.01), suggesting self-selection bias. This is not surprising since recruitment of study participants was voluntary. People who were already conserving more were apparently more likely to enroll and agree to convert a portion of their respective properties. This does not however invalidate the results, as (i.) this incentive-based approach is essentially the same as the approach used for enrolling people in the actual program SNWA has (see Appendix 5) and, more importantly (ii.), there is no compelling evidence that the Comparison Group experienced significant reduction over the same time period so the savings are likely attributable exclusively to the landscape conversion.

The analysis procedures in the Scope (Appendix 1) suggest that the impact of submetering on outdoor irrigation may be revealed by comparing consumption at the conventionally landscaped properties with submeters (the TS Group) to that for the associated comparisons for that Group. The data appearing in Table 12 fulfill this prescribed Scope treatment.

TABLE 12: Pre-/Post-Retrofit Analyses for TS Group

	Pre-submetering (kgal/year)	**Post-submetering (kgal/year)**	**Difference in Means (kgal/yr)**	**t-tests (* denotes significance)**
Submetered Conventionally Landscaped Treatment n=205	**Mean=352** Median=303	**Mean=319** Median=268	**34*** (10% reduction from pre-retrofit)	**t=5.08* p<0.01**
Comparison n=179	**Mean=364** Median=314	**Mean=347** Median=296	**17*** (5% reduction over timeframe)	**t=2.08* p<0.05**
DIFFERENCE IN MEANS (KGAL/YR)	**12**	**28**		
T-TESTS (* DENOTES SIGNIFICANCE)	**t=0.52 p=0.60**	**t=1.41 p=0.16**		

There are two potential issues though with trying to consider this analysis an evaluation of the effectiveness of submetering. First, submetering is typically studied where the scenario is one where water consumption through the submeter is relayed to end-use customers and where the customers are billed for it. Without consumption data and billing, the residents in this study have received no price signal to encourage them to read the meter or reduce consumption. This theory corresponds with what staff members have observed in the field with respect to the behavior of customers. Most participants apparently did not even think about the meter until it was time for their yearly site review and often they stated they had forgotten it was even there. So here, the dynamic of submetering is rather unique and the impact most likely minimal.

The second consideration, at least as potentially significant, is the fact that participants had been exposed to annual site visits, which is likely a more important variable in terms of modifying behavior (no conservation training or formal education took place at site visits, though staff members did answer questions posed to them). Indeed, the Comparison Group provides for a good gauge of the impacts on treatment groups due to site visits. Initially, results seem to suggest a reduction of possibly up to 34,000 gallons annually associated with visits and submetering (t=5.08; $p<0.01$) though, as revealed in the next analyses, this impact appears to be only temporary (seen only in the first year, Table 15) and is probably in actuality much more negligible given half the "reduction" also appears to have taken place in the control group (t=2.08, $p<0.05$). The control group reduction may be due to background conservation at the community level.

With respect to understanding how submetering with consumption billing may be of conservation benefit, a national research effort (Mayer et al. 2004[14]), supported in part by SNWA, has just been completed which provides much more insight into the benefits of submeters for water conservation purposes (also see Rosales[15] et al. 2002).

Assessment of Savings Potential Across Time and Seasons

For the XS Group, significant reduction in total yearly consumption took place immediately following conversion and remained relatively stable at that decreased level through subsequent years, showing no erosion with time (Table 13 and Figure 2). In every year, the XS Group consistently had lower consumption than the Comparison Groups, and this was statistically significant (Table 13). This suggests that conversions are a viable way to gain substantial water savings over at least a medium-term timeframe and quite possibly over a long one as well. It also resolves questions about whether or not xericape takes more water in the first year following conversion (apparently the answer is no) and it suggests that, at least over the medium-term, there is no erosion of savings obtained from conversions due to residents' response to growth of plants in their xeric areas.

For the XS Group, the relative reduction in consumption became even more pronounced in the summer (Table 14) where, savings averaged 13,000 gallons per summer month (Table 14: t=18.5;$p<0.01$) versus an average of 8,000 per month over the entire year. It should be noted that a very small, but statistically significant reduction of 1,600 gallons per month appears to have also taken place in the Comparison Group during the summer (in a pre- vs. post-comparison of the study timeframe, Table 14: t=1.98; $p<0.05$). Overall, the results are consistent with the theory that xeric landscapes save the most during the summer. The comparative per-unit analyses that follow reveal why this is the case.

In considering savings stability over extended time, it was found that the submetered TS group only demonstrated significantly decreased consumption for the first year following retrofit, after which savings were not significant (Table 15; statistics in table). This initial reduction might be due to residents' interest in the research and in conservation when new to the study, this wearing off with time. Again, it is important to recall that in no single year was the consumption statistically different from the comparison group properties. The submetered TS Group did have significantly lower consumption in the summer, with a savings of 3,300 gallons per month (Table 16: t=3.78;p<0.01) whereas the comparison group to the TS Group showed no such reduction (Table 16: t=1.03;p=0.31). However, there was no difference in average monthly summer consumption between the submetered properties and the controls after the retrofit (Table 16: t=1.03;p=0.31). Overall the results in Table 15 seem to reflect the finding that little enduring change in consumption was achieved by the TS Group over time despite submeter installation.

FIGURE 2: Pre-/Post-Retrofit Consumption for XS Group Across Time

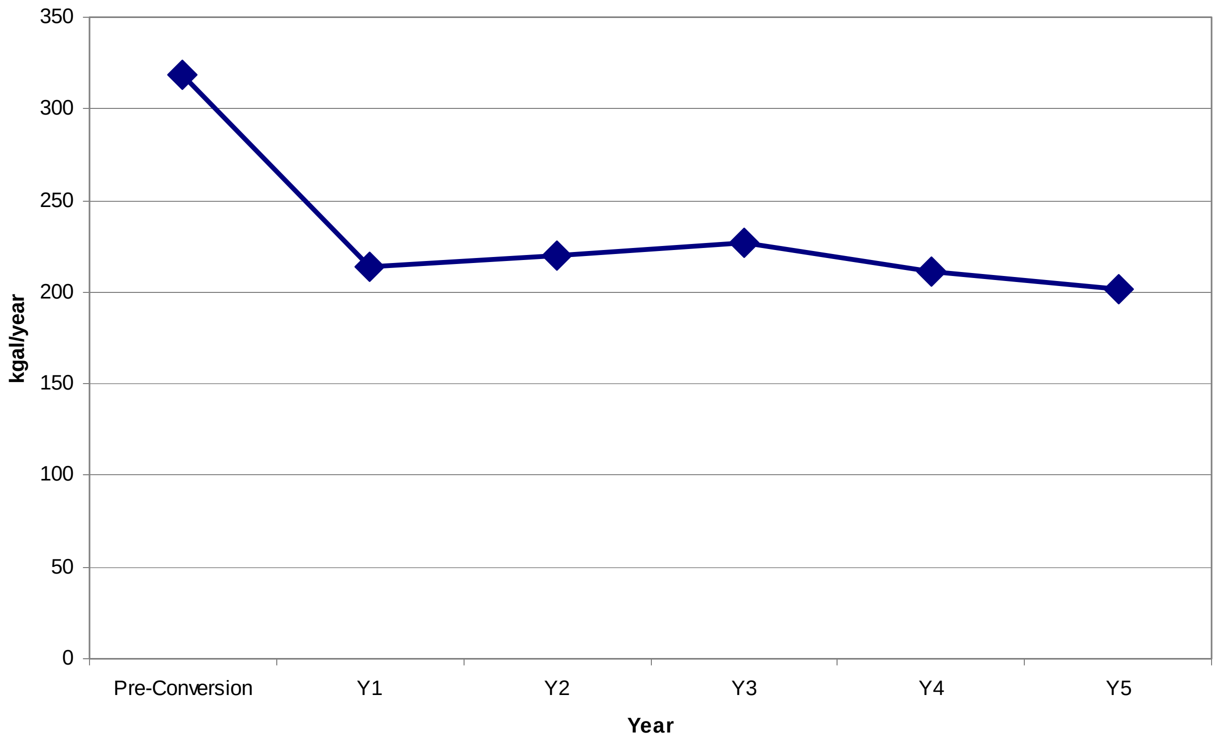


TABLE 13: Enhanced Post-Retrofit Analyses for XS Group Across Time

Post-retrofit Consumption	First Year Post-retrofit (Y1)	Second Year Post-retrofit (Y2)	Third Year Post-retrofit (Y3)	Fourth Year Post-retrofit (Y4)	Fifth Year Post-retrofit (Y5)
Xeriscape Treatment (kgal/year)	**214^{Δ}** (32% reduction from pre-retrofit) n=320	**220^{Δ}** (30% reduction from pre-retrofit) n=318	**227^{Δ}** (28% reduction from pre-retrofit) n=306	**211^{Δ}** (33% reduction from pre-retrofit) n=211	**202^{Δ}** (36% reduction from pre-retrofit) n=61
Comparison Group (kgal/year)	**372** n=280	**387** n=275	**383** n=260	**362** n=183	**345** n=54
Difference in Means (kgal/year)	**158**	**167**	**156**	**151**	**143**
t-tests (* denotes significance)	**t=9.98* p<0.01**	**t=9.29* p<0.01**	**t=9.08* p<0.01**	**t=8.02* p<0.01**	**t=4.85* p<0.01**

Treatment group values with a $^{\Delta}$ are significantly lower than pre-retrofit value.

TABLE 14: Summer Post-Retrofit Analyses for XS Group

	Pre-Retrofit Summer Consumption (kgal/month)	Post-Retrofit Summer Consumption (kgal/month)	Difference in Means (kgal/month)	t-tests (* denotes significance)
Xeriscape Treatment n=321	**Mean=38** Median=31	**Mean=25** Median=19	**13***	**t=18.5* p<0.01**
Comparison Group n=288	**Mean=47** Median=38	**Mean=46** Median=35	**1.6***	**t=1.98* p<0.05**
Difference in Means (kgal/month)	**9***	**21***		
t-tests (* denotes significance)	**t=4.23* p<0.01**	**t=10.1* p<0.01**		

TABLE 15: Enhanced Post-Retrofit Analyses for TS Group Across Time

Post-submetering Consumption	First Year Post-submetering (Y1)	Second Year Post-submetering (Y2)	Third Year Post-submetering (Y3)	Fourth Year Post-submetering (Y4)	Fifth Year Post-submetering (Y5)
Submetered Conventionally Landscaped Treatment (kgal/year)	**291**$^{\Delta}$ (6% decrease from pre-submetering) n=228	**312** (1% increase from pre-submetering) n=229	**317** (2% increase from pre-submetering) n=228	**315** (2% increase from pre-submetering) n=146	**No Data Available**
Comparison Group (kgal/year)	**332** n=170	**357** n=173	**351** n=167	**351** n=108	**No Data Available**
Difference in Means	**41**	**45**	**34**	**36**	
t-tests (* denotes significance)	**t=2.28 p=0.02**	**t=2.39 p=0.02**	**t=1.65 p=0.10**	**t=1.40 p=0.16**	

Treatment group values with a $^{\Delta}$ are significantly lower than pre-submetering value.

TABLE 16: Summer Post-Retrofit Analyses for TS Group

	Pre-Submetering Summer Consumption (kgal/month)	Post-Submetering Summer Consumption (kgal/month)	Difference in Means (kgal/month)	t-tests (* denotes significance)
Submetered Conventionally Landscaped Treatment n= 205	**Mean=41.7** Median=34.0	**Mean=38.5** Median=31.0	**3.3***	**t=3.78* p<0.01**
Comparison Group n=179	**Mean=42.0** Median=36.0	**Mean=41.0** Median=34.7	**1.0**	**t=1.02 p=0.31**
Difference in Means (kgal/month)	**0.3**	**2.5**		
t-tests (* denotes significance)	**t=0.97 p=0.92**	**t=1.03 p=0.31**		

COMPARISON OF PER-UNIT AREA WATER APPLICATION BETWEEN TURFGRASS AND XERIC LANDSCAPE

Annual application

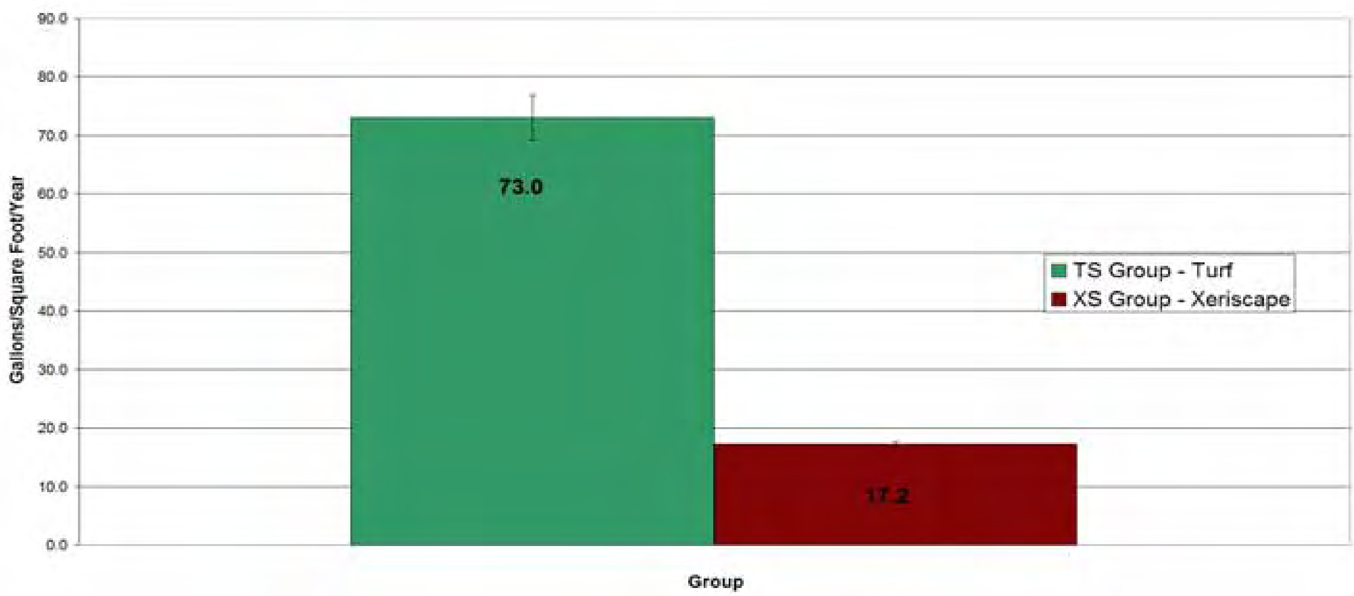
Annual per unit area irrigation application data summaries are found in Table 17 and Figures 3 and 4. There was a great difference in the annual water application to turf and xeric landscape areas (Table 17 and Figure 3). Turf received an average of 73.0 gallons per square foot annually (117.2 inches), while xeriscape received on average, just 17.2 gallons (27.6 inches) each year (only 23.6% of the amount of water applied for turfgrass maintenance). The difference was thus 55.8 gallons per square foot per year (89.6 inches), and this was found to be highly significant assuming a normal distribution of data ($t=27.0$; $p<0.01$).

TABLE 17: Annual Per-Unit Area Application to Turf and Xeriscape

	Per Unit Area Application (gallons/square foot/year)	Per Unit Area Application (inches/year)	Sample Distribution Statistics
Submetered Turf (TS Group) $n_s=107$	**Mean=73.0** Median=64.3	**Mean=117.2** Median=103.2	**Standard Deviation=40.0 Skewness=1.17 Kurtosis=1.36**
Submetered Xeriscape (XS Group) $n_s=1550$	**Mean=17.2** Median=11.5	**Mean=27.6** Median=18.5	**Standard Deviation=18.6 Skewness=3.14 Kurtosis=14.9**
Difference (gallons/square foot/year)	**Mean=55.8**	**Mean=89.6**	
t-tests (* denotes significance)	**t=27.0* p<0.01**		
Levene's Test (* denotes significance)	**F(1, 1655)=130.3* p<0.01**		
Mann-Whitney U Test (* denotes significance)	**U=10177 z=15.2* p<0.01**		

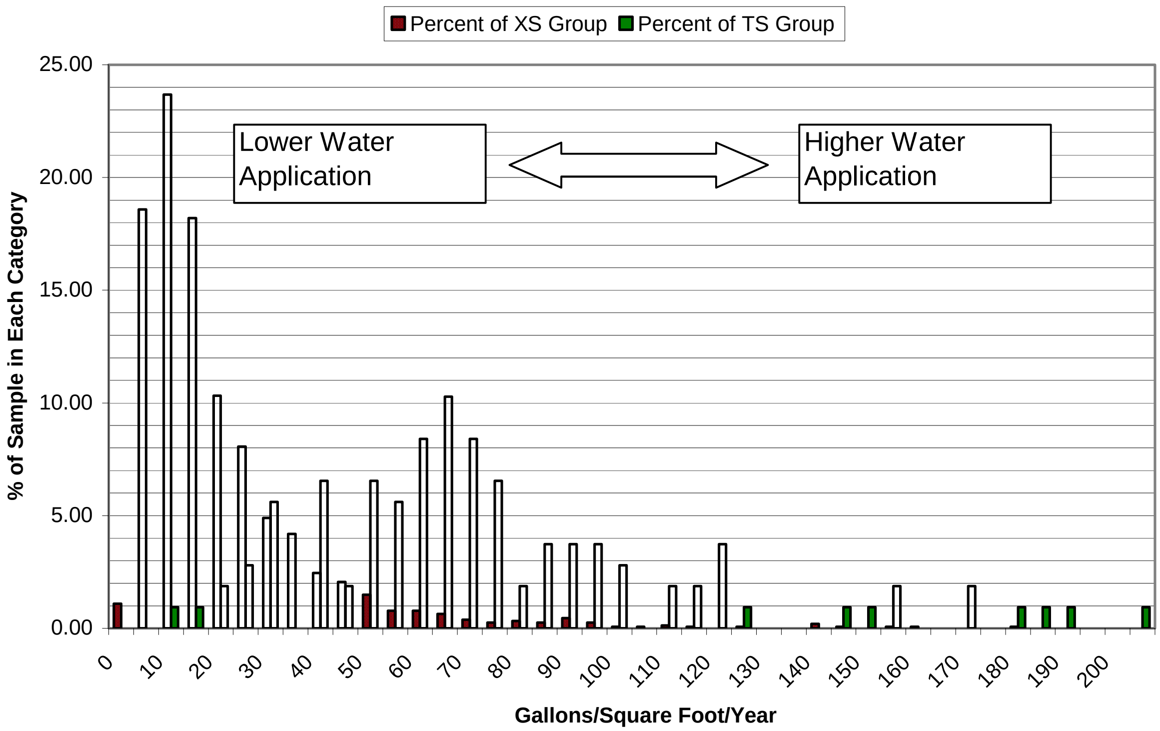
Detailed statistics were not generated for the small set of multifamily and commercial sites; however, the average consumption on those xeric areas where viable data could be collected was 16.7 gallons per square foot per year ($n_s=22$). This suggests the use of xeric landscape in these sectors may result in similar savings as that observed above on a comparative landscape basis (i.e., savings of ca. 55.8 gallons per square foot annually versus what application would have been for turf).

FIGURE 3: Annual Per Unit Area Application to Turf and Xeriscape



Distinct differences in the sample distributions for the XS and TS irrigation data were of concern from a statistical analysis perspective. Both distributions had features strongly suggesting data was not distributed homogenously across the two groups (Table 17 and Figure 4). In particular, the XS Group data was heavily skewed with the vast majority of participants using very little water. Turf application, while indeed skewed, appears almost normal compared to xeric application, which is very heavily skewed (skewness = 3.14) and peaks sharply (kurtosis=14.9) at the lower end of the distribution. This is because the vast majority of XS participants used a *very* small amount of water to irrigate their xeric areas, while a handful used greatly more volume on theirs. Because *t*-tests assume normality, the atypical and non-congruent distributions were of sufficient concern to justify running a Levene's Test simultaneous with the *t*-tests to assess the potential need to apply non-parametric analytical techniques (though in practice the need for normality is lessened with large sample sizes due to the tendency of such a collection of data to mimic a normal distribution; aka. the central limit theorem). Indeed, the Levene's Tests demonstrated significant differences in the distributions [Levene $F(1,1655) = 130.3$; $p<0.01$]. This suggested the need to backup the findings with non-parametric approaches. *Mann-Whitney U* (a summation and ranking based approach to the problem) was chosen as a good backup test. Associated *z* statistics for this test with corresponding probabilities are thus reported with the results in Table 17 as supporting evidence for statistical difference in irrigation application between the groups.

FIGURE 4: Distribution of Annual Per Unit Area Application Data for Turf and Xeriscape



Monthly Application

Monthly submeter data summaries for the XS Group and exclusively monitored turf TS Group participants appear in Table 18. It should be noted that at times the interval between reads stretched over more than one month and thus the dataset for the monthly data is slightly different than that for the above annual comparison as only consumption data deemed complete and assignable to a given month could be included (sometimes consumption across a two-month gap was averaged to fill the gap). There were issues with resolution in monitoring because typically at least a thousand gallons had to pass through the meter between reads in order for the consumption figure to be advanced and registered by the reader, and sometimes this did not happen for XS Group submeters monitoring relatively small areas due to low consumption. Both these factors likely result in slight inflation of monthly consumption values for both groups and this indeed appears to be manifest if monthly averages are summed across the year (i.e., this per unit area consumption figure is slightly higher than the annual one calculated in the previous section). Still, on a monthly basis the data is generally valid and valuable in comparative analyses and in comparing water application to irrigation requirements. Per-unit area application data is displayed graphically in Figure 5.

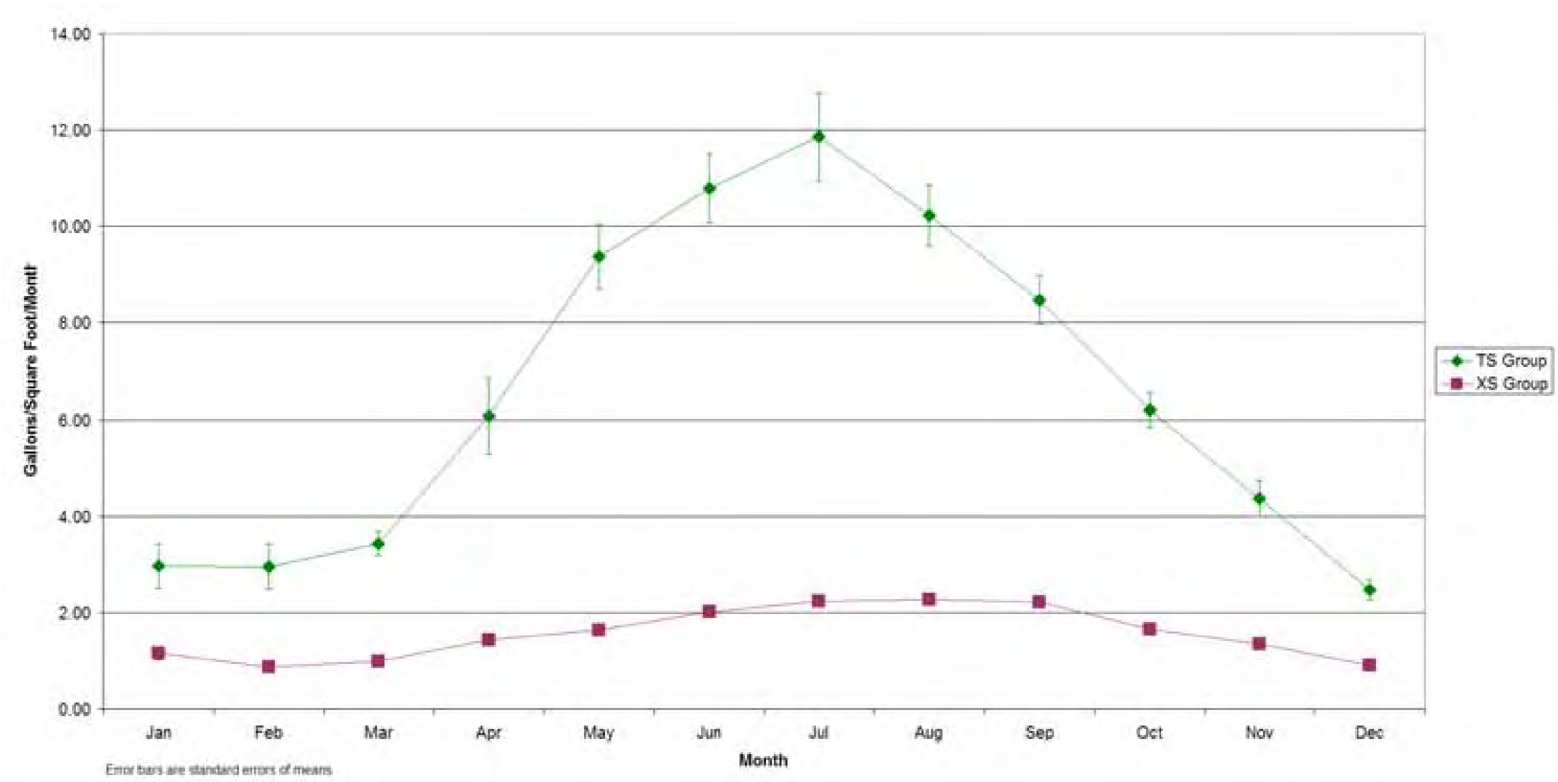
TABLE 18: **Monthly Per-Unit Area Application to Turf and Xeriscape**

	Jan Gal/SqFt	Feb Gal/SqFt	Mar Gal/SqFt	Apr Gal/SqFt	May Gal/SqFt	Jun Gal/SqFt	Jul Gal/SqFt	Aug Gal/SqFt	Sep Gal/SqFt	Oct Gal/SqFt	Nov Gal/SqFt	Dec Gal/SqFt
Submetered Turf (TS Group)	**2.97** 2.11 n_s=85	**2.96** 2.06 n_s=85	**3.44** 3.29 n_s=85	**6.07** 4.85 n_s=88	**9.37** 7.86 n_s=93	**10.79** 9.38 n_s=93	**11.86** 10.50 n_s=95	**10.23** 8.71 n_s=96	**8.47** 7.15 n_s=99	**6.20** 5.29 n_s=105	**4.37** 3.50 n_s=107	**2.47** 1.96 n_s=106
Submetered Xeriscape (XS Group)	**1.16** 0.46 n_s=1291	**0.87** 0.43 n_s=1337	**0.99** 0.57 n_s=1377	**1.43** 0.83 n_s=1409	**1.64** 1.08 n_s=1412	**2.01** 1.30 n_s=1421	**2.24** 1.40 n_s=1431	**2.27** 1.39 n_s=1456	**2.22** 1.27 n_s=1496	**1.66** 1.02 n_s=1519	**1.35** 0.77 n_s=1534	**0.91** 0.48 n_s=1534
Difference (Gallons/Sqft)	**1.81**	**2.09**	**2.45**	**4.64**	**7.74**	**8.78**	**9.62**	**7.96**	**6.25**	**4.54**	**3.02**	**1.56**
t-tests (* denotes significance)	**t=73.36* p<0.01**	**t=7.52* p<0.01**	**t=13.33* p<0.01**	**t=9.92* p<0.01**	**t=29.87* p<0.01**	**t=27.7* p<0.01**	**t=26.22* p<0.01**	**t=21.96* p<0.01**	**t=13.15* p<0.01**	**t=17.59* p<0.01**	**t=13.45* p<0.01**	**t=9.39* p<0.01**
Mann-Whitney U Tests (* denotes significance)	**U=23499 z=8.84* p<0.01**	**U=18127 z=10.54* p<0.01**	**U=15959 z=11.27* p<0.01**	**U=14225 z=12.14* p<0.01**	**U=6824 z=14.49* p<0.01**	**U=4415 z=15.10* p<0.01**	**U=6062 z=14.89* p<0.01**	**U=9776 z=14.13* p<0.01**	**U=12307 z=13.91* p<0.01**	**U=14501 z=14.04* p<0.01**	**U=25290 z=11.98* p<0.01**	**U=31202 z=10.62* p<0.01**

Note: bold gal/sqft values are means; regular font gal/sqft values are medians

The first, most obvious finding from the graph is that, turf application exceeds xeric application by a large statistically significant margin in every month. Ultimately, this is what constitutes the large annual savings seen at the annual landscape application and total home consumption levels.

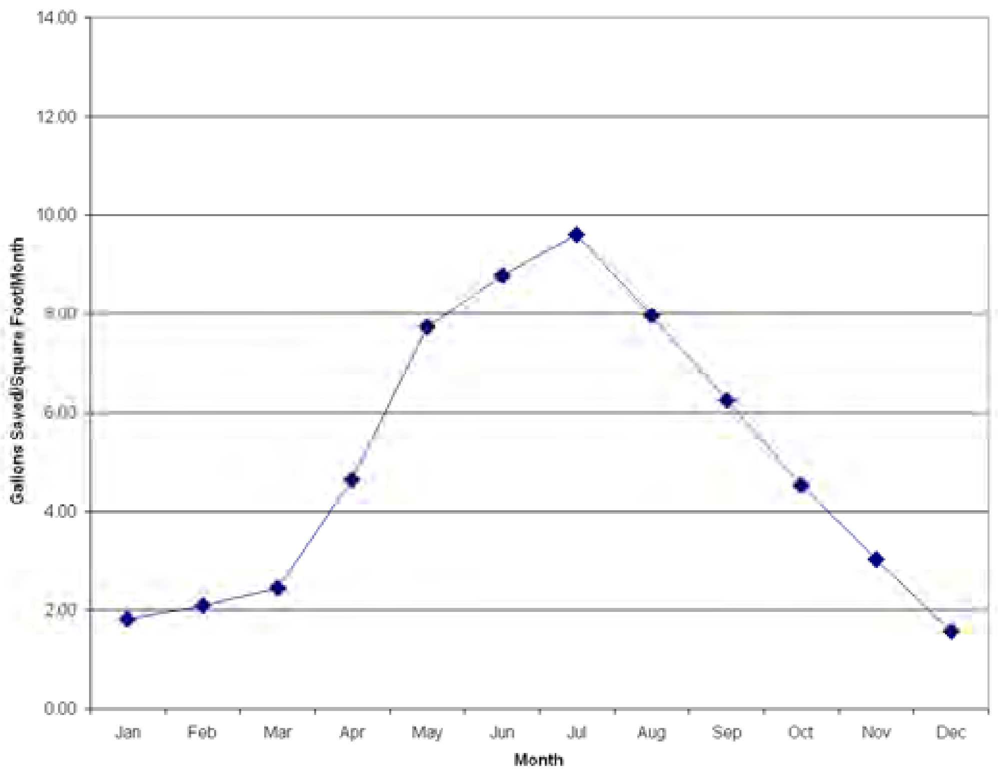
FIGURE 5: Monthly Per-Unit Area Application for Turf and Xeric Areas



The data also suggests, among other things, that the reason for the aforementioned enhancement of savings during the summer is because turf application peaks drastically in the summer whereas application to xeriscape does not. A graph of the difference between the groups (Figure 6) demonstrates this is the case, and the observed pattern in savings obtained each month parallels the pattern observed for turfgrass application (Figure 5). It appears that the reason xeriscape saves so much water in this climate is related as much to the high demand of turfgrasses vs. plantings of most other taxa as it is to any inherent aspect of xeric landscape *per se*. Furthermore, inefficiencies in spray irrigation system design, installation, and operation further contribute to the savings of having xeric landscape in place of turf because these inefficiencies even further drive up application to the turfgrass to the point that it is much higher than the rate of evapotranspiration over the same timeframe (Figure 7).

Additional inferences can be made about the application of water to turfgrass areas by the participants. Specifically, on average, whereas they irrigated relatively efficiently in the spring, with the onset of summer temperatures in May, residents quickly increased their application, ultimately going way above ET_o. Moreover, they tended to stay well above ET_o through November. While it is expected that due to system inefficiencies, a high K_c for Fescue (Source: Cooperative Extension Office), leaching fraction considerations, and other factors, application usually would tend to exceed ET_o for turfgrass locally, the pattern suggests that overall people irrigate relatively efficiently in spring as the weather warms and ET_o rises, probably due to the immediate feedback they receive as the grass yellows in response to moisture deficits. As they observe their landscape beginning to show visible signs of stress due to deficit irrigation, they increase their application accordingly. However, in May, they appear to start overreacting to the increasing stress and increase irrigation to well over the requirement. In fall, they do not however appear to respond in a correspondent way "coming down the curve," probably because they do not have the same sort of visual feedback mechanism as they do in spring (i.e., they do not view the grass being "too green," wet, nor the occurrence of runoff as something amiss). The result is a long lag in returning to application rates more closely approximating ET_o in the fall and early winter (Figure 7).

FIGURE 6: Monthly Per-Unit Area Savings (Turf Area Application– Xeric Area Application)



It is more difficult to make similar types of inferences with respect to xeric area application. While there is research under way on a variety of desert taxa to attempt to quantify irrigation demand and there have been generalized attempts to model or approximate xeriscape need based on observations and fractions of reference ET_o, at this time it would be risky to make highly specific inferences. The relative flatness of the xeric curve in Figure 5 does though seem to suggest that residents may irrigate xeric areas inefficiently as they seem to show little response to demands of different seasons.

FIGURE 7: Monthly Per-Unit Area Application to Turf and Reference Evapotranspirational Demand

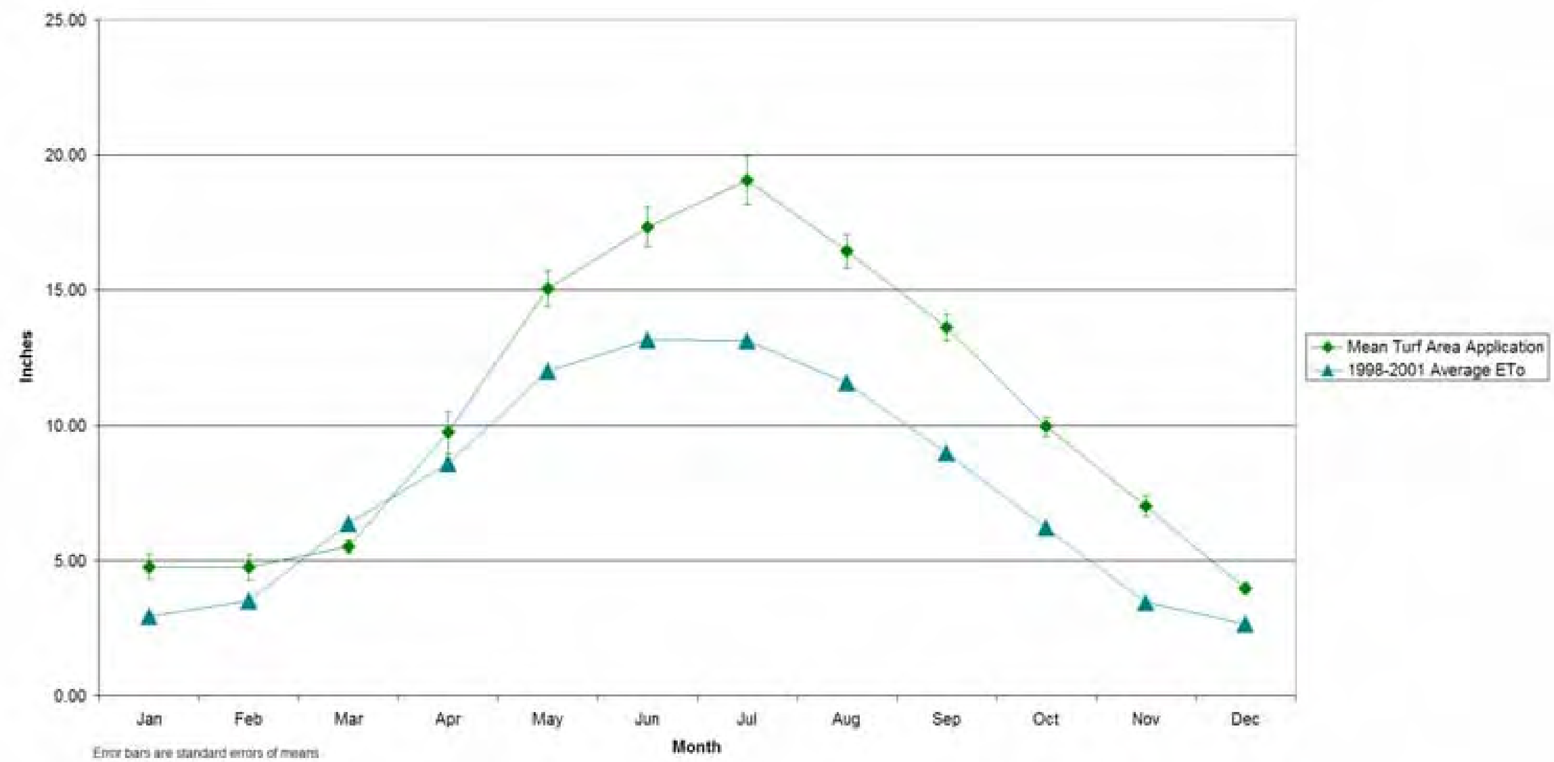
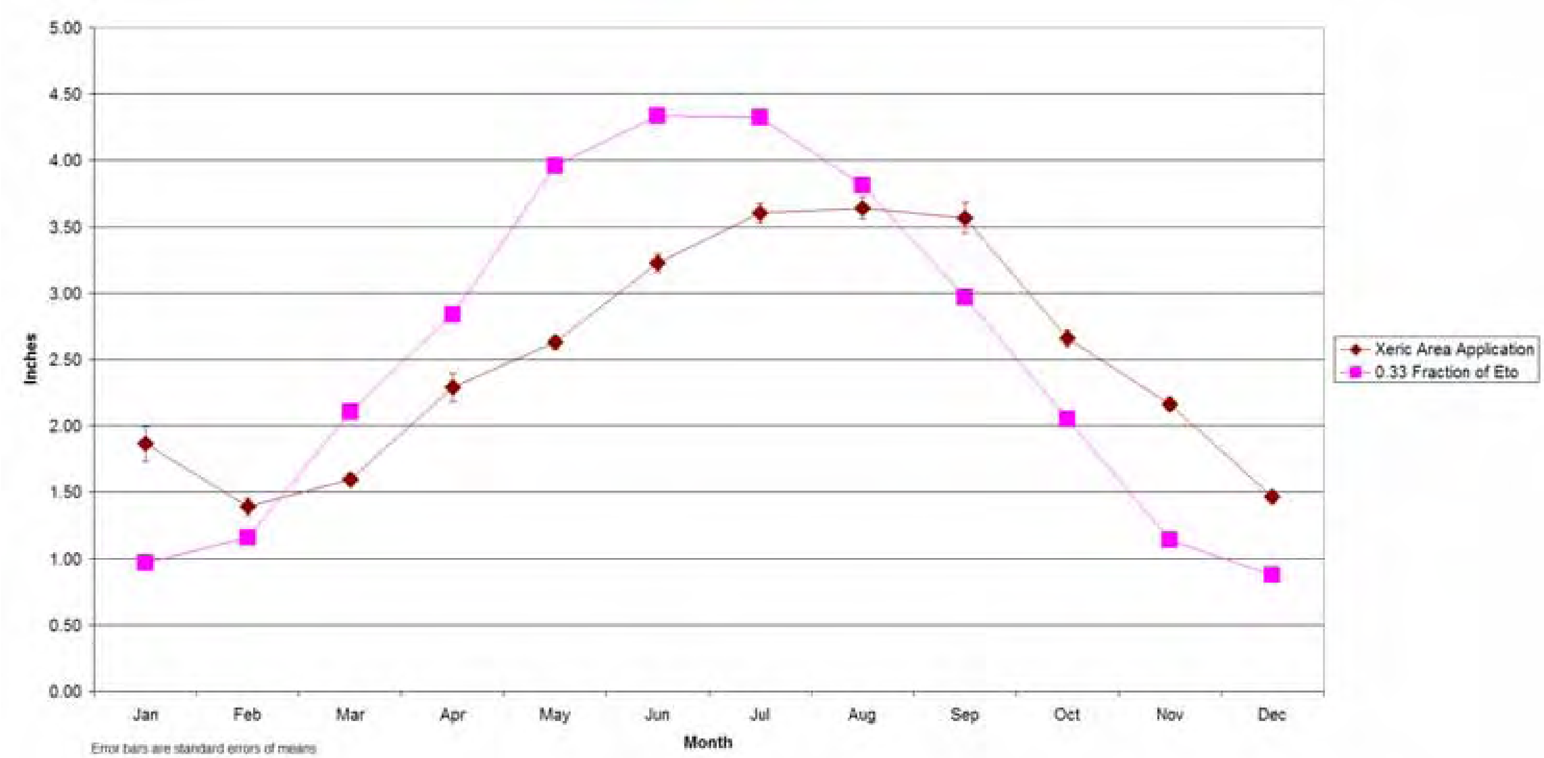


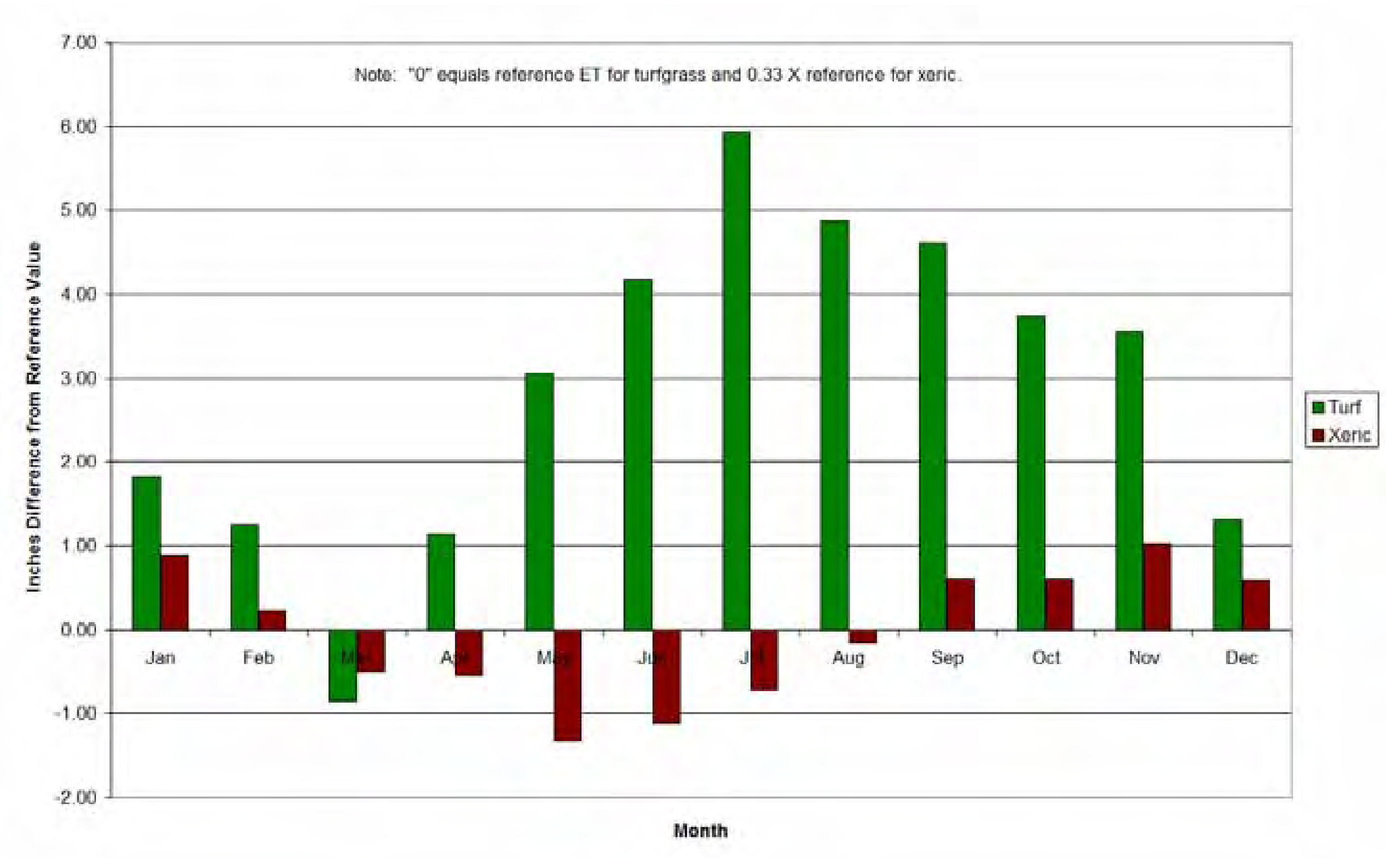
FIGURE 8: Monthly Per-Unit Area Application to Xeric Areas and 1/3 of Reference Evapotranspirational Demand



If one does assume a sometimes-used local “rule-of-thumb” which states that xeriscape requires about a third of what turf needs, one can compare per-unit area application for xeriscape and this modified reference value (Figure 8). Using a one-third ET_o value is not out-of-line with modification approaches employed by the Irrigation Association[16] (2001) or WUCOLS[17] (2000) for estimating needs of low-water-use woody taxa in high-temperature southwestern regions. It is quite noteworthy that the summation of monthly xeric-area application values yields a yearly xeric-area application usage of 30.1 inches per year - nearly identical to the summation of monthly $.33(ET_o)$ values, which is 30.5 inches. This would appear, initially at least, to suggest that this rule of thumb may work quite well on average for approximating xeric landscape usage over broad spatial and long temporal scales, even if it may not precisely work in a given month.

Normalizing these aforementioned potential reference values and the absolute departure from these in observed water application may reveal insights about when during the year the greatest absolute potential savings can be obtained. In Figure 9, this is done such that the absolute difference between mean application and respective references is quantified and displayed. Here, “0” (reference) is ET_o for turf and $.33(ET_o)$ for xeric landscape respectively.

FIGURE 9: Absolute Departure in Irrigation Application from Derived Respective Reference ET_0 Values (Turf and Xeric Areas)



Even with the xeric reference but a third of ET_0, it appears that, in addition to the differences due to plant usage, much more water is wasted in application to turfgrass than to xeric landscape. The greatest waste for turfgrass occurs in the period of May through November. Thus, any improvements in turfgrass irrigation efficiency during this timeframe will have the greatest absolute impact in terms of water conservation. Interestingly, the greatest absolute potential for savings for xeric areas is not during this period, but rather from September thru January. Indeed to look upon the graph, one might initially conclude that residents under-irrigate xeric areas in spring and summer. Caution should be observed though in this type of reasoning as the .33(ET_0) reference is only theoretical and developed here as a guideline. That stated, the findings may suggest that, on average, little potential exists during the spring and summer for significant water savings by irrigation improvements to xeriscape. Finally, on an absolute basis, little total potential appears to exist for squeezing additional conservation out of xeric landscapes as, considered over the span of an entire year, xeric area irrigation appears to be efficient.

In contrast, opportunities to save great volumes of water appear to exist for turf areas throughout most of the year. Significant overwatering appears to occur May through November; efficiency improvements will yield the most absolute benefit during this period of the year. But how does the issue appear when one considers the problem through the perspective of *when can the most readily obtainable savings be achieved*?

Considering absolute irrigation departure from reference as above gives insights into the total potential to save water through a variety of irrigation improvements. However, there is also the question of how much water could be saved principally by relatively simple improvements in *controller management*. Figure 10 is such an attempt to view the problem through this framework,where the blue line is ET_o for turf and .33(ET_o) for xeric areas respectively, and is equivalent to 100% of each respective types reference value or "perfect efficiency." Absolute values for inches application were normalized by converting them to percent departure from normalized respective reference values. In this way the relative departure from these aforementioned references is displayed as a percent value.

FIGURE 10: Relative Departure in Irrigation Application from Derived Respective Reference ET_0 Values (Turf and Xeric Areas)

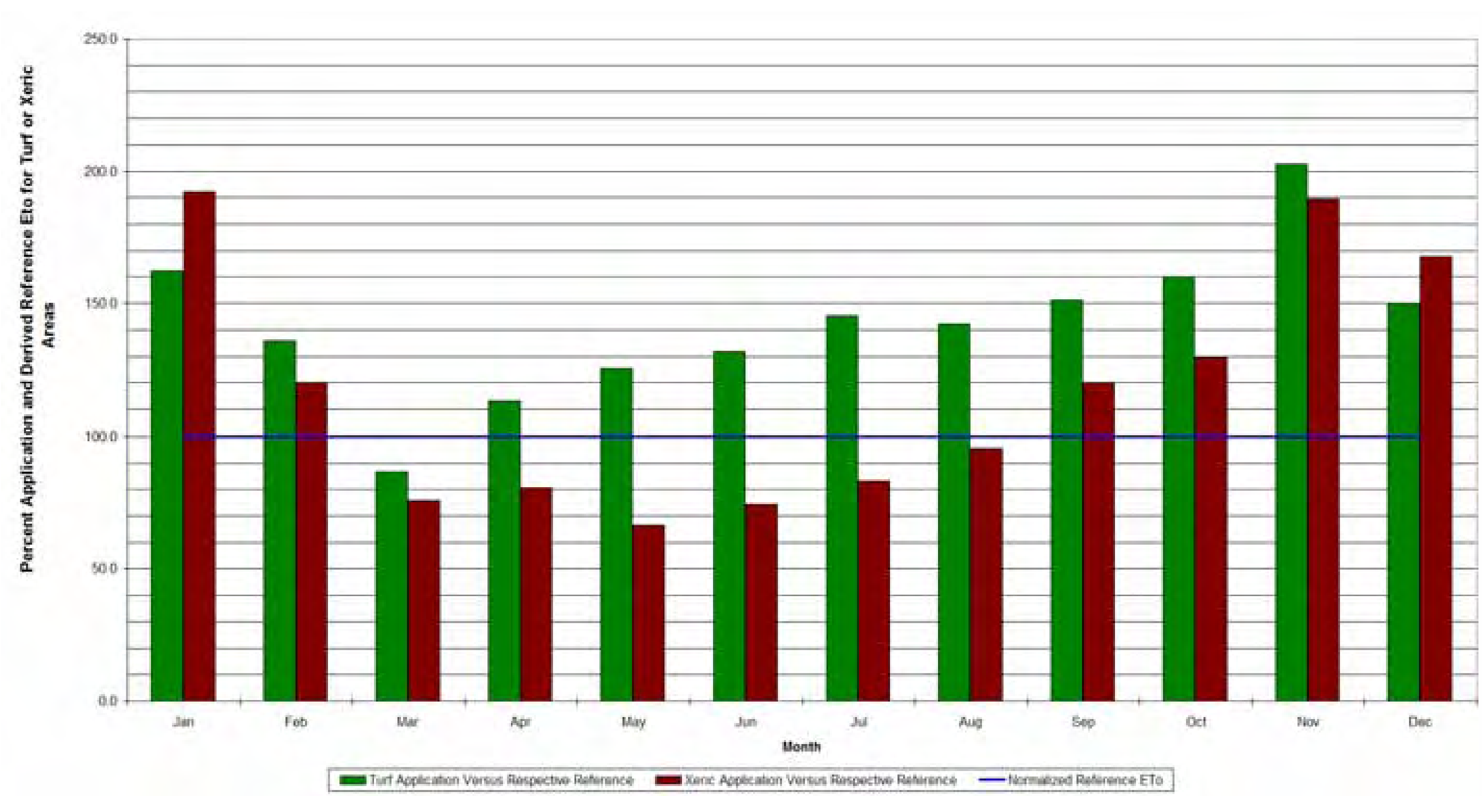
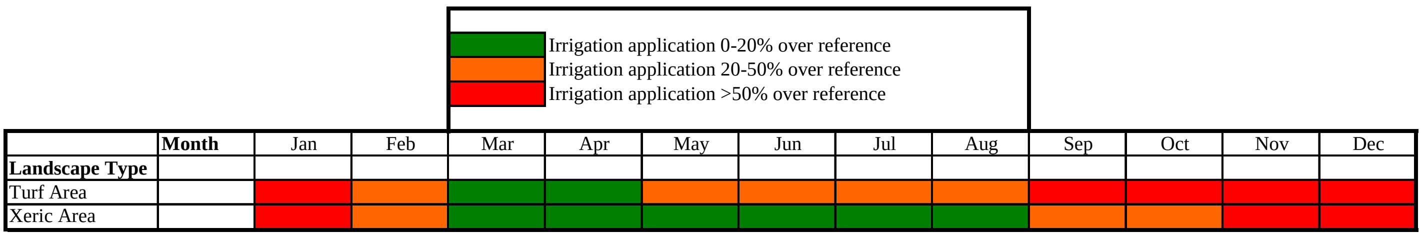


Figure 10 may suggest that there are specific times of the year when people irrigate both turf and xeric landscapes more or less efficiency than the ideal. As interpreted from Figure 10, the most inefficient irrigation, in a relative sense, may actually occur during non-peak months if efficiency is defined to be the difference between theoretical requirement and application. Expanding on this type of analysis and breaking the above relative departure values into efficiency classes yielded a summary of when people appear to irrigate most and least efficiently (Figure 11).

FIGURE 11: Relative Departure in Irrigation Application from Derived Respective Reference ET_0 Values (Turf and Xeric Areas)



It is well understood that, in practice, there is no such thing as a perfectly efficient irrigation system and, for this reason, the green designation in Figure 11 includes relative applications ranging from subreference values to those up to 20% above reference (this allows that there is typically a need in practice to compensate for lacking distribution uniformity in irrigation systems).

Interpretation of Figure 11 suggests that both xeric and turf areas are irrigated relatively efficiently in the spring. Irrigation efficiency for turfgrass areas starts to decline in May to the point where significant waste starts to occur and this continues until about September. In contrast xeric irrigation continues to be quite efficient during this time. Around September, turf is starting to be very inefficiently watered, in a relative sense, owing to residents' failure to respond to the lower rate of evapotranspiration and decrease irrigation accordingly. A similar, if less severe, pattern is observed for xeric area irrigation, where at this time, these areas are also beginning to be irrigated inefficiently, probably for the same reason. By November, both xeric and turfgrass areas are, on average, being severely over-irrigated and this pattern continues through the cool season until February. Finally, efficiency starts to recover and both areas are actually being irrigated under suggested reference values by the end of March.

It needs to be acknowledged that some of this conclusion includes theoretical and speculative reasoning, especially considering the lack of data on xeric landscape water requirements and the fact that in actuality stress impacts, including those from water stress, lag in woody vegetation (Kozlowski et al. 1990[18]) so efficiency as considered here is much harder to gauge. Nevertheless, again, failure of residents to more effectively tie controller management (irrigation frequency and duration) to the changing environmental conditions appears to be one of the most pressing reasons for efficiency losses in both study groups, it is just to a lesser extent (and much lesser absolute impact in gallons) for those with more xeriscape.

This set of analyses provides SNWA with quantitative data on what parts of the year it should focus its strongest controller-management-oriented conservation messaging. This could be considered the "low hanging fruit" in terms of water conservation; it is where messaging to effect changes that may not require significant work and monetary investments on the part of residents may produce significant water conservation results. To recap, the findings in this section suggest the most value can be obtained by targeting controller-management messaging to the late summer and early fall as people begin to depart from "reasonable" efficiency values owing to their collective failure to adjust irrigation down for the cooler, low ET season. Reemphasis of this messaging should continue all winter long.

The exploration of application per-unit area vs. reference values is important for making inferences about management efficiency of water application. This; however, should not obscure the result that on average, per-unit area, xeric landscapes in this study received much less water in totality (Figures 3 and 4) and the pattern of received irrigation showed much less tendency towards "peaking" (Figure 5) than those areas planted with turf.

SOURCES OF SIGNIFICANT VARIABILITY IN SINGLE-FAMILY RESIDENTIAL CONSUMPTION

As explained in Methodology, multivariate regression analyses were employed to identify and quantify sources of variability of mainmeter and xeric submeter data. Specifically, variables in the combined study groups are explored for association to total household consumption and, for the XS Group, to xeric landscape submeter consumption. Regression modeling proceeded with the goal being to yield an optimum combination of the highest reasonable R-squared value with due consideration given to maximizing the degree to which the model was "complete" (to the extent possible given the available collected data). Details of the final selected multivariate regression models appear in Appendix 2. Explanation and discussion of each variable included follow for each of the respective models.

Presented models are only designed to broadly assess variables' impacts. The models presented here are "estimation" models as defined (see *Methodology*). These models are not intended for use as "engineering" or "computational" type model applications whereby collecting certain data one could be reasonably certain that the answer yielded would closely approximate the real consumption at a given property.

Variability in Annual Residential Consumption

Discussions of the selected independent variables included in the annual consumption model for the dependent variable *annual residential consumption* (labeled MAINMETE) follow. Overall, the annual consumption model appears to be a very good "fit" (adjusted R^2= 0.80) for this type of work (Nelson[3] 1994, Gregg[4] et al. 1994, Gregg[19] et al. 1999). This is likely due as much to the strong tie between outdoor usage (and the ability of independent variables associated with outdoor use to be practically measured) as to any design elements or analytical methods associated with the study. While relatively strong for the sample size, it must be stressed that this model's utility is mostly in terms of helping to uncover and, to some extent, explain variables discreet associations with consumption at single-family residences. Quantifications of these associations in the multivariate context are limited to only those variables deemed significant.

<u>TOTALTUR</u>

Definition of Variable:
The total amount of turf at a residence in square feet as determined by research personnel. This includes all turf regardless of whether it is part of a submetered area and regardless of what type of grass it is.

Results and Discussion:
This was the most significant variable by far (t=14.86), and was found to be strongly positively associated with single-family residential consumption. It is a principal component of the model, contributing the bulk of its strength (β=0.622). The results suggest that consumption increases roughly 59.1 gallons annually for each square foot of turf at the average home. It then increases *further* if the grass is Fescue (the impact of Fescue vs. other grasses is further explored below). Since the alternative grass is almost always Bermuda, the result suggests the average application rate for this warm-season grass by the study participants is about 59 gallons per square foot (see variable FESCUE for more discussion on this).

It should be noted that earlier multivariate work attempted to deduce the influence of landscape type by scrutinizing how much xeric landscape was found at a residence (DeOreo[8] et al 2000). While this is an acceptable approach, the amount of turfgrass present appears to be much more closely correlated with total annual consumption and, when included, typically displaces xeric area as a significant variable in the final models developed. Furthermore, since the amount of xeriscape was not significant in multivariate context (nor were other individual landscape types) it should be understood that the savings developed by SNWA's Water Smart Landscapes program are mostly due to it, in essence, being a turf-removal program more than an alternative-landscape-promotion program. The results also suggest further significant lowering of household consumption probably would not be yielded by permitting the owner to get a rebate for turf removal at the expense of a quality landscape (for example, incentivizing the aforementioned "zeroscapes" at a higher SNWA incentive rate since they have no vegetation and theoretically require no water – this has been suggested by some). Since the xeric area contribution to annual consumption is so small, the substantial loss in quality of life yielded for the small gains in conservation realized by effectively hardscaping landscape areas makes the argument for choosing hardscape in place of xeriscape for water conservation a position difficult to defend.

TOTVAL

Definition of Variable:
The dollar value of the single-family residential study property as specified in the Clark County Assessor's Office database. This should not be considered to equate to a home's market value.

Results and Significance:
The assessed monetary value of the property, like the amount of turf at a residence, was a very highly significant variable in the model (t=5.45). It is reasonable to assume that higher value properties are associated with higher consumption because (i.) they are likely to contain larger homes with typically larger, possibly more extravagant water-intensive landscapes and (ii.) they are, by nature, likely to be inhabited by people of greater wealth who are less sensitive to the price of water and thus more likely to use a greater volume of it. In a multivariate context, annual water consumption on average increases ca. 2.1 gallons alongside each dollar increase in Assessor's Office property value.

That increased wealth is associated with greater individual consumption is a well-understood tenant of economics and is a well-established concept in understanding persons' household utility consumption patterns. The impact of wealth in a similar context was explored by Gregg[19] et al. (1999) where the impact of neighborhood wealth was a significant factor in determining water usage.

NLTHOMEA

Definition of Variable:
The age of the residence is calculated as the difference between the analysis year (2004) and the year of construction as recorded in the Clark County Assessor's Office database. This should not automatically be taken to be the age of the landscape or even, necessarily, the exact age of the specific study residence due to the way many developments are built as components of phases in this community.

Results and Significance:
This was a quite significant variable (t=2.67) and one easily worthy of inclusion in the model. On average, consumption increased ca. 1600 gallons for each additional year older the property was.

There are several potential reasons for this. First, older properties in the Las Vegas area tend, on average, to be larger and the ratio of hardscape footprint to landscapeable area is lower. Next, older properties are more likely to incorporate landscape elements heavy on traditional themes (i.e., large areas of turfgrasses) in contrast to newer residences with landscapes built in a time where water conservation began to be a significant consideration (in the 1990s restrictions on the amount of turfgrass that could be installed at single-family residences were passed). Older properties are more likely to have irrigation systems that incorporate lower-efficiency devices and fixtures (ex. brass spray heads). Finally, as irrigation systems age they inevitably become less efficient and more likely to leak.

Aspects of indoor use also likely contribute to the pattern. The installation of high-efficiency, low-flow fixtures and appliances after being legally mandated is anticipated to have contributed to newer properties having, on average, lower consumption. Also, as fixtures wear they may leak for some time without notice (toilet flappers for example) so, without timely maintenance, older properties are more likely to have continuous indoor leaks further contributing to higher consumption. The increased efficiency gains in homes with newer fixtures have been well documented (see Mayer and DeOreo[8] et al. 1999) and the overall finding that older homes tend to have higher water consumption is not surprising.

APROXINC

Definition of Variable:
Approximate total household income as revealed by 2001 survey data. To make the income survey question less intimidating, and more likely to generate valid, significant numbers of responses, the potential answers were categorical with ranges and it was explicitly stated that this question was optional. Analysis proceeded based on the mean values of response ranges. While a great number of participants did respond, many of course did not and income is, unsurprisingly, the most limiting of independent variables in the multiple regression.

Results and Significance:
It is to be expected that, everything else being equal, increasing household income would on average be associable with higher per-household consumption of all commodities. This is the case for water as well in this multivariate model, which suggests that, on average, annual consumption may increase on average ca. 3000 gallons for every $10,000 rise in income level (t=2.16). Some may be surprised this should be given the fact that indoor water use is relatively constant per capita across a range of conditions and thus the sensitivity of the relationship between water consumption and price is usually considered to be rather muted. But, while water is indeed inelastic by common economic standards, in the Southwest, where a high proportion is used outdoors, it may be considered to be more discretionary in nature, especially when that outdoor use is for irrigation of landscapes (instead of crops), which are after all just ornamental. Certainly this study suggests that income is an important consideration in water consumption, as have others. Furthermore, higher incomes could be considered to be well correlated with large houses, large landscapeable areas, and more lush landscapes, all of which further drive up consumption in their own right.

There was considerable discussion between the principal author and some reviewers as to whether or not the income data should be included in the model. The arguments for inclusion were that it was found to be a significant variable in most comparisons, it is a different indicator than home value in that the former is more indicative of wealth and the latter is more indicative of actual disposable income (which could be spent on water use beyond necessity), and that removing it significantly weakens the model. The arguments for removing it include the supposition that often people give erroneous or fictional answers to questions about income, that income is potentially highly covariate with home value, that home value is really a better proxy variable for income (and indeed in many studies using multiple regression it has been used for this purpose), and that its deletion does not weaken models such as this. Finally significant improvement in model sample size would be obtained by removing income as many people opted not to report it and thus it is very limiting to the model's available degrees of freedom.

The author considered the arguments for and against inclusion of income data carefully and proceeded to investigate the relationship between income and home value. The results of a correlation analysis between these two variables showed relatively little correlation (R^2= 0.288) as did a scatterplot of the data. Nonetheless, the concern was valid enough (and the possibility of significantly more degrees of freedom of sufficient interest) to justify creation of an incarnation of the model without income as an independent model variable. This exercise however resulted in an increase in the standard error of the estimate (i.e., an increased error of over 7,000 gallons per year) and a drop in the overall model fit (adjusted R^2= 0.740). However, most tellingly, the B values were off significantly from what one would expect (ex. Variable POOL B= 27.8; yearly evaporation in gallons per year is far in excess of this). Based on these findings it was decided that the APPROXINC variable should remain in the model.

<u>FESCUE</u>

Definition of Variable:
Whether or not the turfgrass present at a residence is Fescue or an alternative turfgrass. This is a binary (i.e., "dummy" in the vernacular) variable indicating presence (1) or absence (0) of a variable's specified condition.

Results and Significance:
Fescue grasses (which are widely popular cool-season grasses found in local landscapes) have been observed to require large volumes of water in the Las Vegas area (ca. 91 inches), over 62% more annually than the other somewhat less popular warm-season Bermuda grass (requiring ca. 56 inches; calculations for both grasses are based on data from the local Cooperative Extension Office). Locally, Fescue is much less drought tolerant than Bermuda and has a correspondingly higher K_c value (the July K_c value for Fescue is calculated to be a very high 1.10 whilst only being ca. 0.71 for non-overseeded Bermuda; Source: University of Nevada Cooperative Extension Office).

Furthermore, being a cool-season grass, Fescue is capable of active photosynthesis all year long with sufficient irrigation and management, which is no doubt the reason for its desirability; it can yield an attractive green year round. Bermuda on the other hand usually goes into dormancy in the winter and it is likely many people curtail irrigation at dormancy so its total yearly application is even further reduced relative to Fescue. While there are of course different requirements for different types and morphologic forms of grasses (ex. tall vs. short fescue), the general finding that the cool-season grasses require more water than the warm season ones is well understood and this apparently translates into residences with Fescue having, on average, higher annual consumption at the household level (t=2.09) (note: most residences had at least some turfgrass integral to their landscapes). Based on the multivariate analysis, a residence with Fescue may on average use more than 25,000 gallons more annually than one with a lower-water-use grass.

There is another possible inference that may be made. The submeter data is heavily dominated by Fescue landscapes and thus the highlighted gallons-per-square-foot application rates are probably at or near the actual *for Fescue*. It should be noted though that from the model, one might infer that in situations where there is <u>not</u> Fescue at the site, the B value of 59.1 may be the typical application rate, in gallons per square foot per year, for Bermuda installed at a residence. Though this derived value of 59.1 gallons per square foot per year (94.9 inches precipitation equivalents) is somewhat suppositional, and no doubt not exact given the standard error of the model, it appears to be a very reasonable average application rate that could be expected locally for Bermuda grass.

<u>PARCEL SIZE</u>

Definition of Variable:
The size, in square feet, of the parcels of study residences as specified in the Clark County Assessor's Office database.

Results and Significance:
In the final version of the model, parcel size was technically not significant (t=1.79); however, it was positively correlated with higher residential consumption in most multiple regressions developed so it is included here. It is reasonable to assume that, on average, residences associated with larger parcels are more likely to have higher consumption because they would be expected to have (i.) more, possibly lusher, landscape (they are also more likely to have a pool) and (ii.) typically larger homes situated on them. Both of these would be anticipated to raise consumption due to larger residential landscapes having higher total outdoor irrigation requirements and larger houses being more likely to be inhabited by more or, perhaps, simply more heavily consuming, residents.

<u>POOL</u>

Definition of Variable:
The total water surface area of pools and spas in square feet at residences as measured by research personnel. For residences without pools this variable equates to zero.

Results and Significance:
As with parcel size, pool surface area was not significant in the final most complete version of the model (t=1.70), but often cropped up as significant in alternative models as being positively correlated with higher consumption. It is reasonable to include this variable as it is to be expected that the more evaporative water surface area outside at a residence owing to a pool and/or spa, the higher the evaporative water loss at the residence and the greater the need, in gallons, to replenish it.

<u>TOTALOCC</u>

Definition of Variable:
The total number of occupants at each study property in the analysis year (2001) as determined by survey.

Results and Significance:
Though not a statistically significant independent variable in the final model (*t*=1.62), and only occasionally significant in alternatives, the number of people living at the residences was ultimately included, as it lends explanatory strength to the model (β=0.524) and it is logical to assume that consumption does increase with more people living at a location. That it is not statistically significant is actually a testament to the dominance of outdoor end uses in determining total yearly consumption at single-family properties in this region.

<u>TOTALLAN</u>

Definition of Variable:
The total landscapeable area at a property. This includes areas with landscape as well as areas potentially landscapeable.

Results and Significance:
This variable is difficult to interpret and was not significant in this particular model (*t*=-1.41). The only reason for its inclusion is the sheer number of times it cropped up as significant in different alternative models. Here, however its sign is inverse of what would be anticipated (that greater landscapeable area would lead to higher consumption). It may be that it captures the inverse of the building and hardscape footprints, but this is only theory.
check from here on…

Variability in Annual Consumption for Irrigation of Monitored Xeric Landscape

A model of yearly consumption for the monitored xeric component of landscapes for XS Group homes was also developed to attempt to evaluate the impacts of variables listed in the Scope (Appendix 1). The developed model has a much lesser fit than the total consumption model (adjusted R^2= 0.40), in part, one speculates, because other important but non-quantified or hidden variables are not included (one possible example – detailed data on controller management which may be more associated with management of turf rather than xeric areas). For this reason, no attempt is made to quantify impacts in a multivariate context as above, but rather the goal is to identify variables likely associated with xeric area consumption (for some attempts at quantification using univariate approaches consult Sovocool and Rosales[11] 2001).

Despite the limitations due to the weaker model, many variables did appear significant in most if not all modeling attempts, and these are discussed below in a format similar to the above discussion on annual consumption. The same strength of association denotation as used for the annual consumption model is applied to the xeric areas variable discussion as well. See introduction to *Sources of Significant Variability in Single-Family Residential Consumption* for more information.

TOTALCAN

Definition of Variable:
The total canopy coverage in the monitored xeric area of the XS Group properties, in square feet. This is calculated by first taking the observed plant diameters from the 2001 site review, dividing this number by two to get radius, then applying the formula for getting the area of a circle ($A=\pi r^2$). This area result is then multiplied by the quantity of those plants observed to be at that size. The summation of all areas of all plants of all size classes in the study area is the total canopy coverage.

Results and Significance:
It is reasonable to expect that total plant canopy coverage within the monitored xeric area would positively correlate to the total amount of water applied to that area as plant leaf surface area (evapotranspirational area) is the principal locale of water loss from vegetation. To replace this loss, areas with higher plant coverage should theoretically require more water and it should be expected that residents would respond by irrigating these more (via both longer run times and having irrigation systems of greater application capacitance). Examination for a link between total canopy coverage and total yearly consumption for xeric areas in a multivariate context confirms a significant association (t=4.31; the relationship between coverage and per unit area consumption was also noted and explored in Sovocool and Rosales[11] 2001). One acknowledgement; this is a relatively simplistic finding, which does not fully explain the relationship between consumption and the taxa present and species' specific water use characteristics (this was beyond the practical scope of this investigation). Data on specific xeric species' water requirements is needed for this and this area remains worthy of more in-depth research.

AVGFLOWR

Definition of Variable:
The arithmetic average flow rate, in gallons per minute, of all irrigation stations servicing monitored xeric landscape for each of the XS Group properties.

Results and Significance:
It has long been suspected that within the range of lower flow types of irrigation systems used to irrigate xeric areas, those capable of delivering water relatively faster via high-flow emitters may contribute to higher water consumption, especially when used by someone less knowledgeable about how to irrigate with different types of emitters. For this reason, SNWA's current Water Smart Landscapes program limits individual emitters to a maximum output of 20 gph as part of the program requirements (Appendix 5). Based on this research, this concern appears well-placed as the model shows stations with higher average flow rates are indeed associated with higher consumption in this study (t=4.14). Typically, such station configurations may have one or more of the following conditions: sprays used for xeric-area irrigation, incorporation of high-flow emitters (such as turf bubblers), use of microsprays, stations composed of mixed types of irrigation emitters, and individual stations irrigating large and/or lush expansions of xeriscape (an exploration of how emitter class relates to average flow rates also appears in Sovocool and

Rosales[11] 2001; this manuscript suggested a strong association between irrigation system design and xeric area consumption as well).

<u>STUDYA</u>

Definition of Variable:
The xeric study land area (in square feet) monitored via submeter for XS Group properties.

Results and Significance:
It is logical to assume that, on average, the more area monitored by the submeter, the greater the consumption through that meter, and the significant association between monitored xeric-study area and total yearly consumption (t=3.08) is consistent with this expectation (for further exploration of per-unit area savings, see *Comparison of Per-Unit Area Water Application between Turfgrass and Xeric Landscape*).

<u>TOTVAL</u>

Definition of Variable:
The dollar value of the residence as specified in the Clark County Assessor's Office database. This should not be considered the same as the home's market value.

Results and Significance:
There was a positive association between the total value of the property and total consumption for xeric area consumption (t=2.94). A discussion of how this variable tends to be positively associated with water consumption appears above in the discussion of the annual consumption model. It is worthwhile to again emphasize that given water use for residential landscapes can ultimately be considered discretionary, higher homeowners' wealth (here, evidenced by higher property value) may be anticipated to lead to greater consumption for landscape irrigation.

<u>PARCEL SIZE</u>

Definition of Variable:
The size, in square feet, of the parcel of a study residence as specified in the Clark County Assessor's Office database.

Results and Significance:
The parcel size of the residence was significantly inversely associated with consumption for xeric area irrigation (t=-2.78). This result was unexpected, as a relationship or mechanism acting to result in a link between parcel size and the irrigation of xeric areas on that parcel is not immediately obvious. The possibility that there is an inverse relationship between xeric study area and parcel area was examined, but this is not the case (rather, as would be expected, larger properties tended to be positively correlated with larger study areas, though this relationship is weak; R^2=0.064). Likewise, the theory that perhaps larger parcels had xeric areas that might be sparser in terms of canopy was examined and rejected (the data does not support this).

Discussion and consideration of other findings led to some other possible explanations. One possibility is that those residences with larger parcels were more likely to incorporate native, lower-water-requirement plants in their landscapes. Some data supports the theory that owners of large properties may indeed make more use of native taxa, but only marginally so (the properties in the top 10% in parcel size had an average of 10.9% of their plant palette composed of native vegetation; the average for the rest of the properties was 6.9%).

Another theory is that larger xeriscape installations may be more likely to necessitate the need for a contractor, who is more likely to install a properly designed drip system and, as suggested by the findings linking station flow rate to consumption and (as revealed below) "drip-only" systems are more likely to result in lower total yearly consumption than those piecemealed together with multiple types of emitters. Since those residents doing larger xeriscape conversion projects were found to be more likely to use a contractor, there is some evidence supporting this second theory.

Perhaps the most likely reason for this finding is that people with smaller parcels are more able to afford to consume more water outdoors. To understand this reasoning better, consider an example of two sets of land, one acre each, in a similar area and climate each with all landscapeable area landscaped. One has a single residence upon it, the other acre, more subdivided, supports five homes (and thus is composed of five parcels). One would conclude, usually correctly, that the outdoor consumption for the *total area* would be greater for the one-home case, owing to its maintaining a greater amount of landscaped area (more of the available area is consumed as development in the five-homes case). But what about total water consumption for irrigation on a *per-parcel* basis? Each of the family income streams in the five-homes-per-acre case support less irrigated area than that for the single home on the one acre. Thus, each of these five owners can afford to support more discretionary water use as their respective landscape irrigation "shares" are less than for the one owner supporting all of that area. As a result, the owners of the smaller parcels may use more irrigation water per parcel than in the alternative case, and this may be what is being observed here (internal research by SNWA has shown that subdivision tends to result in higher per-parcel usage while decreasing usage for the total equivalent area).

Without more information, these are only hypotheses. At this time, while the inverse relationship between parcel area and xeric area consumption stands, the mechanism behind the relationship is not completely understood.

<u>DRIP</u>

Definition of Variable:
Presence (1) or absence (0) of an exclusively drip irrigation system irrigating the xeric study area. This is a binary variable.

Results and Significance:
This is a different type of measure of the influence of irrigation system design on total xeric area water application. Specifically evaluated was whether the presence of a "true" drip system (no bubblers, microsprays, mixed systems) was associated with xeriscapes with lower consumption than others. The model does support this theory, with a significant finding that such "drip-only"

xeriscapes do have lower consumption (t=-2.27). As suggested by Sovocool and Rosales[11] 2001, such systems typically have the lowest flow rates (average per-station flow rate = 4.0 gpm) of the types used to irrigate xeric landscape, so if run similar amounts of time to other systems, it would be expected that these would output lower total volume over a year. Based on the data, it does seem likely that many residents run their systems without careful consideration as to which kind of emitters they actually have, in turn resulting in systems composed exclusively of true drip emitters being associated with the least amount of water consumed over the year. Since slow application rates are generally the preference in irrigating drought-tolerant vegetation (this is especially the case with woody taxa) and because landscapes with "true" drip systems had the lowest consumption, this finding may be worthy of future considerations relevant to SNWA's Water Smart Landscapes program.

<u>DONTKNOW</u>

Definition of Variable:
Whether or not the respondent was knowledgeable about the level of enforcement of local restrictions designed to reduce water waste. This binary variable indicating presence (1) or absence (0) of understanding was adapted from part of an alternative answer to a question asking respondents if they felt enforcement of water waste provisions was "too lax," "good," or "too strict." In addition to these responses, residents taking the survey were also given the option of answering "Don't Know" if they did not have any sense of how aggressively water waste regulations in the area were enforced.

Results and Significance:
Theoretically a person's viewpoints on water waste enforcement could tie into how diligently they practice good irrigation management. Recognizing this, the study staff formulated a question addressing this for the survey implemented in 2001. In preliminary analyses (Sovocool[12] 2002) there really was not a difference in per-unit area irrigation for xeriscapes between those respondents answering "too lax" and "good" (only two people said enforcement was "too strict" resulting in no ability to tie this to consumption with any statistical precision, though this is quite telling of how the community viewed enforcement in 2001). However, interestingly there was a difference between respondents with any kind of an opinion and respondents who had no sense of the issue. This suggested at the time that *awareness* of enforcement of water waste regulations may be a principal motivator to conserve, regardless of one's viewpoint on how appropriate the level of enforcement is. The recurrence of this basic result, here in a multivariate scheme (i.e., those answering "don't know" were associated with higher consumption in the regression model; t=2.13) suggests that sensitizing the public about enforcement of water waste restrictions may be a powerful motivator for achieving outdoor water conservation.

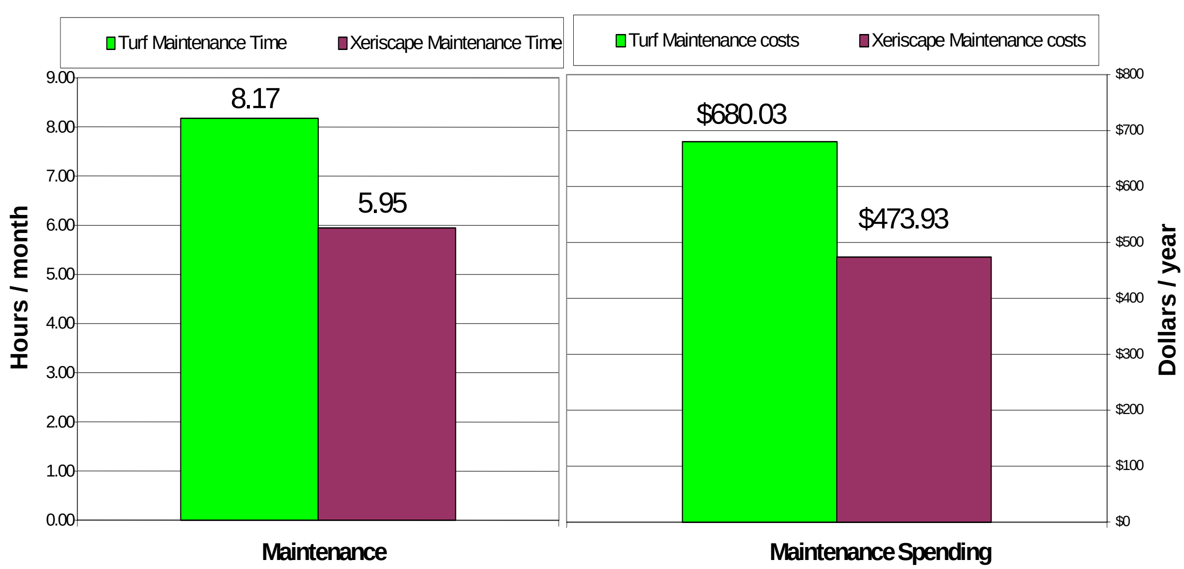
FINANCIAL SAVINGS ASSOCIATED WITH CONVERSION PROJECTS AND COST EFFICIENCY

As explained in the methods section, the research scope included a mandate to study some of the economics of xeriscape conversions, as this has been left relatively uninvestigated to date. Specifically, the directives were to quantify costs associated with the conversion and the subsequent maintenance of the xeriscape and to develop estimates as to what incentive level would theoretically be necessary to entice people into doing conversion projects. Collection and analysis of this data is explained in *Methodology*, below, and in *Appendices 5* and *6*. Results are as follows below, starting with the conversion costs findings.

The average cost of the conversion for those converting in the XS Group was obtained via data collected on parts and materials, as well as contractor receipts. The average cost for all participants was $2,881.21 for 1,862.1 sqft converted ($1.55 per square foot for 91 participants sampled). The average cost for those who did the conversion themselves was $2,428.31 for 1,766.22 sqft ($1.37 per square foot), and the cost for those hiring a contractor was $4,076.88 for 2,115.22 sqft ($1.93 per square foot). These dollar amounts for costs and dollar valuations are as they stood in the late 1990s and have likely climbed slightly by today. As might be anticipated, it appears that residents may on average be more likely to hire a contractor for larger conversion projects.

Landscape maintenance requirements constitute a significant cost in labor and dollars directly spent. The relative amount of xeriscape at a residence figured prominently in landscape maintenance reductions for both these costs (Figure 12). For those who had at least 60% of their landscapeable area as xeric landscaping, maintenance savings of about one-third were realized versus those with 60% or more turf. The average difference is 2.2 hours/month in labor and $206 per annum in direct expenditures (N=216). Landscape maintenance savings are value added on top of water bill savings. This serves to greatly enhance the attractiveness of xeriscape to the customer. Hessling[12] (2001) provides a detail of the capital costs and savings obtained.

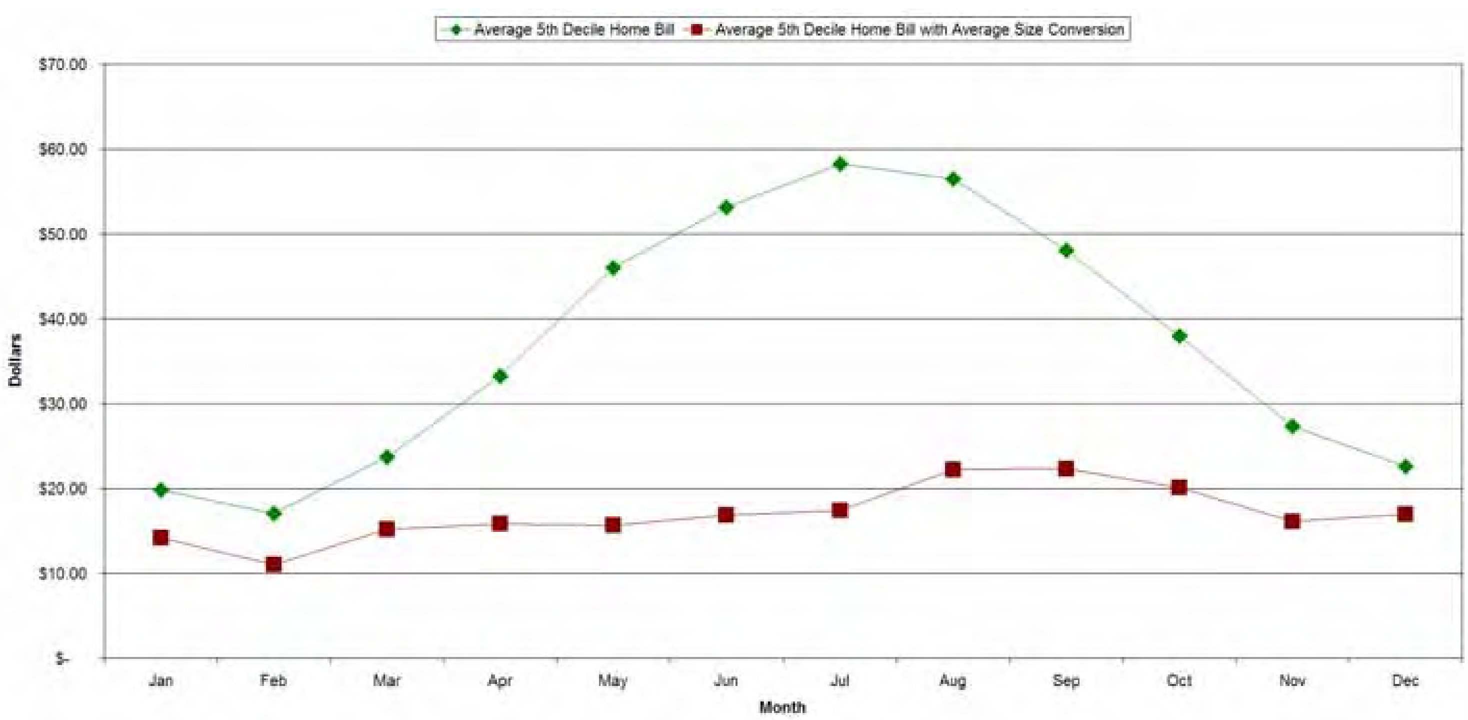
FIGURE 12: Average Monthly Maintenance Time and Annual Direct Expenditures for Participants Having At least 60% Turf or Xeriscape



Bill savings for a typical mid-consumption range customer were modeled as explained in *Methodology* and in Appendix 4. Results show that there is a large difference in the monthly bills between a modeled residence with and without the conversion throughout the majority of the year (Figure 13). The total difference in the annual cost for water between these two homes using the current (2004) rate structure is $239.92 - a significant savings attributable to the conversion (nearly $0.15 per square foot converted per annum). It should be noted that this savings of 54% in total annual water charges is greater than would initially be anticipated from consumption savings data (Figure 6). This is because the Las Vegas Valley Water District, as well as the other SNWA member agencies, uses a tiered, increasing block rate structure.

Increasing block rate structures (also called conservation rate structures) are setup such that the more a user consumes on an average daily basis within a cycle, the more expensive, per unit (i.e., per gallon), water becomes. The high per-unit area application to turfgrass results in residences with more grass typically crossing thresholds into higher billing rate strata much more frequently and this in turn exacerbates their water costs per unit and, ultimately, their total costs. In this case, the difference in per-unit water charges for the two fifth-decile homes, with all charges considered over the entire year is about $0.28 per thousand gallons (i.e., there is a 13% difference; effective prices of $1.85 vs. $2.13 per thousand gallons, respectively). The comparison highlights the utility of tiered rate structures as a conservation tool and for promotion of xeriscape as a conservation tactic.

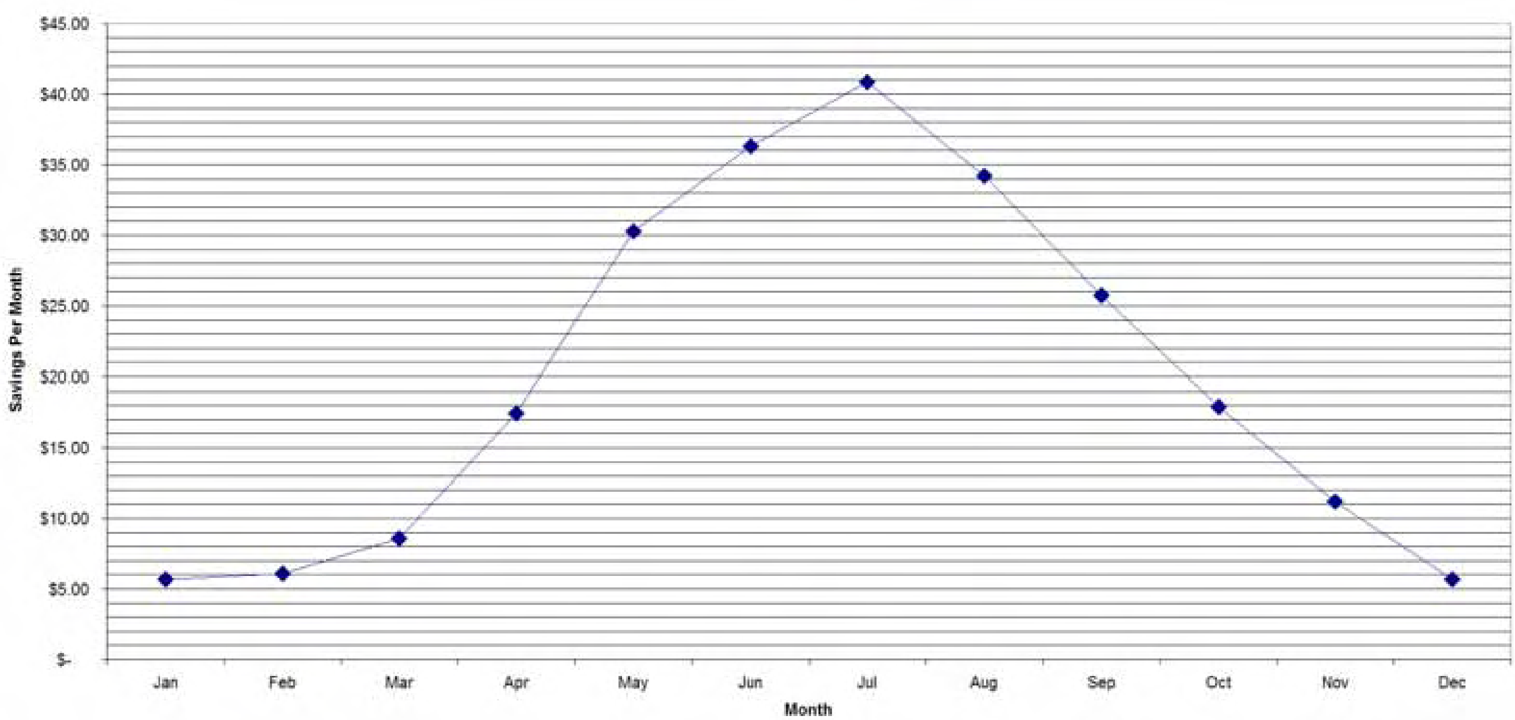
FIGURE 13: Modeled Monthly Water Bill for a Typical Las Vegas Area Home and The Same Home with an Average-Size Conversion



The expected water bill savings a resident of a typical home would realize from doing an average-size conversion of turfgrass to xeriscape (anticipated monthly savings – including tier rate impacts) is thus as illustrated in Figure 14. As can be seen, the typical monthly water bill savings range from a low of $5.68 (25%) in December to a high of $40.84 (70%) in July, again reemphasizing that the greatest savings obtained by having xeric landscape are realized in the extremes of summer in this area. The savings obtainable serves to create a strong price signal to convert, especially when coupled with the incentive offered by SNWA currently ($1.00 per square foot for qualifying residential conversions).

As suggested by Figures 13 and 14, on average xeriscape not only results in significant savings in water utility charges, it also makes the charges more manageable as they no longer "peak" to anywhere near the extent they did under the "no-conversion" condition. For the "no-conversion" model, the low-consumption month to high-consumption month ratio is 1:2.93 (the peak month is July). For the same house with the conversion, the ratio is 1:1.58 and the peak is pushed out to September owing to the difference in xeric irrigation pattern (Figure 8). For homes proximal to the modeled condition, xeriscape conversions appear to make paying monthly bills easier because the peak is (i.) greatly attenuated and (ii.) potentially pushed out until later in the year, so it does not parallel other local utility bills which peak in the summer (power, for example).

FIGURE 14: Modeled Monthly Water Bill Savings for A Typical Las Vegas Area Home Completing an Average Size Conversion



ESTIMATED APPROPRIATE LEVEL OF FINANCIAL INCENTIVE

Homeowner Perspective

Hessling[13] (2001) performed analyses of the financial viability of SNWA's xeriscape conversion program, "Southern Nevada Xeriscapes" (since revised and renamed to "Water Smart Landscapes"). It should be noted that at the time Hessling did his analysis, the program paid recipients an incentive of $0.40 per square foot. He presented a Net Present Value (NPV) analysis demonstrating that, from the homeowner perspective, the return on investment by SNWA's conversion facilitation program is two to three years for a resident and that the incentive is not really required to induce change as the NPV is positive, even when no incentive is rewarded. See Hessling's manuscript for additional details.

A constructed model (Appendix 5) using a similar approach (and more recent data) seems to support the finding that no incentive is theoretically necessary for a typical do-it-yourself xericape conversion where subsequent financial savings in landscape maintenance are realized. However, the incentive may be important in a variety of other situations. The scenario, similar to the one used by Hessling as well as others, was explored by the model developed by SNWA (Appendix 5). Some of the most common scenarios explored, with findings from model outputs, are summarized in Figure 15.

In Figure 15, there are four different scenarios modeled (see explanation below), and each scenario has four associated results (*Methodology* and Appendix 5). The outputs associated with each exercise are: the average payback time (at a dollar per square foot) for a typical home doing a typical conversion (see Appendix 5), the average payback time without an incentive, the incentive required for a 3-year return on investment (ROI), and the incentive required for a 5-year ROI. Special note should be made regarding the expression of payback times. The display is not the range of payback times given the combination of scenario conditions, rather, it reflects that the expected average payback time falls sometime between the years shown. The model is based on annual, not monthly data thus the need to display outputs in this manner. The "incentive required" outputs, are simply average model outputs and are not to be considered appropriate for any one condition; their value is principally in comparative analyses between scenarios and in broad generalizations.

The summary (Figure 15) is designed to facilitate inferences about the economics of the conversion project. Along the horizontal axis are the "Only Conversion Material Costs" and "Conversion Material Costs + Labor" titles. The first scenario condition refers to situations where only the direct costs for materials, supplies, rentals, and other such items are considered. Residents doing their own xeriscape conversion might consider this to be their scenario if they consider only the real financial outlays paid and don't consider their time spent on the conversion to be a real financial cost. In contrast, the "Conversion Material Costs + Labor" condition includes a valuation of the time to actually do the conversion, which naturally lengthens the payback time. This perspective is more appropriate for those who consider the labor outputted by themselves to be a true financial expenditure. It is also the appropriate model perspective to consider if the project is performed by a contractor.

Along the vertical axis of Figure 15, are the titles “Only Maintenance Goods Conserved” and “Conserved Maintenance Goods and Labor.” Similar to above, the “Only Maintenance Goods Conserved” condition reflects consideration of savings associated with only direct expenditures on things such as fertilizer, replacement irrigation parts, occasional replacement of capital items such as shovels, etc. (so long as the conversion is significant enough to yield savings in these areas; see the discussion surrounding Figure 12). The category “Only Maintenance Goods Conserved” would be most appropriate for people who do not consider the savings in labor obtained by having some of their area as xeriscape to be equivalent to a monetary outlay, situations where not enough of the total landscape area is converted to obtain this type of savings, or when a landscape maintenance company, which may or may not realize the savings, is either unwilling or unable to pass on labor savings to the customer as realized by the landscape retrofit. Again, there is an alternative category for the consideration of realized maintenance savings in labor costs resulting from the conversion. The maintenance savings plus labor savings category, “Conserved Maintenance Goods and Labor,” is most appropriate when enough of the yard has been converted that real savings in maintenance labor can be realized and when the owner attaches value to this. It would also be appropriate when the homeowner’s landscape company passes on realized labor savings to him or her.

The matrix of results developed (Figure 15) permits some inferences to be made about what scenarios turn around financially the fastest and are thus most readily facilitated by a landscape conversion incentive. In increasing order of time to payback (i.e., the first bulleted scenario is the most readily facilitated) these are:

Shorter Time to Investment Return

- Situations where only the material costs of the conversion are valued and where savings in both maintenance goods and labor can be realized (in fact, this scenario theoretically may not even require an incentive to generate financial savings in an acceptable investment timeframe).
- Situations where both the material costs of the conversion and the labor cost of the conversion are valued and where savings in both maintenance goods and labor can be realized.
- Situations where only the material costs of the conversion are valued and where only savings in maintenance goods (not labor) can be realized.
- Situations where both the material costs of the conversion and the labor cost of the conversion are valued and where only savings in maintenance goods (not labor) can be realized.

Longer Time to Investment Return

Considering that the optimal price point for the first three of these scenarios is probably covered by the current incentive level, but not the old $0.40-per-square-foot incentive, it may be that the SNWA hit upon a <u>critical</u> threshold value in stimulating the marketplace when it went to the

$1.00 per-square-foot level in 2003. A recent surge in program interest in the residential sector is consistent with this (Appendix 5). Even in the fourth scenario, the current incentive level shortens the payback time such that the project might be deemed affordable by many people (see the associated 5-yr ROI). While few, if any, residents do a detailed economic assessment of the payback time for their respective xeriscape conversion projects, the dollar per square-foot is almost certainly perceived to make conversion projects much more “affordable,” plus there is significant symbolic value to the $1.00-per-square-foot figure versus the past sub-dollar incentive levels.

If the payback time outputs presented in this model are close to reality, it may be that SNWA’s Water Smart Landscapes program will continue to experience high interest until a point where materials, supply (i.e., practically convertible turf), or services associated with the conversion project come to be in short supply and/or become expensive enough to cause feedback such that program enrollment is slowed.

FIGURE 15: Summary of Economics of Typical Single-Family Xeriscape Conversion Projects Under Different Scenarios

	Only Conversion Material Costs	Conversion Material Costs + Labor
Only Maintenance Goods Conserved (or when labor savings not realizable)	Avg. Payback Time at $1.00 per SqFt: 3-4 Years Avg. Payback Time Without Incentive: 5-6 Years Incentive Required for 3-Year ROI: $1.03/SqFt Incentive Required for 5-Year ROI: $0.14/SqFt	Avg. Payback Time at $1.00 per SqFt: 5-6 Years Avg. Payback Time Without Incentive: 8-9 Years Incentive Required for 3-Year ROI: $2.23/SqFt Incentive Required for 5-Year ROI: $1.34/SqFt
Conserved Maintenance Goods and Labor	Avg. Payback Time at $1.00 per SqFt: 1-2 Years Avg. Payback Time Without Incentive: 2-3 Years Incentive Required for 3-Year ROI: None Req. Incentive Required for 5-Year ROI: None Req.	Avg. Payback Time at $1.00 per SqFt: 2-3 Years Avg. Payback Time Without Incentive: 4-5 Years Incentive Required for 3-Year ROI: $0.91/Sqft Incentive Required for 5-Year ROI: None Req.

SNWA Perspective

The financial viability of SNWA's Water Smart Landscapes Program is difficult to assess as resource alternatives available to the Authority against which this "water option" may be measured are diverse and have widely divergent respective costs (SNWA[20] 2003). Furthermore, availability of water resources is not constant and shortage or surplus conditions can exist which can make using these as standards against which conservation programs can be measured again difficult. A prime and current example of this is the drought that the Lower Colorado River Basin is experiencing which is currently impacting SNWA (SNWA Drought Plan[21] 2003). In these types of situations, the economics of conservation programs are obviously enhanced, and it is against this backdrop that the economics of the Water Smart Landscapes Program is being considered in this study.

In Hessling's analyses[13], the drought had not yet been recognized and designated as such and SNWA had no drought policies in place at the time of the analysis. He grounded his analysis in comparing the marginal cost of water in the Southwest to the marginal benefit realized by the incentive program. In doing so, he concluded that the cost of the incentive program at the time was just offset by its resource value, and the program was thus a worthwhile initiative (see analysis for details).

In 2004, a reanalysis of the Water Smart Landscapes Program was done to consider the economic viability of it in the face of the drought and the current resource and program incentive values. Given the current scarcity of local water resources, the drought, and the fact that SNWA is now approaching the point of withdrawing its full Colorado River allotment (SNWA[20] 2003), the Las Vegas Valley Water District has recently paid $9,500 per acre-foot for undeveloped groundwater rights in the local basin and, furthermore, views this purchase as a bargain (LVVWD[22] 2003). Because the largest purveyor member in the SNWA is willing to pay this amount currently for undeveloped, non-administered water rights, this should be a good alternative price for comparing the cost effectiveness of the program on a per-square-foot basis (not including administrative and advertising costs).

It follows that to estimate the savings yielded by the program in dollars per square foot, the above marginal cost of water, converted to a square-foot basis, can be multiplied by the savings per square foot yielded by the conversion as below:

$9,500 per acre-foot X 325851 gallons per acre-foot X 55.8 gallons per sqft yield = $1.627 per sqft

The cost calculation is slightly more complex, as the SNWA not only spends the $1.00 per square foot to incentivize the conversion, but it also forgoes the yield it would have claimed on this amount had it invested it. The mature yield of municipal bonds in February 2004 is used as this alternative rate. Thus the true cost per square foot for SNWA can be estimated as:

$1.00 per sqft expended + ($1.00 + 4.65% mature interest yield if invested instead) = $1.047

The cost-effectiveness of the program can then be calculated as the difference between these values:

$1.627 per sqft saved - $1.047 per sqft saved = $0.58 per sqft net positive value to SNWA

The analysis suggests that for each dollar the SNWA is spending for the incentive, it is bringing in $1.58 and that the program appears as such to be a good deal from a financial perspective for SNWA. The ca. 37% net positive value means the program should be financially advantageous even with addition of the program advertising and administration costs which have not to date been quantified.

In considering the theoretical maximum that SNWA could pay for the program (a component of Objective 6), it should be noted that $1.627 is not the maximum as, again, the yield of the alternative investment must be considered. Subtracting out this missed or forgone yield results in a figure of $1.55 and this is the theoretical maximum price SNWA could currently justifiably sustain. Again, the actual maximum would be anticipated to be lower due to program administration costs.

Executive Summary and Conclusions

The major conclusions of this research are as follows:

1. Xeriscape conversion projects can save vast quantities of water at single-family residences. Homes in this study saved an average of 96,000 gallons annually following completion of an average-size conversion project. This is a savings of 30% in total annual consumption; a finding in line with those yielded by other research studies in this region.

2. Over the long timeframe of this study, total yearly savings have neither eroded nor improved across the years. On average, household consumption drops immediately and quickly stabilizes.

3. There is an enormous difference in application of water to locally used turfgrasses and xeric landscape by residents. On average, each year residents applied 73.0 gallons per square foot (117.2 inches) of water to grow turfgrass in this area and just 17.2 gallons per square foot (27.6 inches) to xeric landscape areas. The difference between these two figures, 55.8 gallons per square foot (89.6 inches) is the theoretical average savings yielded annually by having xeriscape in lieu of turf in this area. This is a *substantial* savings (76.4%) when considered in the context of the available residential water conservation measures. A sub-study of other commercial properties with xeriscape found the average application to xeric areas by these customers to be essentially equivalent to that observed for the residential customers.

4. Over the course of a year, the difference in application between turf and xeric areas varies in a predictable bell-shaped-curve manner, with the greatest difference occurring in summer. This is because turf irrigation peaks to a much greater extent in summer than xeric irrigation. The difference in irrigation between these two types of landscape varies from as little as 1.56 gallons per square foot for the month of December, on up to 9.62 gallons per square foot for the month of July.

5. In comparing irrigation application to the reference evapotranspirational rate (ET_o), it was found that on average application to turf exceeded ET_o in every month except March, exceeding it the most May through November. In contrast, xeric application remained well below ET_o year round.

6. The author experimented with using a locally invoked “rule-of-thumb” which holds that xeric plantings require about a third of the evapotranspirational rate as needed for turf. In comparing this developed reference, $0.33(ET_o)$, to application, it was found that these values were, in absolute terms, somewhat close month to month and very close over the entire year. In comparing this developed reference to application, it was found that xeric application was below $0.33(ET_o)$ half the year and above it the other half of the year (September-February).

7. Relative to questions about irrigation management and the potential for further efficiency gains, findings associated with conclusions 4 through 6 and subsequent analyses led the author to the suggest that (i.) the greatest absolute savings from assorted improvements in irrigation will be realized in the summer, but (ii.) the most readily obtained efficiency improvements (i.e., not requiring capital outlays) yielded from better controller management may be obtained September through January, as this is the period when a lot of residents fail to successfully decrease irrigation in response to lower irrigation requirements (for both types of landscape).

8. Multivariate regression modeling was used to help discover some of the factors associated with variability in water consumption at single-family residences. These are:
   i. The amount of turf at the residence (positive correlation).
   ii. The property value of the residence (as indicated by the local assessor's office; positive correlation).
   iii. The age of the residence (positive correlation).
   iv. The total income of the property's residents (positive correlation).
   v. Whether or not the turfgrass present at the residence is Fescue (a locally popular cool-season grass; positive correlation). As a side-result from one of the multivariate analyses, Bermuda grass may be receiving approximately 59 gallons per square foot per year – certainly less than the application for the much more common cool-season grass in this study.

   Some variables which were significant in many other incarnations of the model (but not the final model) include parcel size, surface area of open water for pools and spas, the total number of occupants living at the residence, and total landscapeable area.

9. A similar approach was used to identify some of the factors associated with variability in irrigation application to monitored xeric areas. These are:
   i. The total canopy coverage within the xeric area (positive correlation).
   ii. The average per-station flow rate of the installed irrigation system serving the xeric area (positive correlation).
   iii. The size of the xeric area (positive correlation).
   iv. The property value of the residence (positive correlation).
   v. Parcel size (inverse correlation).
   vi. Whether or not the irrigation system was exclusively a drip irrigation system (i.e., not composed of microsprays, bubblers, other higher flow emitters, or combinations of emitters; inverse correlation).
   vii. Whether or not the resident responsible for managing irrigation at the home is knowledgeable about enforcement of local provisions prohibiting outdoor water waste (inverse correlation).

10. Tracking of the costs residents incurred when converting their landscapes from turf to xeric landscape revealed that at the time of the study, the average conversion cost was \$1.55 per square foot across all of the conversion projects for which data was available. The average cost for those who did the work themselves was \$1.37 per square foot, and for those employing a contractor, it was \$1.93 per square foot. All of these costs are probably higher today due to inflation and a strong market for conversion projects.

11. In comparing those with 60% or more of their landscape as xeric landscaping and those whose landscape was 60% or more turf, it was found that those with the majority as xeriscape condition enjoyed a 2.2 hrs-per-month reduction in landscape maintenance and an additional $206 per annum savings in direct maintenance expenditures as well. This represented a savings of about a third in total landscape labor and maintenance expenditures, respectively.

12. A model of two identical homes, one near the average for consumption (technically in the fifth decile for consumption), the other the same, but having completed an average-size conversion, revealed the following:
    i. The annual water bill savings yielded by landscape conversion projects can be large. For the Las Vegas Valley Water District customer modeled, the annual financial savings was $239.92 (figure includes all applicable surcharges). This equates to a savings of nearly $0.15 per square foot.
    ii. This is a large savings of 54% in total annual charges for water consumption. This level of savings is elevated over what might have been initially anticipated due to an aggressive tiered water rate structure. The effective average fifth-decile annual water charges with all surcharges added would be $2.13/kgal for the typical traditional home and $1.85/kgal for the one having completed the average-size conversion.
    iii. The savings vary by season as expected by the findings associated with the submeter data. Whereas the bill payer of the home having done the conversion saved 25% ($5.68) in charges for December vs. the typical homeowner, the same individual would realize an enormous savings of 70% ($40.84) for July. One of the great benefits of xeriscape is that it drastically mediates “peaking” in summer, making summer bills much more affordable for households, especially since power bills also peak in summer.

13. A model was also created to explore payback time and the appropriateness of the financial incentive. This revealed that payback time varies in part on whether or not homeowners do the work themselves or enlist the assistance of a contractor and whether or not savings in maintenance labor is actually realized. Modeling proceeded such that different combinations of these scenarios were explored. The results suggest that in most situations the current SNWA incentive is sufficient to help facilitate conversions such that there is an acceptable time to return on investment (ROI) for the homeowner. In order of increasing time to ROI from the point of conversion, with a dollar-per-square foot incentive from SNWA, these are as follows:
    - Situations where only the material costs of the conversion are valued and where savings in both maintenance goods and labor can be realized (average payback time of one to two years).
    - Situations where both the material costs of the conversion and the labor cost of the conversion are valued and where savings in both maintenance goods and labor can be realized (average payback time of two to three years).

- Situations where only the material costs of the conversion are valued and where only savings in maintenance goods (not labor) can be realized (average payback time of three to four years).
- Situations where both the material costs of the conversion and the labor cost of the conversion are valued and where only savings in maintenance goods (not labor) can be realized (average payback time of five to six years).

14. An economic analysis of the cost-efficiency of SNWA's Water Smart Landscapes Program suggests that in theory the program is cost-efficient and could be bringing in the equivalent of $1.58 for each $1.00 spent on rebate incentives (a 37% positive return) by way of effectively freeing up local water resources for immediate use. When the opportunity cost is included in the calculation, it is determined that the theoretical maximum incentive SNWA should be currently willing to pay in 2004 dollars is $1.55 per square foot (the actual maximum is less due to program administration costs). In practice, this means it is probably not cost-effective to raise the incentive further at this time as the level necessary to yield a 3-yr ROI for those not yet facilitated to convert (i.e., the final bulleted scenario in Conclusion 13) equates to $2.23, an incentive level far in excess of the theoretical top-out point for an incentive provided by SNWA. Furthermore, in the majority of modeled scenarios, the dollar per-square-foot is sufficient incentive for homeowners to justify the landscape conversion project.

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Appendices

APPENDIX 1: ATTACHMENT A (SCOPE OF WORK) FOR BOR AGREEMENT 5-FC-30-00440 AS REVISED 11/19/98

APPENDIX 2: MULTIVARIATE MODEL DETAILS

Note: Detailed definitions of variables and units for with each variable for both of the below models appear in the corresponding sections within *Sources of Significant Variability in Single-Family Residential Consumption.*

TABLE 19: Multivariate Regression Model of Annual Single-Family Residential Consumption

Regression Summary
Dependent Variable: MAINMETE (i.e., annual consumption registered through mainmeter)
R^2=0.80889235; Adjusted R^2=0.80046113
F(9,204) = 95.940; p<0.0001
Std. Error of Estimate=76890

Variable	Beta	Std. Error of Beta	B	Std. Error of B	*t*(204)	p - level
Intercept			-90852.6	25413.77	-3.57494	0.000437
POOL	0.060698	0.035627	51.3	30.13	1.70371	0.089959
TOTALTUR	0.622464	0.041887	59.1	3.98	14.86045	0.000000
TOTALLAN	-0.145252	0.102765	-5.5	3.90	-1.41344	0.159051
APPROXINC	0.073217	0.033839	0.3	0.14	2.16370	0.031649
FESCUE	0.068672	0.032854	25756	12322.71	2.09020	0.037839
TOTVAL	0.281661	0.051686	2.1	0.39	5.44950	0.000000
PARCELSI	0.214206	0.119536	5.9	3.28	1.79197	0.074620
NLTHOMEA	0.117091	0.043809	1600.6	598.85	2.67274	0.008132
TOTALOCC	0.52416	0.032356	8860.4	5469.42	1.61999	0.106780

TABLE 20: Multivariate Regression Model of Annual Xeric Study Area Consumption

Regression Summary
Dependent Variable: SUBMETER (i.e., annual consumption registered through submeter)
R^2=.64787230; Adjusted R^2=.41973852
F(7,178) = 18.394; p<0.0001
Std. Error of Estimate=32272

Variable	Beta	Std. Error of Beta	B	Std. Error of B	*t*(178)	p - level
Intercept			-7697.6	8973.436	-0.85782	0.392144
STUDYA	0.211132	0.068633	6.4	2.087	3.07623	0.002427
TOTALCAN	0.299352	0.069467	9.2	2.126	4.30934	0.000027
DONTKNOW	0.122082	0.57381	10922.2	5133.663	2.12756	0.034750
TOTVAL	0.213746	0.072592	0.4	0.137	2.94447	0.003667
PARCELSI	-0.211758	0.076239	-1.5	0.524	-2.77756	0.006064
AVGFLOWR	0.265679	0.064116	3637.4	877.802	4.14372	0.000053
DRIP	-0.133730	0.058997	-13615	6006.406	-2.26674	0.024609

APPENDIX 3: RAW DATA

Raw data for possible further analysis is included in the file "BORdata.mdb." A copy of this Microsoft Access database file is being included on disk with submission of this report to BOR. Below is the data description and dictionary for the file (this is also saved on disk).

<u>Xeriscape Conversion Study Data Description</u>

1. **tblCustomerList – 716 Records,** basic customer information.
    a. ClientID – SNWA Customer identification number
        i. Number – Long Integer
        ii. Primary Key
    b. Program – Indicates if the property is a xeriscape or turf study site
        i. Text – 50
        ii. XS = Xeriscape Study, TS = Turf Study
    c. FirstName – Property occupant's first name
        i. Text – 50
    d. LastName – Property occupant's last name
        i. Text – 50
    e. Address – Address of property
        i. Text – 50
    f. City
        i. Text – 50
    g. Zip – Postal code
        i. Text – 5
    h. HomePhone
        i. Text – 50
    i. WorkPhone
        i. Text – 50
    j. Comments – Optional comment field
        i. Memo
    k. OwnerChange – Indicates if there has been a change in the ownership of the property.
        i. Boolean
    l. FollowupMonth – Number of the month the property has been assigned to schedule an annual follow-up site visit.
        i. Text – 2
    m. AccountNum – LVVWD / SNWA account number assigned to the property
        i. Number – Long Integer
    n. ServiceArea – Indicates if the customer receives service from LVVWD or one of the other entities.
        i. Text – 50
        ii. S = LVVWD Service, O = Outside Entity.

o. Agreement – Date the customer signed the agreement to become a participant in the study.
    i. Date/Time
p. FinalReview – Date final inspection site visit was conducted after the installation of the submeter.
    i. Date/Time
q. Status – File quality status indication.
    i. Text – 50
r. FileQuality – Quality rating of file information
    i. Text – 50

2. **tblAllSubmeterData – 2667 Records,** customer's submetered consumption data.
    a. nltClientID – SNWA Customer identification number
        i. Number – Long Integer
        ii. Primary Key
    b. nitYear
        i. Number – Integer
        ii. Primary Key
    c. txtEntity – Indicates which water provider services the customer
        i. Text – 5
    d. txtProgram – Indicates if the property is a xeriscape or turf study site
        i. Text – 2
        ii. XS = Xeriscape Study, TS = Turf Study
    e. nstJan – January submeter consumption in gallons
        i. Number – Single Precision
    f. nstFeb – February submeter consumption in gallons
        i. Number – Single Precision
    g. nstMar – March submeter consumption in gallons
        i. Number – Single Precision
    h. nstApr – April submeter consumption in gallons
        i. Number – Single Precision
    i. nstMay – May submeter consumption in gallons
        i. Number – Single Precision
    j. nstJun – June submeter consumption in gallons
        i. Number – Single Precision
    k. nstJul – July submeter consumption in gallons
        i. Number – Single Precision
    l. nstAug – August submeter consumption in gallons
        i. Number – Single Precision
    m. nstSep – September submeter consumption in gallons
        i. Number – Single Precision
    n. nstOct – October submeter consumption in gallons
        i. Number – Single Precision
    o. nstNov – November submeter consumption in gallons
        i. Number – Single Precision

p. nstDec – December submeter consumption in gallons
    i. Number – Single Precision
q. nstTotal – Total yearly submeter consumption in gallons
    i. Number – Single Precision

3. **tblAOX2 – 702 Records,** parcel information from Assessor's database
    a. ClientID – SNWA Customer identification number
        i. Number – Long Integer
        ii. Primary Key
    b. PLDECKSQF – Pool decking square footage
        i. Number – Single Precision
    c. STORAGESQF – Storage area square footage
        i. Number – Single Precision
    d. PAVE1SQF – Paved area one square footage
        i. Number – Single Precision
    e. PAVE2SQF – Paved area two square footage
        i. Number – Single Precision
    f. PATIO1SQF – Patio one square footage.
        i. Number – Single Precision
    g. PATIO2SQF – Patio two square footage
        i. Number – Single Precision
    h. PATIO3SQF – Patio three square footage
        i. Number – Single Precision
    i. GARAGE1SQF – Garage area 1 square footage
        i. Number – Single Precision
    j. GARAGE2SQF – Garage area 2 square footage
        i. Number – Single Precision
    k. CARPORTSQF – Carport area square footage
        i. Number – Single Precision
    l. FIRSTFLSQF – First floor footprint square footage
        i. Number – Single Precision
    m. TOTALHS – Total of all hardscape areas
        i. Number – Single Precision
    n. PARCEL – Assessor's parcel number
        i. Text – 11

4. **tblETDatawithCustomerIDs – 716 Records,** total monthly and annual evapotranspiration rates for 2001 by month correlated with SNWA client identification numbers.
    a. ClientID – SNWA Customer identification number
        i. Number – Long Integer
        ii. Primary Key
    b. ETType
        i. Text - 50
    c. JanET
        i. Number – Single Precision

d. FebET
    i. Number – Single Precision
e. MarET
    i. Number – Single Precision
f. AprET
    i. Number – Single Precision
g. MayET
    i. Number – Single Precision
h. JunET
    i. Number – Single Precision
i. JulET
    i. Number – Single Precision
j. AugET
    i. Number – Single Precision
k. SepET
    i. Number – Single Precision
l. OctET
    i. Number – Single Precision
m. NovET
    i. Number – Single Precision
n. DecET
    i. Number – Single Precision
o. TotalET
    i. Number – Single Precision

5. **tblETDatawithCustomerIDsAvg – 716 Records,** average monthly and annual evapotranspiration rates for 2001 by month correlated with SNWA client identification numbers.
    a. ClientID – SNWA Customer identification number
        i. Number – Long Integer
        ii. Primary Key
    b. ETType
        i. Text – 50
    c. JanAvgET
        i. Number – Single Precision
    d. FebAvgET
        i. Number – Single Precision
    e. MarAvgET
        i. Number – Single Precision
    f. AprAvgET
        i. Number – Single Precision
    g. MayAvgET
        i. Number – Single Precision
    h. JunAvgET
        i. Number – Single Precision

i. JulAvgET
    i. Number – Single Precision
j. AugAvgET
    i. Number – Single Precision
k. SepAvgET
    i. Number – Single Precision
l. OctAvgET
    i. Number – Single Precision
m. NovAvgET
    i. Number – Single Precision
n. DecAvgET
    i. Number – Single Precision
o. TotalAvgET
    i. Number – Single Precision

6. **tblInstalledCanopy – 447 Records,** total of square feet of plant coverage of xeriscape participants upon installation of the landscape.
    a. ClientID – SNWA Customer identification number
        i. Number – Long Integer
        ii. Primary Key
    b. InstCanopyArea – Installed plant canopy square feet.
        i. Number – Single Precision

7. **tblParcelInfo – 702 Records,** Information from Clark County Assessor's office database extracted November 2002.
    a. ClientID – SNWA Customer identification number
        i. Number – Long Integer
        ii. Primary Key
    b. ParcelNum – Assessor's office parcel number
        i. Text – 11
    c. ParcelSize – Size of parcel in square feet
        i. Number – Single Precision
    d. CONSTYR – Construction year
        i. Number – Integer
    SALEPRICE – Last Sales price
        ii. Number – Long Integer
    e. LYTOTAL – Last years assessed value land and improvement
        i. Number – Long Integer
    f. SALEDATE – Last sales date (Year)
        i. Text - 6
    g. nltHomeAge – Age of home calculated by construction year from the year 2001.
        i. Number – Long Integer

8. **tblResults – 603 Records,** collection of landscape areas, yearly water consumption data, other site, and customer information
    a. nltClientID – SNWA Customer identification number
        i. Number – Long Integer
        ii. Primary Key
    b. Program – (TS = Turf Study Participant, XS = Xeriscape Study)
        i. Text – 50
    c. Converted – Area converted if XS participant
        i. Number – Single Precision
    d. Pool – Square footage of pool surface if present
        i. Number – Single Precision
    e. GardenMon – Square footage of garden area where the irrigation is monitored by the submeter
        i. Number – Single Precision
    f. GardenUnmon – Square footage of garden area where the irrigation is not monitored by the submeter
        i. Number – Single Precision
    g. Other – Square footage of other undeveloped property area. No irrigation, plants, or hardscape present.
        i. Number – Single Precision
    h. Study – Total xeriscape area where irrigation is monitored by the submeter. Applies to XS participant only.
        i. Number – Single Precision
    i. TurfMon – Square footage of turf grass where irrigation is monitored by the submeter.
        i. Number – Single Precision
    j. TurfUnmon – Square footage of turf area where the irrigation is not monitored by the submeter
        i. Number – Single Precision
    k. XeriMon – Square footage of xeriscape where irrigation is monitored by the submeter. (Applies to Turf Study Group)
        i. Number – Single Precision
    l. XeriUnmon – Square footage of xeriscape area where the irrigation is not monitored by the submeter.
        i. Number – Single Precision
    m. TotalLandscape – Total of all landscapable area on the property.
        i. Number – Single Precision
    n. TotalEvaporative – Total of all landscapable area with pool area added.
        i. Number – Single Precision
    o. dtt2001SR – Date of final annual visit conducted in 2001.
        i. Date/Time
    p. AgeOfXeriscape – Age of xeriscape in days calculated by the difference in days between the post submeter installation inspection and the final 2001 follow-up site visit.
        i. Number – Long Integer

q. TotalXeriArea – Total of all xeriscape areas, monitored and unmonitored.
    i. Number – Single Precision
r. Status – File quality status indication.
    i. Text - 50
s. TotalCanopy – Total of all plant canopy areas as of the 2001 annual site visit.
    i. Number – Single Precision
t. nitYear
    i. Number – Integer
u. txtEntity – Water agency that services the customer.
    i. Text - 5
v. Submeter2001 – Total gallons used in the year 2001 through the submeter
    i. Number – Single Precision
w. Mainmeter2001 – Total gallons used in the year 2001 through the main meter
    i. Number – Single Precision
x. pctGarden – Percent of total landscape area in garden
    i. Number – Single Precision
y. pctXeri – Percent of total landscape in xeriscape
    i. Number – Single Precision
z. pctTurf – Percent of total landscape area in turf
    i. Number – Single Precision
aa. pctOther – Percent of total landscape in other non-landscaped area
    i. Number – Single Precision
bb. pctPool – Percent of total landscape area in pool
    i. Number – Single Precision
cc. pctXeriRank – Xeriscape study participants were divided into ten percent ranges based upon percentage of landscape in xeriscape and given a ranking.
    i. Number – Single Precision
dd. XeriDensity – Percent of plant coverage per square foot of xeriscape.
    i. Number – Single Precision
ee. TurfType – Type of turf (Bermuda, Fescue, etc.) on property if present.
    i. Text – 50
ff. BarrierType – Type of weed barrier present if Xeriscape study participant.
    i. Text – 50

9. **tblSurveyInfoOfInterest – 603 Records,** Responses to survey questions. Each possible response is listed as a separate field. The responses are grouped where appropriate.
    a. CLIENTID – SNWA Customer identification number
        i. Number – Long Integer
        ii. Primary Key
    b. SurveyAnswered – “Yes” or “No” Indicates if the customer answered any of the questions on the survey.
        i. Text – 3
    c. CLOCKADJ – How many times per year the irrigation clock was adjusted
        i. Number – Byte

d. INCBILL – How much of an increase in the monthly bill would produce conservation?
    i. Number – Integer
e. RESPAGE – Respondent's age
    i. Number – Byte
f. Respondent's gender
    i. MALE
        1. Number – Byte (1 = Yes, 0 = No)
    ii. FEMALE
        1. Number – Byte (1 = Yes, 0 = No)
g. Respondent's marital status
    i. MARRIED
        1. Number – Byte (1 = Yes, 0 = No)
    ii. SINGLE
        1. Number – Byte (1 = Yes, 0 = No)
    iii. WIDOWED
        1. Number – Byte (1 = Yes, 0 = No)
h. RETIRED – Indicates if respondent is retired or not
    i. Number – Byte (1 = Yes, 0 = No)
i. NATIVE – Native to southern Nevada?
    i. Number – Byte (1 = Yes, 0 = No)
j. AGE65PLS – Number of residents at the property age 65 and older
    i. Number – Byte
k. APROXINC – Median of a range of household income
    i. Number – Long Integer
l. Respondent's opinion on Water Waste enforcement
    i. DONTKNOW
        1. Number – Byte (1 = Yes, 0 = No)
    ii. GOOD
        1. Number – Byte (1 = Yes, 0 = No)
    iii. LAX
        1. Number – Byte (1 = Yes, 0 = No)
    iv. STRICT
        1. Number – Byte (1 = Yes, 0 = No)
m. Highest Education Level
    i. ASSOCDEG – Associate's degree
        1. Number – Byte (1 = Yes, 0 = No)
    ii. BACHDEG – Bachelor's degree
        1. Number – Byte (1 = Yes, 0 = No)
    iii. GRADDEG – Graduate degree
        1. Number – Byte (1 = Yes, 0 = No)
    iv. HSDEG – High school degree
        1. Number – Byte (1 = Yes, 0 = No)

v. SOMECOLL – Some College
1. Number – Byte (1 = Yes, 0 = No)
vi. SOMEGRAD – Some graduate education
1. Number – Byte (1 = Yes, 0 = No)
vii. TECHTRAD – Technical or trade school
1. Number – Byte (1 = Yes, 0 = No)
viii. ADTECTRN – Advanced technical training
1. Number – Byte (1 = Yes, 0 = No)

n. Type of Grass at residence
i. BERMUDA
1. Number – Byte (1 = Yes, 0 = No)
ii. FESCUE
1. Number – Byte (1 = Yes, 0 = No)
iii. BUFFALO
1. Number – Byte (1 = Yes, 0 = No)
iv. BFMIX – Bermuda / Fescue Mix
1. Number – Byte (1 = Yes, 0 = No)
v. UNKNOWN
1. Number – Byte (1 = Yes, 0 = No)
vi. NONE
1. Number – Byte (1 = Yes, 0 = No)

10. **tblSurveryTotBath – 623 Records,** total number of bathrooms on the property
a. ClientID – SNWA Customer identification number
i. Number – Long Integer
ii. Primary Key
b. Bathrooms
i. Number – Single Precision

11. **tblSurveyTotOccupants- 341 Records,** total number of occupants in the household at the time of the survey.
a. nltClientID – SNWA Customer identification number
i. Number – Long Integer
ii. Primary Key
b. TotalOccupants
i. Number – Integer

12. **tblIrrigationData – 355 Records,** Irrigation system components for each property were assessed, and each property assigned to one of the following categories.
a. ClientID – SNWA Customer identification number
i. Number – Long Integer
ii. Primary Key
b. AvgFlowRate – Average flow rate of all stations
i. Number – Single Precision
c. BubblerDrip – Irrigation system is composed of bubbler and drip systems
i. Number – Integer (1 = Yes, 0 = No)

d. BubblerDripSpray – Irrigation system is composed of bubbler, drip, and spray systems
    i. Number – Integer (1 = Yes, 0 = No)
e. Bubblers – Irrigation system is composed of bubblers
    i. Number – Integer (1 = Yes, 0 = No)
f. BubblerSpray – Irrigation system is composed of bubbler and spray systems
    i. Number – Integer (1 = Yes, 0 = No)
g. Drip – Irrigation system is composed of drip systems
    i. Number – Integer (1 = Yes, 0 = No)
h. DripOff – Irrigation system is composed of drip systems with one or more other irrigation zones turned off
    i. Number – Integer (1 = Yes, 0 = No)
i. DripMicro – Irrigation system is composed of drip and micro-spray systems
    i. Number – Integer (1 = Yes, 0 = No)
j. DripPopup – Irrigation system is composed of drip and popup spray systems
    i. Number – Integer (1 = Yes, 0 = No)
k. DripSpray – Irrigation system is composed of drip and spray systems
    i. Number – Integer (1 = Yes, 0 = No)
l. Hose – Irrigation is done with a hose
    i. Number – Integer (1 = Yes, 0 = No)
m. Microspray – Irrigation system is composed of micro-spray systems
    i. Number – Integer (1 = Yes, 0 = No)
n. Sprays – Irrigation system is composed of spray systems
    i. Number – Integer (1 = Yes, 0 = No)
o. BubblerDripPopup – Irrigation system is composed of bubbler, drip, and popup spray systems
    i. Number – Integer (1 = Yes, 0 = No)
p. DripMicroPopup – Irrigation system is composed of drip micro-spray and popup spray systems
    i. Number – Integer (1 = Yes, 0 = No)
q. DripPopupSpray – Irrigation system is composed of drip, popup spray, and spray systems
    i. Number – Integer (1 = Yes, 0 = No)
r. DripPopupRotor – Irrigation system is composed of drip, popup spray, and rotor systems
    i. Number – Integer (1 = Yes, 0 = No)
s. DripLaser – Irrigation system is composed of drip and laser tube systems
    i. Number – Integer (1 = Yes, 0 = No)
t. DripSoaker – Irrigation system is composed of drip and soaker hose systems
    i. Number – Integer (1 = Yes, 0 = No)
u. DripTurfBubbler – Irrigation system is composed of drip and turf bubbler systems
    i. Number – Integer (1 = Yes, 0 = No)
v. DripFountain – Irrigation system is composed of drip systems, and a fountain refill is controlled with the irrigation clock
    i. Number – Integer (1 = Yes, 0 = No)

13. **tblMulches – 715 Records,** mulch and weed barrier information
    a. ClientID – SNWA Customer identification number
        i. Number – Long Integer
        ii. Primary Key
    b. txtMulch – Typical type of mulch
        i. Text - 18
    c. txtMulchSize – Typical size of mulch
        i. Text - 50
    d. txtMulchColor – Typical color of mulch
        i. Text - 6
    e. nstMulchDepth – Depth of mulch in inches
        i. Number – Single Precision
    f. yntWeeds – Indicates if excessive weeds are present
        i. Boolean
    g. yntSlope – Is a steep slope present?
        i. Boolean
    h. yntTraffic – Is there heavy traffic in landscape?
        i. Boolean
    i. yntAlkali – Indicates if excessive alkali deposits present at surface.
        i. Boolean
    j. txtBarrierType – Type of weed barrier
        i. Text – 20
    k. txtBarrierColor – Color of weed barrier
        i. Text – 6
    l. yntBarrierShowing – Is the barrier showing at surface?
        i. Boolean
    m. txtWear – Extent of wear
        i. Text – 6
    n. txtLocationType – Wear location type
        i. Text – 16

14. **tblMainmeterConsumption – 4318 Records,** Gallons used per customer per month as measured by the property's main service meter.
    a. nltClientID – SNWA Customer identification number
        i. Number – Long Integer
        ii. Primary Key
    b. nitYear
        i. Number – Integer
        ii. Primary Key
    c. txtEntity – Indicates which water provider services the customer
        i. Text – 5
    d. nstJan – January consumption in gallons
        i. Number – Single Precision
    e. nstFeb – February consumption in gallons
        i. Number – Single Precision

f. nstMar – March consumption in gallons
    i. Number – Single Precision
g. nstApr – April consumption in gallons
    i. Number – Single Precision
h. nstMay – May consumption in gallons
    i. Number – Single Precision
i. nstJun – June consumption in gallons
    i. Number – Single Precision
j. nstJul – July consumption in gallons
    i. Number – Single Precision
k. nstAug – August consumption in gallons
    i. Number – Single Precision
l. nstSep – September consumption in gallons
    i. Number – Single Precision
m. nstOct – October consumption in gallons
    i. Number – Single Precision
n. nstNov – November consumption in gallons
    i. Number – Single Precision
o. nstDec – December consumption in gallons
    i. Number – Single Precision
p. nstTotal – Total annual consumption in gallons
    i. Number – Single Precision

15. **tbl2001PropAreasOK4 – 673 Records,** Property area information as recorded for the year 2001.
    a. nltClientID – SNWA Customer identification number
        i. Number – Long Integer
        ii. Primary Key
    b. Converted – Area converted from turf to xeriscape. Refers to "XS" Participants only.
        i. Number – Single Precision
    c. Pool – Pool area if applicable
        i. Number – Single Precision
    d. GardenMon – Garden area where irrigation is being monitored by the submeter
        i. Number – Single Precision
    e. GardenUnmon – Garden area where irrigation is unmonitored by the submeter
        i. Number – Single Precision
    f. Other – Square footage of other undeveloped property area. No irrigation, plants or hardscape present.
        i. Number – Single Precision
    g. Study – Total xeriscape area where irrigation is monitored by the submeter. Applies to XS participant only.
        i. Number – Single Precision
    h. TurfMon – Square footage of turf grass where irrigation is monitored by the submeter.
        i. Number – Single Precision

i. TurfUnmon – Square footage of turf area where the irrigation is not monitored by the submeter
    i. Number – Single Precision
j. XeriMon – Square footage of xeriscape where irrigation is monitored by the submeter. (Applies to xeriscape study Group)
    i. Number – Single Precision
k. XeriUnmon – Square footage of xeriscape area where the irrigation is not monitored by the submeter.
    i. Number – Single Precision
l. TotalEvaporative – Total of all landscape areas plus pool area.
    i. Number – Single Precision
m. TotalLandscape – Total of all landscape areas.
    i. Number – Single Precision
n. dtt2001SR – Date of 2001 follow-up site visit
    i. Date / Time
o. AgeOfXeriscape – Age of xeriscape in days calculated by the difference between the post submeter installation inspection and the final 2001 follow-up site visit.
    i. Number – Long Integer
p. TotalXeriArea – Total of all xeriscaped areas
    i. Number – Single Precision
q. TotalGarden – Total of all garden areas
    i. Number – Single Precision
r. TotalTurf – Total of all Turf areas
    i. Number – Single Precision
s. PctGarden – Percent of total landscape area in garden
    i. Number – Single Precision
t. PctXeri – Percent of total landscape in xeriscape
    i. Number – Single Precision
u. PctTurf – Percent of total landscape area in turf
    i. Number – Single Precision
v. PctOther – Percent of total landscape in other non-landscaped area
    i. Number – Single Precision
w. PctPool – Percent of total landscape in pool
    i. Number – Single Precision
x. PctXeriRank – Xeriscape study participants were divided into ten percent ranges based upon percentage of landscape in xeriscape and given a ranking.
    i. Number – Long Integer

16. **tblTurfOnlySubMonthly – 107 Records,** monthly submeter consumption data and per square foot usage for turf study group of participants. Note – this usage is limited to those TS participants where ONLY turf was irrigated with submeter-monitored usage.
    a. ClientID – SNWA Customer identification number
        i. Number – Long Integer
        ii. Primary Key
    b. Year
        i. Number – Integer

c. Entity – Water purveyor that serves the customer
    i. Text – 5
d. FileQuality – Quality rating of file information
    i. Text – 10
e. Status – Customer status
    i. Text – 7
f. TurfMon – Square feet of grass where irrigation is monitored by the submeter
    i. Number – Single
g. JanCons – January submeter consumption in gallons
    i. Number – Single
h. FebCons – February submeter consumption in gallons
    i. Number – Single
i. MarCons – March submeter consumption in gallons
    i. Number – Single
j. AprCons – April submeter consumption in gallons
    i. Number – Single
k. MayCons – May submeter consumption in gallons
    i. Number – Single
l. JunCons – June submeter consumption in gallons
    i. Number – Single
m. JulCons – July submeter consumption in gallons
    i. Number – Single
n. AugCons – August submeter consumption in gallons
    i. Number – Single
o. SepCons – September submeter consumption in gallons
    i. Number – Single
p. OctCons – October submeter consumption in gallons
    i. Number – Single
q. NovCons – November submeter consumption in gallons
    i. Number – Single
r. DecCons – December submeter consumption in gallons
    i. Number – Single
s. JanGalSF – Gallons used per square foot of turf in January
    i. Number – Single
t. FebGalSF – Gallons used per square foot of turf in February
    i. Number – Single
u. MarGalSF – Gallons used per square foot of turf in March
    i. Number – Single
v. AprGalSF – Gallons used per square foot of turf in April
    i. Number – Single
w. MayGalSF – Gallons used per square foot of turf in May
    i. Number – Single
x. JunGalSF – Gallons used per square foot of turf in June
    i. Number – Single
y. JulGalSF – Gallons used per square foot of turf in July
    i. Number – Single

z. AugGalSF – Gallons used per square foot of turf in August
    i. Number – Single
aa. SepGalSF – Gallons used per square foot of turf in September
    i. Number – Single
bb. OctGalSF – Gallons used per square foot of turf in October
    i. Number – Single
cc. NovGalSF – Gallons used per square foot of turf in November
    i. Number – Single
dd. DecGalSF – Gallons used per square foot of turf in December
    i. Number – Single

17. **tblTurfOnlySubYearly – 107 Records,** yearly submeter consumption data and per square foot usage for turf study group of participants. Note – this usage is limited to those TS participants where ONLY turf was irrigated with submeter-monitored usage.
    a. ClientID – SNWA Customer identification number
        i. Number – Long Integer
        ii. Primary Key
    b. Year
        i. Number – Integer
        ii. Primary Key
    c. Entity – Water purveyor that serves the customer
        i. Text – 5
    d. TurfMon – Square feet of grass where irrigation is monitored by the submeter
        i. Number – Single
    e. GalSqFt – Gallons used per square foot of turf per year
        i. Number – Single
    f. YearlyCons – Total submetered consumption for the year.
        i. Number – Single
    g. FileQuality – Quality rating of file information
        i. Text - 8
    h. Status – Customer status
        i. Text – 7

18. **tblXeriOnlySubMonthly – 1550 Records,** monthly submeter consumption data and per square foot usage for xeriscape study group of participants. Note – this usage is limited to those XS participants where ONLY xeriscape was irrigated with submeter-monitored usage.
    a. ClientID – SNWA Customer identification number
        i. Number – Long Integer
        ii. Primary Key
    b. Year
        i. Number – Integer
        ii. Primary Key
    c. Entity – Water purveyor that serves the customer
        i. Text – 5

d. ConvNew – Indicates if the property's xeriscape was a new installation or a conversion of grass to xeriscape.
    i. Text – 4
e. Status – Customer status
    i. Text – 7
f. FileQuality – Quality rating of file information
    i. Text – 10
g. XeriMon – Square feet of xeriscape where irrigation is monitored by the submeter
    i. Number – Single Precision
h. JanCons – January submeter consumption in gallons
    i. Number – Single Precision
i. FebCons – February submeter consumption in gallons
    i. Number – Single Precision
j. MarCons – March submeter consumption in gallons
    i. Number – Single Precision
k. AprCons – April submeter consumption in gallons
    i. Number – Single Precision
l. MayCons – May submeter consumption in gallons
    i. Number – Single Precision
m. JunCons – June submeter consumption in gallons
    i. Number – Single Precision
n. SepCons – September submeter consumption in gallons
    i. Number – Single Precision
o. OctCons – October submeter consumption in gallons
    i. Number – Single Precision
p. NovCons – November submeter consumption in gallons
    i. Number – Single Precision
q. DecCons – December submeter consumption in gallons
    i. Number – Single Precision
r. JanGalSF – Gallons used per square foot of xeriscape in January
    i. Number – Single
s. FebGalSF – Gallons used per square foot of xeriscape in February
    i. Number – Single
t. MarGalSF – Gallons used per square foot of xeriscape in March
    i. Number – Single
u. AprGalSF – Gallons used per square foot of xeriscape in April
    i. Number – Single
v. MayGalSF – Gallons used per square foot of xeriscape in May
    i. Number – Single
w. JunGalSF – Gallons used per square foot of xeriscape in June
    i. Number – Single
x. JulGalSF – Gallons used per square foot of xeriscape in July
    i. Number – Single
y. AugGalSF – Gallons used per square foot of xeriscape in August
    i. Number – Single

z. SepGalSF – Gallons used per square foot of xeriscape in September
    i. Number – Single
aa. OctGalSF – Gallons used per square foot of xeriscape in October
    i. Number – Single
bb. NovGalSF – Gallons used per square foot of xeriscape in November
    i. Number – Single
cc. DecGalSF – Gallons used per square foot of xeriscape in December
    i. Number – Single

19. **tblXeriOnlySubYearly – 1550 Records,** yearly submeter consumption data and per square foot usage for xeriscape study group of participants. Note – this usage is limited to those XS participants where ONLY xeriscape was irrigated with submeter-monitored usage.
    a. ClientID – SNWA Customer identification number
        i. Number – Long Integer
        ii. Primary Key
    b. Year
        i. Number – Integer
        ii. Primary Key
    c. Entity – Water purveyor that serves the customer
        i. Text – 5
    d. ConvNew – Indicates if the property's xeriscape was a new installation or a conversion of grass to xeriscape.
        i. Text – 4
    e. XeriMon – Square feet of xeriscape where irrigation is monitored by the submeter
        i. Number – Single Precision
    f. YearlyCons– Total submetered consumption for the year.
        i. Number – Single
    g. GalSqFt – Gallons used per square foot of monitored xeriscape per year
        i. Number – Single
    h. FileQuality – Quality rating of file information
        i. Text – 10
    i. Status – Customer status
        i. Text – 7

20. **tblPlantList – 538 Records,** list of plants used to verify xeriscape participant's compliance with minimum canopy standards for program participation and classification of landscape plants in subsequent follow-up visits.
    a. PlantID
        i. Number – Long Integer
        ii. Primary Key
    b. Genus
        i. Text - 50
    c. Species
        i. Text - 50

d. Var/Cult – Variety or cultivar of plant
    i. Text - 50
e. Common Name
    i. Text - 50
f. Width – Expected mature width of the plant
    i. Number - Single
g. Height – Expected mature height of the plant
    i. Number - Integer
h. Plant Habit – Type of plant (shrub, tree, etc.)
    i. Text - 50
i. H20Use – Rated plant water needs.
    i. Text – 50

21. tbl2001HomeSales – 45 Records, data provided by SalesTraq. Information related to home sales in Southern Nevada area in the year 2001 by zip code.

a. Zipcode
    i. Text – 5
    ii. Primary Key
b. NumberSold – Number of homes sold in zip code
    i. Number – Single Precision
c. MedianPrice – Median price of homes sold in zip code
    i. Number – Single Precision
d. AvgPrice – Average price of homes sold in zip code.
    i. Number – Single Precision
e. AvgPricePerSqFt – Average Price per square foot of homes sold in zip code.
    i. Number – Single Precision
f. AvgSize – Average size of homes sold in zip code.
    i. Number – Single Precision
g. Volume – Total value of homes sold in zip code
    i. Number – Single Precision
h. AvgAge – Average age of homes sold in zip code
    i. Number – Single Precision

22. tblMeterInfo – 716 Records

a. ClientID – SNWA Customer identification number
    i. Number – Long Integer
    ii. Primary Key
b. MeterNum – Serial number stamped on submeter by manufacturer
    i. Text – 50
c. Installed – Date submeter was installed by contractor
    i. Date/Time
d. Cost – Cost of meter installation
    i. Number – Single Precision
e. RetrofitNum – AS/400 account number assigned to submeter
    i. Number – Long Integer

f. Location – approximate location of submeter on site.
    i. Memo

APPENDIX 4: INFORMATION ON SINGLE-FAMILY RESIDENTIAL WATER BILL MODEL

A model was used to explore the differences in water consumption charges for a typical fifth decile in consumption LUC 110 property (single-family home) and one doing an average-size conversion. The model assumes the properties are in the Las Vegas Valley Water District's service area and subject to its regular service rules. A typical 5/8-inch-meter size was assumed (meter size in large part determines rate per consumption unit). Rates for each tier and the size of the tier rate block appear below in the screen shot of the actual modeling processes for the model used in this report. As demonstrated, within a given billing cycle the rate for the first 5,000 gallons is $1.05/kgal, the *next* 5,000 gallons after the initial 5000 costs $1.75/kgal, the next 10,000 gallons after these first 10,000 gallons is $2.38/kgal and so on (for billing purposes, the utility rounds to the nearest thousand gallons). In addition to the direct charges for the water, SNWA purveyor members bills commonly include a service charge, a commodity charge, and a reliability charge and these are reflected in the model below, so that the outputs are reflective of actual bills. A 30-day billing cycle was assumed.

In practical terms, the calculation of outputs in the model and the savings is derived by multiplying the expected average savings per square foot per month that would be yielded by a conversion (as calculated from Table 18) by the average-size conversion and then subtracting this from the fith-decile consumption level. This yielded the costs with having done the conversion (below called "Total Bill). In contrast, the cost without doing the conversion (i.e., "Average Fifth-Decile bill without reduction") is shown under the "did conversion" scenario. The difference between these, highlighted in red, is the anticipated monthly bill savings yielded from having completed the conversion project.

<u>Water Bill Calculator Screen Shot</u>

Meter Size: 5/8 | ☑ Residential | Percent Reduction 0% | Select Entity: LVVWD Current | Average SF WSL Conversion (n=3651): 1615.8

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Totals			
		10670	9369	12255	16174	21107	23447	25084	24519	21788	18112	13738	11795	208 057	5th Decile average consumption		
		1.81	2.09	2.45	4.64	7.74	8.78	9.62	7.96	6.25	4.54	3.02	1.56		Average Gallons Per SqFt Reduction		
		2925	3377	3959	7497	12506	14187	15544	12862	10099	7336	4880	2521	97691	Avg Gal / SqFt Reduction * Avg SF WSL Conversion		
Tier Rates	Tier Blocks	8	6	8	9	9	9	10	12	12	11	9	9	110366	Avg 5th Decile Cons - (Reduction * Avg WSL Conversion)		
1.05	5	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	63.00			
1.75	5	4.80	1.74	5.77	6.43	6.30	7.46	7.94	8.75	8.75	8.75	6.75	7.48	80.93			
2.38	10								3.94	4.02	1.85			9.81			
3.02	20													0.00			
	Water Cost	10.05	6.99	11.02	11.68	11.55	12.71	13.19	17.94	18.02	15.85	12.00	12.73	153.74	Price Per 1000 Gal. Annual	$	1.39
3.069	Service Charge	3.67	3.67	3.67	3.67	3.67	3.67	3.67	3.67	3.67	3.67	3.67	3.67	44.03			
0.05	Commodity Charge	0.39	0.30	0.41	0.43	0.43	0.46	0.48	0.58	0.58	0.54	0.44	0.46	5.52			
0.25%	Reliability Surcharge	0.04	0.03	0.04	0.04	0.04	0.04	0.04	0.06	0.06	0.05	0.04	0.04	0.51			
	Total Bill	14.15	10.98	15.14	15.83	15.69	16.88	17.38	22.25	22.33	20.11	16.16	16.90	203.79	Price Per 1000 Gal. Annual	$	1.85
		19.85	17.08	23.71	33.25	45.98	53.18	58.22	56.48	48.08	37.98	27.32	22.59	443.72	Average 5th Decile bill without reduction	$	2.13
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	$ [illegible]	Total Savings with Red		

APPENDIX 5: INFORMATION ON HOMEOWNER PERSPECTIVE MODEL

The model is a dynamic Net Present Value Model that calculates the NPV of the project in future years. It does this by computing the difference in the yield by converting to xeriscape to the costs (water and maintenance) incurred by keeping turfgrass over the years.

"Conversion cost" and "awarded incentive" are products of the associated rates and the square feet converted. These are onetime costs. The "interest rate" is the discount or alternative rate (i.e., the rate associated with the loss incurred by spending money on the conversion rather than placing it in an interest-bearing account). The "average yearly rate increase" is the long-time average increase in water costs. "Yearly maintenance savings" is a product of the "Labor Savings" and "Direct Maintenance" variables (which are themselves calculated in a manner similar to "awarded incentive," however, these savings are yielded each year). "Average total bill savings for a year" is not automatically calculated, but entered either by use of real data or modeled bill savings (see Appendix 4). Model Outputs are "NPV" and "Year." Year 0 is the year of the conversion.

This model can directly yield the payback time with and without the incentive. By iterative process one can then develop what the input variables values would need to provide for a positive NPV at a given year. This is how the values for the third and fifth-year ROIs were developed for Figure 15. Example inputs and outputs are given below. In this case, at $1.00 per square foot, the conversion reached a positive NPV between years one and two.

In terms of yielding the actual data in Table 15, the following were used as data sources:

"Square Feet Converted" – This was the average conversion size for SNWA's Water Smart Landscapes Program in early 2004.

"Incentive Level" – This was the $1.00 per square foot incentive level for almost all single-family conversion projects in SNWA's Water Smart Landscapes Program in early 2004 (also see Appendix 5).

"Conversion cost" – This was the conversion cost as revealed by survey. This was one of the variables that were modified to reflect whether or not one did the conversion themselves or utilized contract assistance. Rates for each of these scenarios were developed based on compilation of receipts from both types of installations.

"average total bill savings for a year" – This was the yearly savings as provided by a model of the Las Vegas Valley Water District for a LUC 110 property in the fifth decile (mid-range) of consumption (see Appendix 4 for details on this model).

"interest rate" – This was the interest rate of a home equity loan in early February 2004.

"average yearly rate increase" – This is the average yearly rate increase for the Las Vegas Valley Water District over the long term. In practice, the District has often gone significant periods of time without a rate increase and then increased them much more than 3%, but this was the most practical method of doing the calculation for purposes of creating the model.

"Labor Savings" – This was adapted from Hessling[12] (2001). This savings was effectively turned on or off to see the impacts of the situations when labor savings are and are not realized. See text for additional information.

"Direct Maintenance" – This rate was derived from the maintenance survey data and is per Hessling[12] (2001).

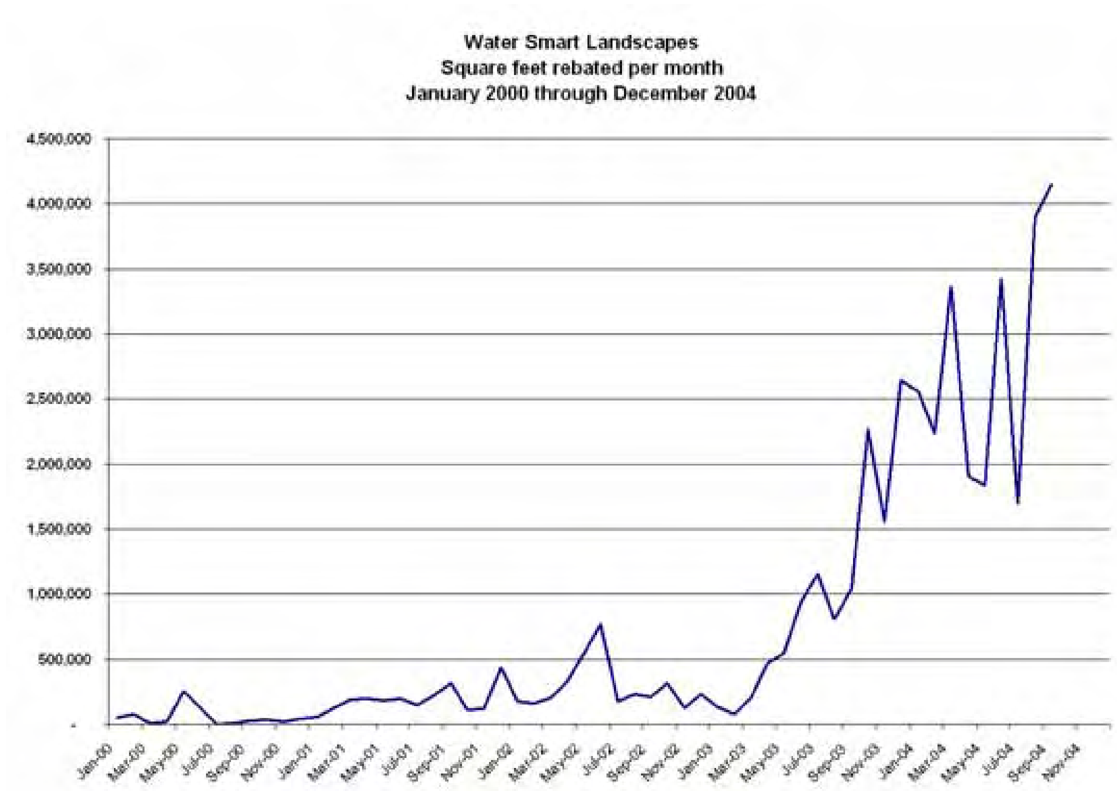
Examples of Homeowner Perspective Model Inputs and Outputs

Inputs:	Type
Square Feet Converted	1616
Incentive level	$1.00
Conversion cost:	$1.37
conversion cost:	$2,213.92
average total bill savings for a year:	$240.00
awarded incentive:	$1,616.00
interest rate:	6.32%
average yearly rate increase	3.00%
Labor Savings	$0.20
Labor Savings	$323.20
Direct Maintenance	$0.11
Direct Maintenance	$177.76
Yearly maintenance savings	$500.96

NPV	**Year**
($2,070.88)	0
($636.58)	1
$751.63	2
$2,095.24	3
$3,395.67	4
$4,654.31	5

APPENDIX 6: INFORMATION ON SNWA'S WATER SMART LANDSCAPES PROGRAM

Growth of Program:



See Program Application (following)

Appendix B

SNWA Case Study

Southern Nevada Water Authority
Water Smart Landscapes Rebate Program

Water Utility Journal 27: 1-13, 2021.

The potential effects of climate change and drawdown on a newly constructed drinking water intake: Study case in Las Vegas, NV, USA

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Abstract: Lake Mead is a large reservoir in the desert southwest, USA, that provides drinking and irrigation water for over 40 million people in Arizona, California, Nevada, and Mexico. The Southern Nevada Water Authority (SNWA) utilizes Lake Mead to provide 90% of the water consumed in the Las Vegas Valley. Recently, SNWA spent $1.4 billion USD to construct a new drinking water intake, Low Lake Level Pump Station 3 (L3PS), deep within Boulder Basin. The goal of this project is to ensure resiliency of the water supply to the Las Vegas Valley and maintain consistency of raw water quality even under extreme drought conditions. In this study, the effects of climate change, including extreme drawdown on the lake coupled with projected rising air temperatures, were investigated. The three-dimensional hydrodynamic and water quality model for Lake Mead was used to determine the effect of climate change on water quality parameters of interest at the drinking water intake, including water temperature, dissolved oxygen, nitrogen, phosphorus, and wastewater effluent. The goal of this work is to determine how raw water withdrawn through L3PS could change under projected future climate scenarios, and how these changes could impact the processes used at SNWA's water treatment plants. Simulated lake drawdown was found to be the driver for changes to raw water quality, most notably an increase in temperature, leading to the potential need for modifications to the treatment process. Among other side effects, formation of total trihalomethanes, which are regulated disinfection byproducts, will increase as raw water temperatures increase.

Key words: Drinking water; AEM3D; Lake Mead; Global Climate Model, direct filtration; ozonation

1. INTRODUCTION

Lake Mead, a large reservoir in the desert southwest, USA, is a crucial link in the Lower Colorado River Basin, supplying drinking and irrigation water for over 40 million people (CRWUA, 2020; Milly and Dunne, 2020). Lake Mead is located in the Lower Colorado River Basin and is impounded by the Hoover Dam. The Las Vegas Valley relies on Lake Mead for water as it supplies 90% of the water consumed in the valley. Consequently, maintaining the quality of Lake Mead is crucial for both the Las Vegas Valley and downstream users in Arizona, California, and Mexico. Climate change is anticipated to have critical effects on Lake Mead, including changes to water quality parameters as a result of lake drawdown and rising air temperatures (Udall and Overpeck, 2017).

The Southern Nevada Water Authority (SNWA) relies on Lake Mead to provide reliable, high-quality water to consumers in the Las Vegas Valley. Raw water from the lake is pumped to two water treatment plants (WTPs), treated, and distributed throughout the valley. Previously, SNWA used two intakes located near Saddle Island in Boulder Basin of Lake Mead (Figure 1). Intake 1 was constructed at an elevation of 1050 ft (320.04 m) above sea level. Intake 2 is located 1000 ft (304.8 m) above sea level.

At full capacity, Lake Mead has an elevation of 1221 ft (371.9 m) above sea level. When Intakes 1 and 2 were constructed in 1971, Lake Mead was near full capacity; therefore, the intakes withdrew high-quality water from deep in the water column. Today, if utilized, Intakes 1 and 2 have the potential to withdraw epilimnetic water during the summer, due to lower lake levels from extended drought and the deepening of the surface layer of the lake, seasonally.

Rising air temperatures, changes to thermal stratification, and closer proximity between the water surface and drinking water intakes could result in warmer water at drinking water treatment facilities. Warmer water temperatures result in beneficial lower concentration×time requirements for ozone and chlorine disinfection (USEPA, 2020). However, warmer water is also associated with harmful cyanobacterial blooms (Paerl and Huisman, 2009), faster chlorine residual decay (Roccaro et al., 2008), faster trihalomethane formation (Roccaro et al., 2008), and Legionella growth (Rhoads et al., 2017).

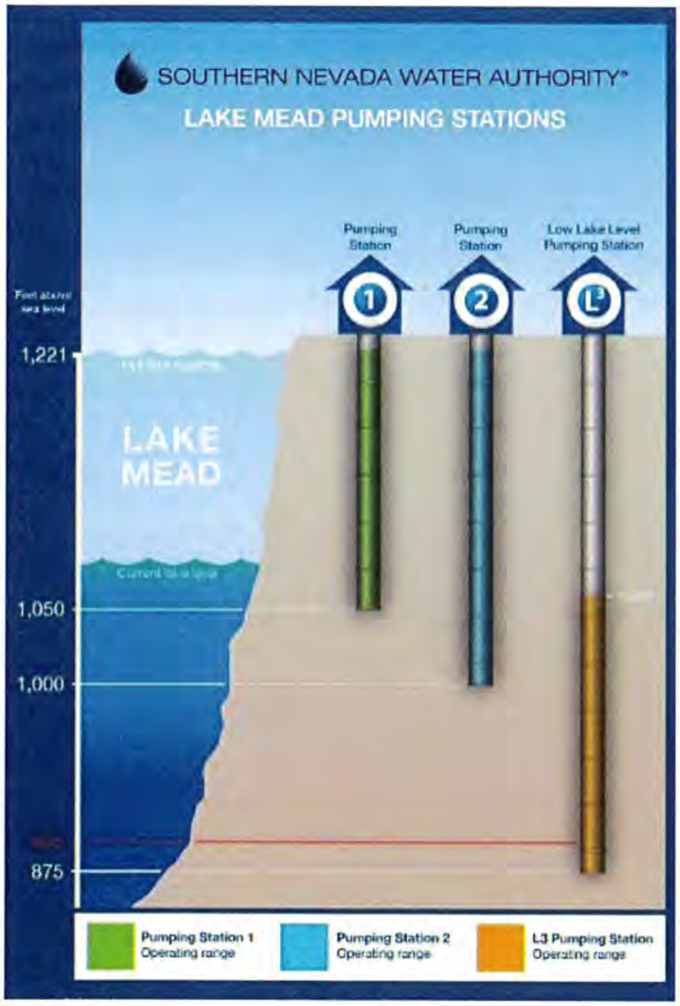

Figure 1. Intake withdrawal depths.

In Lake Mead, closer proximity between the water surface and a drinking water intake could potentially increase the water quality impact of the Las Vegas Wash, the primary drainage of the Las Vegas Valley / metropolitan area and the regions wastewater treatment facilities. During parts of the year, water from the Las Vegas Wash travels through the Boulder Basin of Lake Mead as a distinct inflow, generally around 10 m deep (Snyder and Benotti, 2010). The Las Vegas Wash is approximately 85% wastewater effluent from the Las Vegas Valley (Benotti et al., 2010). The Las Vegas Wash has elevated concentrations of selenium, pharmaceuticals, endocrine disruptors, *N*-nitrosodimethylamine precursors, and poly- and perfluoroalkyl substances (Ryan and Zhou, 2010; Bai and Son, 2021; Benotti et al., 2010; Woods and Dickenson, 2016).

SNWA constructed a third intake, L3PS Intake No 3, which began conveying water to SNWA's water treatment facilities in September 2015. L3PS was built at 895 ft (272.8 m) above sea level, considerably lower than intakes 1 and 2. This intake enabled SNWA to access deeper, cooler water. In 2020, the low lake level pump station (L3PS) was completed and allowed the third intake to continue to operate, even if lake elevations dropped below 1000 ft (304.8 m) above sea level. These collective projects were constructed at a considerable expense, nearly $1.4 billion USD, to ensure the longevity and sustainability of the water supply provided by SNWA to the Las Vegas Valley. Water that is conveyed to the WTPs is currently exclusively drawn from this deeper intake.

SNWA transfers raw water to its two treatment plants - River Mountains Water Treatment Facility (RMWTF) and Alfred Merritt Smith Water Treatment Facility (AMSWTF). Both RMWTF and AMSWTF use advanced direct filtration to convert raw water to potable water. The four steps include (SNWA, 2020):

1. Disinfection with ozone (O3),
2. Coagulation with ferric chloride (FeCl3),
3. Filtering with anthracite and granular activated carbon, and
4. Finishing the water with chlorination to maintain a disinfectant residual, corrosion control, and addition of fluoride.

From AMSWTF and RMWTF, the finished water enters the distribution system, where it serves 2.2 million customers in the Las Vegas Valley and 42.5 million annual visitors (LVCVA, 2020).

This case study uses a 3-dimensional hydrodynamic and water quality model for Lake Mead that incorporates potential lake drawdown coupled with rising air temperature projections to determine how the raw water withdrawn at L3PS may change, and consequently how the treatment processes at AMSWTF and RMWTF may be impacted.

Previous studies performed on Lake Mead have separately considered the effects of climate change (Preston and Tietjen, 2014) or lake drawdown (Preston et al., 2014b) applied to overall lake management strategies. The Lake Mead Model (LMM) was also previously used as a tool to assess the location of L3PS prior to construction. Five locations were considered, and simulations were run with water surface elevation levels (WSELs) between 1000 and 1180 ft (304.8 and 359.7 m). Climate simulations were not a meaningful factor in this study. The primary determining factor in choosing an optimal intake location was the concentration of wastewater effluent from the Las Vegas Wash at each proposed location. Construction costs were also considered in this study, and the current location of L3PS was recommended (Preston et al., 2014b).

This study extends previous work by including much lower water surface elevation levels, while also coupling the effects of climate change and drawdown. In this study, more extreme drawdown was considered, with WSELs ranging from 900 to 1100 ft (274.3 to 335.3 m). Further, climate projections were incorporated into the LMM. The goal of this study is to use the LMM coupled with climate projections and simulated drawdown to understand the effects of climate change on raw water withdrawn at L3PS, and how these changes may affect WTP operations.

Two tools were used to determine the potential effects of climate change on SNWA's drinking water intake. The first is the LMM, which is a full 3D and hydrodynamic water quality model for Lake Mead. The second are the air temperature projections from the Global Climate Models (GCMs), which were coupled with potential drawdown as inputs into the hydrodynamic and water quality model. This work uses the LMM to specifically study potential for raw water quality changes, including changes to temperature, dissolved oxygen, nitrogen, phosphorus, and wastewater effluent for L3PS and applies those changes to the WTFs.

2. METHODOLOGY

2.1 The Lake Mead model

SNWA maintains a full mathematical three-dimensional hydrodynamic and water quality model for Lake Mead that is used to simulate probable future scenarios and aid in management decisions. This model is implemented in Aquatic Ecosystem Model 3D (AEM3D). AEM3D approximates quantities of interest by solving the Reynolds-averaged Navier-Stokes equations with a turbulent eddy closure (Hydronumerics, 2016). The model solves for hydrodynamic and water quality parameters in each grid cell, including, but not limited to, temperature, dissolved oxygen (DO), conductivity, chlorophyll *a*, suspended sediment, conservative and decay tracers, zooplankton, phytoplankton, and chemical parameters such as phosphorus, nitrogen, and carbon (Hodges and Dallimore, 2013).

The LMM grid is based on lake bathymetry and uses a 300 m × 300 m x-y grid, with depth outputs every 2 meters. In this grid, yellow represents the deepest interior cells, red is less deep, and blue are the shallower shoreline cells (Figure 2). The model is computationally intensive and utilizes 215,480 wetted cells at the 1100 ft WSEL. The model inflows are the Colorado River, which accounts for 97% of the inflow volume, with smaller contributions from the Virgin and Muddy Rivers and the Las Vegas Wash. Most outflow is released through the Hoover Dam, with minor withdrawals from SNWA's drinking water intake plus model-computed losses to evapotranspiration (Preston et al., 2014a). Meteorological parameters, such as air temperature, precipitation, wind speed and direction, and solar radiation are input into the model as boundary forcing values.

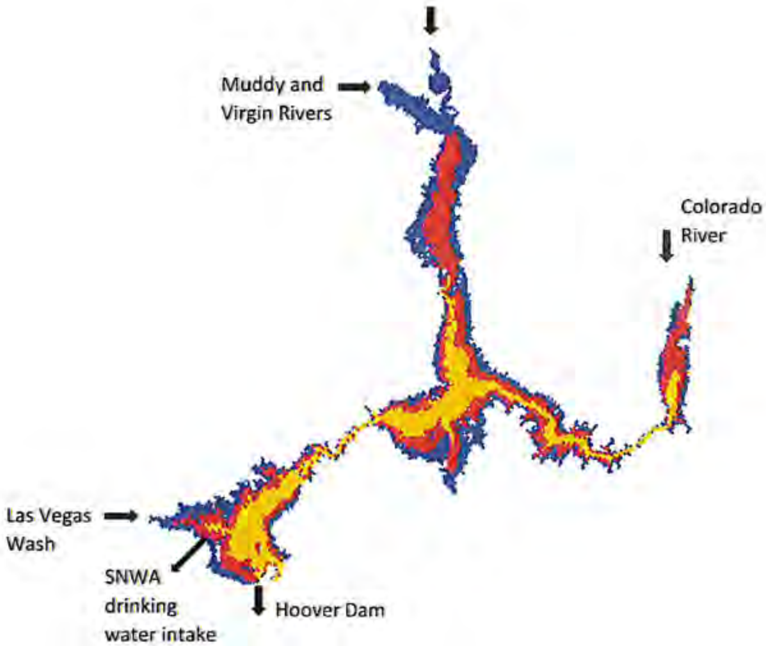

Figure 2. LMM grid.

The LMM was calibrated to measured data to ensure model accuracy and minimization of error as a future planning tool. First, a sensitivity analysis was conducted in MATLAB. Sensitivity analysis calculates a derivative that is used to determine which parameters are most sensitive to small changes (Saltelli, 2000). Through sensitivity analysis, three model parameters were determined to be most affected by perturbations: the wind shear coefficient, the mean albedo, and the surface heat transfer coefficient. Once sensitive parameters were identified, a nonlinear least squares algorithm was used to identify optimal parameter values. The MATLAB nonlinear least squares solver *lsqnonlin*, which is a Levenberg-Marquardt algorithm, was used (MATHWORKS, 2016). Model calibration indicates the LMM provides an excellent fit to collected field data (Hannoun and Tietjen, 2021).

2.2 Climate change projections

Climate change projections for Clark County, NV, were incorporated into the LMM to determine how future climate scenarios may affect Lake Mead. Maximum daily temperatures for Clark

County, NV, were output from six GCMs and downscaled using the Localized Constructed Analogs (LOCA) technique (Pierce et al., 2014). GCMs typically have grid resolutions of 100 – 200 km and need to be downscaled to the more appropriate 4 km grid for local climate studies. This was done for two climate change scenarios, Representative Concentration Pathway 4.5 and 8.5 (RCP 4.5 and RCP 8.5). RCPs represent potential future atmospheric concentrations of greenhouse gases (GHGs) and reflect the amount of radiative forcing that would result in. RCP 8.5 uses 8.5 W/m^2 and RCP 4.5 uses 4.5 W/m^2 (Kalansky, 2018; Kim et al., 2015). RCP 8.5 assumes a business as-usual emission trajectory - that emissions continue to be emitted at the current rate and above, whereas RCP 4.5 is more conservative and assumes a reduction in emissions due to comprehensive global GHG mitigation (Kalansky, 2018). Consistent with literature regarding climate change, RCP 8.5 typically produces more pessimistic (i.e. warmer) results (Chao et al., 2014).

Consistent with the RCPs, air temperature projections for Clark County for three periods, 2010-2039 (near-term), 2040-2069 (mid-century), and 2070-2099 (late-century) were incorporated into the LMM by altering meteorological forcing functions (Kalansky, 2018). The forcing functions were updated to reflect the average predicted increase in air temperature for each year. Further, these air temperature changes were coupled with changes in lake elevation due to drawdown. These predictive changes to the LMM were used to simulate possible future scenarios at L3PS while considering the effects of climate change and lake drawdown.

2.3 LMM simulations

In total, 35 model runs were performed, which represent a wide array of possible future scenarios. Five lake elevations were investigated: 1100 ft, 1050 ft, 1000 ft, 950 ft, and 900 ft (335.3, 320.0, 304.8, 289.6, and 274.3 m). Lake Mead is at full pool at 1220 ft (371.9 m) and dead storage at 895 ft (272.8 m). The selected elevations represent a wide range of possible scenarios. Higher elevations were not considered as the lake is currently at an elevation of 1090 ft as of March of 2021 (332.2 m). Next, three clusters of years were evaluated, 2010-2039 (near-term), 2040-2069 (mid-century), and 2070-2099 (late-century), consistent with Kalansky (2018) and Chao et al. (2014). Then, two climate scenarios were simulated, RCP 4.5 and RCP 8.5. Finally, a baseline simulation where no meteorological parameters were altered was done at each of the five WSELs.

Simulated parameters include water temperature, dissolved oxygen, total nitrogen and phosphorus, total inorganic nitrogen, and a conservative tracer used to simulate treated wastewater entering the lake from the Las Vegas Wash.

2.4 Additional mathematical analyses

To analyze output from the LMM, two additional mathematical tools were used - the Wilcoxon rank sum test and the Maximum Relevance Minimum Redundancy (MRMR) algorithm. The Wilcoxon rank sum test (Gibbons and Chakraboti, 2011) was computed to determine if there are statistically significant changes between the baseline and most pessimistic scenarios in the yearly averages computed for phosphorus, nitrogen, and wastewater effluent. The Wilcoxon test was employed for these parameters as little seasonal variability was seen even at low WSELs, and the goal was to quantify if climate scenarios create a statistically significant change.

To quantify the influence of air temperature compared to water elevation on water quality parameters at L3PS, the MRMR algorithm is used. The MRMR algorithm is a filter-based feature selection method and was chosen for this problem because it has the advantage of performing feature selection independent of the learning process, thus reducing overfitting (Radovic et al, 2017). The MRMR algorithm output is twofold, including a heuristic importance rank as well as a feature selection score (MATHWORKS, 2021). In this study, the feature selection score was normalized to yield a percent contribution of the input variables, lake elevation and air temperature, to the output variables, which are the water quality parameters discussed in Section 3.

3. RESULTS

Trends for quantities of interest at L3PS were studied and reported. Results for each parameter are given below.

3.1 Water temperature

The water temperature at L3PS over baseline and both climate scenarios (RCP 4.5 and RCP 8.5), as well as all five simulated elevations, was studied. Figure 3 shows the RCP 8.5 / late century climate scenario at all five elevations, plotted at intake depth. Temperature at the intake increases with decreasing water level, which is logical as the intake becomes closer to the water surface as the lake loses volume. At 1100 and 1050 ft (335.3 and 320.0 m), the water temperature fluctuates and increases in heat as the year goes on, through seasonal changes in air temperature and lake turnover. At 1000 ft (304.8 m), the water temperature at the intake begins to follow seasonal air temperature trends - warming in the summer and cooling off through fall into winter. The intake at 950 and 900 ft (289.6 and 274.3 m) WSELs is also subject to warming and cooling trends that follow the patterns in air temperature.

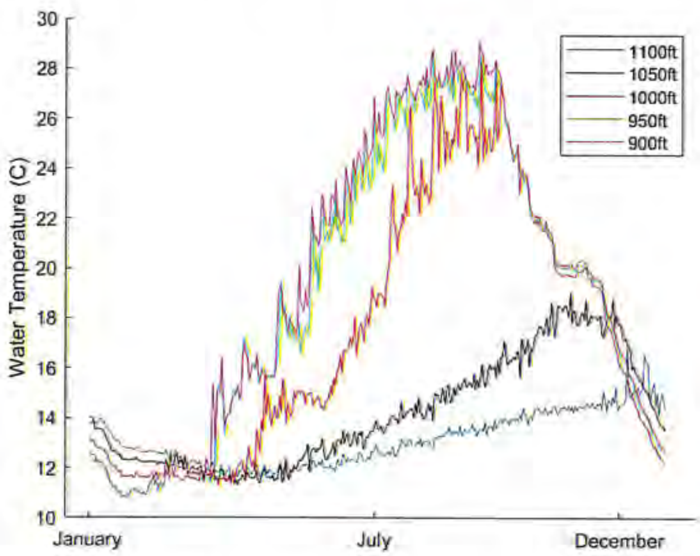

Figure 3. Water temperatures at L3PS for all five simulated WSELs; RCP8.5/late-century (2070-2099) climate scenario.

Table 1 lists the winter and spring baseline average temperatures are close to one another at 1100 and 1050 ft (335.3 and 320.0 m) WSELs, but the 1050 ft (320.0 m) elevation simulation has more warming in summer that perpetuates into autumn. At the three lower elevations, substantial warming in the summer is possible.

Table 1. Baseline average seasonal water temperatures at L3PS.

WSEL (ft)	WSEL (m)	Winter (˚C)	Spring (˚C)	Summer (˚C)	Autumn (˚C)
1100	335.3	13.7	12.0	12.8	14.2
1050	320.0	13.9	11.9	13.9	17.1
1000	304.8	12.7	13.1	21.5	21.9
950	289.6	12.5	15.8	25.6	22.4
900	274.3	12.6	16.1	26.1	22.6

Figures 4 and 5 are plots of the effects of the different climate scenarios at WSELs of 1100 and 900 ft (335.3 and 274.3 m), respectively. The warming air temperatures are reflected in an increased temperature at the drinking water intake, with the late-century (2070-2099) cluster of years leading to the highest increase in water temperature in all cases. The warmer climate scenario (RCP 8.5) results in a larger range in water temperatures for all time periods relative to baseline, whereas RCP 4.5 results in only a small temperature change. All results, however, indicate water temperatures will warm regardless of climate scenario, and the warming will become more pronounced with time.

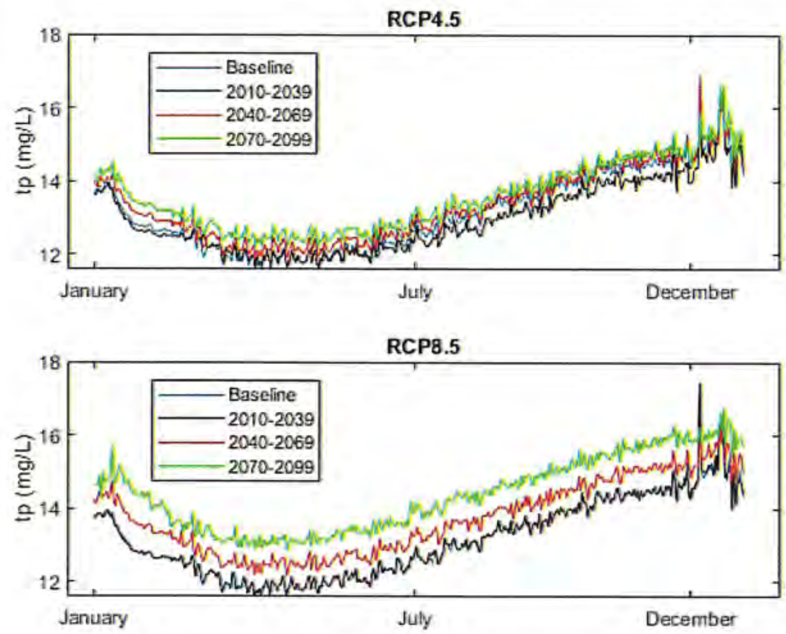

Figure 4. Water temperature at L3PS at 1100 ft (335.3 m) for RCP 4.5 and RCP 8.5 climate scenarios.

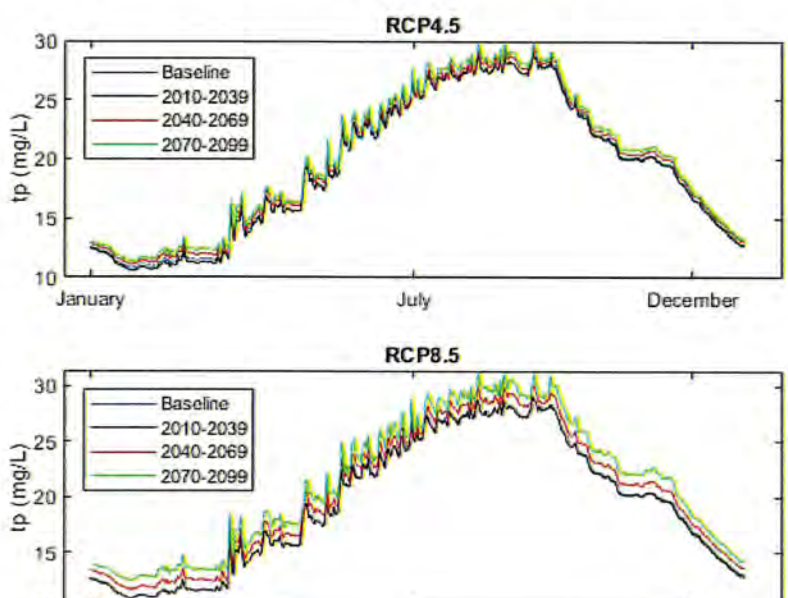

Figure 5. Water temperature at L3PS at 900 ft (274.3 m) for RCP 4.5 and RCP 8.5 climate scenarios.

The MRMR algorithm was used to quantify the influence of air temperature compared to water elevation on water temperatures at L3PS. The MRMR algorithm showed that the WSEL contributes

86% to water temperature, while air temperature contributes 14%. The MRMR analysis confirms the visual observation that WSEL dominates the model output of water temperature.

3.2 Dissolved oxygen

Baseline dissolved oxygen (DO) trends at L3PS intake depth are plotted in Figure 6. There is an increase in the beginning of the year with a decrease in lake level; however, as the year progresses, the higher DO levels decline/decrease with the onset of spring and summer. At 900, 950, and 1000 ft (274.3, 289.6, and 304.8 m) WSELs, the DO levels recover earlier in the winter than predicted at the higher elevations, as the lake mixes from top to bottom earlier. Overall, this indicates that declines in lake levels may lead to more rapid oxygen consumption at depth, but also earlier increases brought on by water column mixing. Overall oxygen concentrations, considered alone, remain within the range that is capable of supporting the current fish and invertebrate communities found in Lake Mead.

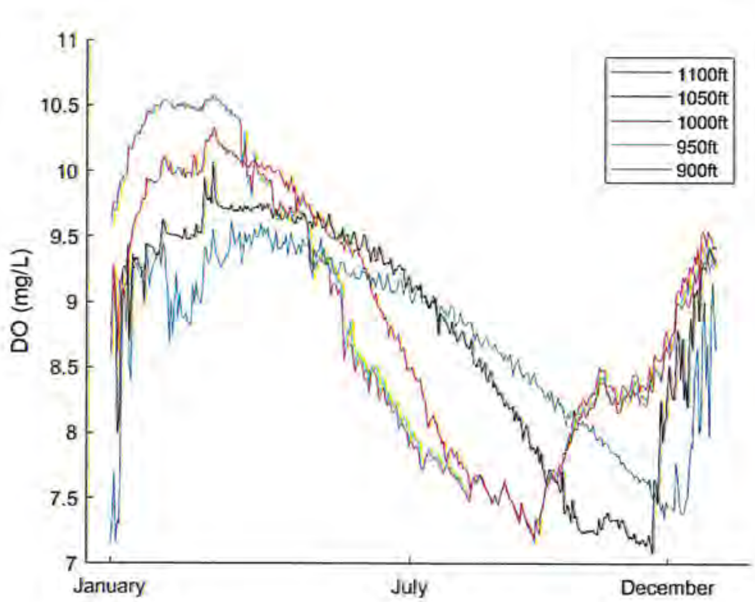

Figure 6. DO at L3PS for all five simulated WSELs; RCP8.5/late-century (2070-2099) climate scenario.

Figures 7 and 8 show the effects of the different RCP scenarios on DO at 1100 and 900 ft (335.3 and 274.3 m), respectively. In all cases, increased climate warming led to decreases in DO. At 1100 ft (353.3 m), the decrease in DO is more pronounced than at 900 feet. All RCP scenarios follow the trends observed in the baseline simulations, with a decrease in DO as climate projections become more pessimistic. These DO decreases are logical because, as the water temperature increases, the saturation potential for DO decreases. The MRMR algorithm was run in the same method as with water temperature and shows that WSEL dominates DO trends (88%), with a small contribution from air temperature (12%).

3.3 Phosphorus and nitrogen

Total phosphorus (TP), total nitrogen (TN), and total inorganic nitrogen (TIN) were simulated at L3PS. Mean TP is observed to increase with a decrease in lake elevation; however, TP levels are still extremely low at L3PS, leading to a phosphorus-limited system (N:P ratio of ~100:1), regardless of elevation. No significant change in seasonal trends was observed with a decrease in lake level. The increase in TP as lake levels decrease is noticeable yet small, and consequently decreases in lake levels are not predicted to lead to any significant changes in TP at L3PS (Table 2). TP concentrations at L3PS for the most pessimistic climate scenario (RCP 8.5 / late-century) were also computed as this represents the worst-case climate state considered in this study. The 1100 ft (335.3 m) WSEL is the result where the Wilcoxon rank sum test determined the means are significantly different.

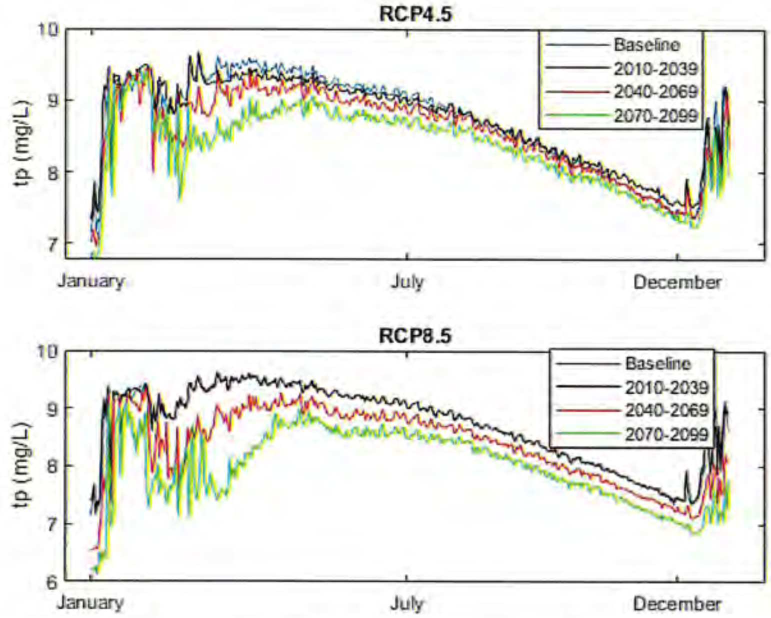

Figure 7. DO at L3PS at 1100 ft (335.3 m) for RCP 4.5 and RCP 8.5 climate scenarios.

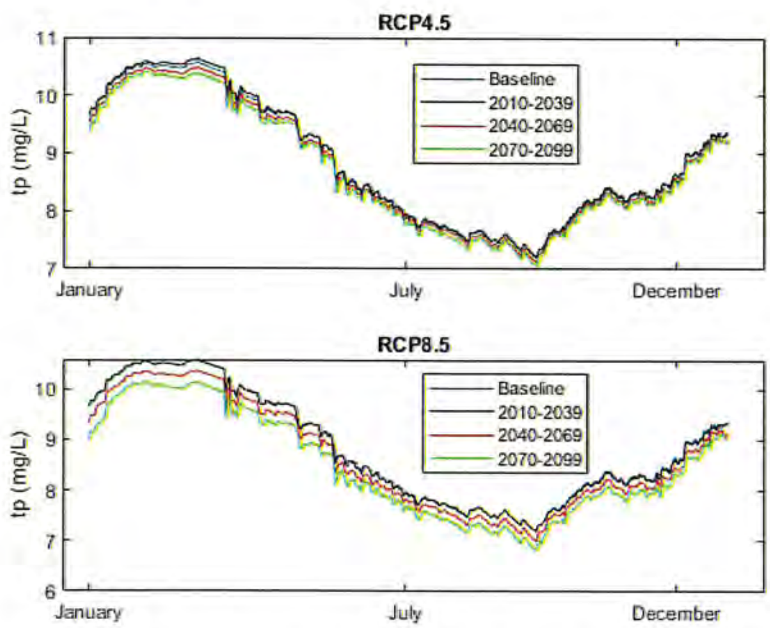

Figure 8. DO at L3PS at 900 ft (274.3 m) for RCP 4.5 and RCP 8.5 climate scenarios.

The Wilcoxon rank sum test was also used to determine if TP changes significantly in response to WSEL within a given climate scenario. Ten combinations of WSELs (5c2) were tested and all had p-values < 0.05, indicating that WSEL has more effect on TP concentration than increasing air temperatures.

Table 2. Yearly mean TP at L3PS.

WSEL (ft)	WSEL (m)	Baseline TP (mg/L)	Most Pessimistic TP (mg/L)	p-value
1100	335.3	9.2e-3	9.0e-3	< 0.05
1050	320.0	9.6e-3	9.6e-3	> 0.05
1000	304.8	1.1e-2	1.1e-2	> 0.05
950	289.6	1.2e-2	1.2e-2	> 0.05
900	274.3	1.2e-2	1.2e-2	> 0.05

Similar analysis for TN and TIN was conducted. TN and TIN levels also show an increase as lake elevations decrease (Tables 3 and 4). TN and TIN are predicted to decrease in a statistically significant way from the baseline to most pessimistic scenario for WSELs of 1100, 1050, and 1000 ft (335.3, 320.0, and 304.8 m). For the remaining two low WSELs, there is not a statistically significant change in either quantity. As with TP, changes in TN and TIN were primarily driven by WSEL.

Table 3. Yearly mean TN at L3PS.

WSEL (ft)	WSEL (m)	Baseline TN (mg/L)	Most Pessimistic TN (mg/L)	p-value
1100	335.3	0.70	0.65	< 0.05
1050	320.0	0.78	0.74	< 0.05
1000	304.8	0.93	0.91	< 0.05
950	289.6	1.1	1.1	> 0.05
900	274.3	1.1	1.1	> 0.05

Table 4. Yearly mean TIN at L3PS.

WSEL (ft)	WSEL (m)	Baseline TIN (mg/L)	Most Pessimistic TIN (mg/L)	p-value
1100	335.3	0.60	0.55	< 0.05
1050	320.0	0.65	0.62	< 0.05
1000	304.8	0.76	0.75	< 0.05
950	289.6	0.89	0.91	> 0.05
900	274.3	0.92	0.94	> 0.05

3.4 Treated wastewater tracer

The treated wastewater discharged into Lake Mead via the Las Vegas Wash is simulated in the LMM with a conservative tracer. The wastewater effluent is represented as a percentage of the total volume of water at L3PS. The mean baseline and most pessimistic climate scenario yearly percentage of effluent is shown in Table 5. As with nutrients, no changes to seasonal trends were observed. Decreased dilution at lower lake elevations coupled with the intake becoming closer to the water surface shows an increase in the concentration of wastewater effluent at L3PS. Climate scenario had a significant effect on wastewater effluent percentage only at the higher WSELs of 1100 and 1050 ft (335.3 and 320.0 m).

Table 5. Yearly mean wastewater effluent (%) at L3PS.

WSEL (ft)	WSEL (m)	Baseline (%)	Most Pessimistic Climate Scenario (%)	p-value
1100	335.3	1.4	1.1	< 0.05
1050	320.0	1.6	1.4	< 0.05
1000	304.8	2.2	2.2	> 0.05
950	289.6	3.2	3.3	> 0.05
900	274.3	3.5	3.6	> 0.05

4. DISCUSSION

Potential drawdown in the lake coupled with projected increases in air temperature lead to higher temperature water being withdrawn from the lake. This is inevitable with any intake placement coupled with drawdown, because as the lake is drained, the intake will more frequently be exposed to epilimnetic waters, and thus more subjected to seasonal air temperature fluctuations. Projected rising air temperatures from RCP 4.5 and RCP 8.5 contribute to increasing raw water temperatures; however, lake elevation is a stronger driver of warming. RMWTF and AMSWTF use ozone as a primary disinfectant, and ozone is less soluble in warmer water; however, the rate constant for disinfection reactions increase with an increase in temperature. Since bacterial activity increases as water temperature increases, these two changes typically yield finished water with the same bacterial count as cooler water (Langlais et al., 1991). Further, formation of total trihalomethanes (TTHMs), which are regulated disinfection byproducts, has been shown to increase as raw water temperatures increase (Valdivia-Garcia et al., 2019).

Raw water temperatures can have a large effect on the coagulation process by altering the optimal pH. As raw water temperatures increase, the optimum pH for coagulation could decrease approximately 0.7 units, although this increase is not projected to have a large impact on treatment processes (Bratby, 2006). Corrosion of heavy metals into potable water is more pronounced at higher temperatures (Khairool, 2013). Therefore, plant operators may need to increase the dosing of anti-corrosion compounds to ensure the delivery of high-quality potable water through the distribution system.

Dissolved oxygen is predicted to become more seasonally variable as lake elevations decrease, and climate projections forecast a potential 20% decrease in DO as climate scenarios become more pessimistic. This is predicted to have little impact on aquatic life in Lake Mead, if predicted concentrations are sustained, and would have very little impact on the treatment process.

Wastewater effluent, TIN, TN, and TP, all showed statistically significant differences between the baseline and most pessimistic climate scenarios at the higher WSELs. Wastewater effluent discharged into Lake Mead via the Las Vegas Wash is a significant conduit for nutrients, and the increase in percent effluent at the two highest WSELs is thought to be a function of the Hoover Dam release protocol (split between high and low withdrawal depths, timing of flows). Sucralose is an artificial sweetener used as a wastewater effluent indicator because it has low susceptibility to natural attenuation processes and high concentrations in wastewater effluent (Mawhinney et al., 2011). In 2019, sucralose mean concentration was 660 ng/L (n=7) at the drinking water intake and 52,000 ng/L (n=5) in the tertiary filtered effluent of the largest of the wastewater treatment facilities discharging to the Las Vegas Wash. These concentrations would indicate a wastewater effluent percentage around 1.3%, which matches the LMM simulation for the baseline scenario.

The change in the three studied nutrients is a function of consumption rates in the water column. As Lake Mead is phosphorus limited (LaBounty and Burns, 2005), the phosphorus available for consumption is used quickly; consequently, there is only a statistically significant change at the highest WSEL thought to be a function of dilution in the lake. Changes to TIN and TN are statistically significant at the three highest WSELs, indicating that the impact of climate change on these nutrients was not diminished by biological activity. The increase in wastewater effluent - and consequently nutrients - is primarily driven by lake drawdown. Ozone dosing at the WTF should be reevaluated, especially at low lake levels, to determine adequate disinfection of raw water is occurring in response to potential changes in overall demand. Increasing ozone doses in raw water also has been shown to increase the formation of bromate in finished water, and high concentrations of bromate can have deleterious health effects (Lin et al., 2014).

The third intake is well-placed to be resilient to the effects of lake drawdown and climate change. The placement of the intake deep in Inner Boulder Basin, far from the influence of the Las Vegas Wash, ensures that the raw water quality is as high as possible, even in cases of extreme drawdown or pessimistic climate projections. Other water quality parameters, such as turbidity and total organic carbon, may be impacted by lake drawdown but were not measured in this study.

Some alterations to the treatment processes, such as additional steps to mitigate corrosion in the distribution system, and increased ozone dosing, may be necessary to counteract the effects of lake drawdown and climate change to ensure the distribution of high-quality potable water throughout the Las Vegas Valley.

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Appendix C

Water Resource Plan and Joint Conservation Plan

Southern Nevada Water Authority
Water Smart Landscapes Rebate Program

SOUTHERN NEVADA WATER AUTHORITY™

2020 WATER RESOURCE PLAN

SOUTHERN NEVADA WATER AUTHORITY

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General Manager

The Southern Nevada Water Authority (SNWA) is a cooperative, not-for-profit agency formed in 1991 to address Southern Nevada's unique water needs on a regional basis.

SOUTHERN NEVADA WATER AUTHORITY

MISSION

Our mission is to provide world class water service in a sustainable, adaptive and responsible manner to our customers through reliable, cost effective systems.

GOALS

Assure quality water through reliable and highly efficient systems.

Deliver an outstanding customer service experience.

Anticipate and adapt to changing climatic conditions while demonstrating stewardship of our environment.

Develop innovative and sustainable solutions through research and technology.

Ensure organizational efficiency and manage financial resources to provide maximum customer value.

Strengthen and uphold a culture of service, excellence and accountability.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

SINCE ITS INCEPTION IN 1991, THE SOUTHERN NEVADA WATER AUTHORITY HAS WORKED TO SECURE NEW WATER RESOURCES FOR SOUTHERN NEVADA, MANAGE EXISTING AND FUTURE WATER SUPPLIES, CONSTRUCT AND OPERATE REGIONAL WATER FACILITIES, AND PROMOTE CONSERVATION.

The Southern Nevada Water Authority (SNWA) was formed in 1991 by a cooperative agreement among seven water and wastewater agencies. Collectively, the SNWA member agencies serve nearly 2.3 million residents in the cities of Boulder City, Henderson, Las Vegas, North Las Vegas and areas of unincorporated Clark County. As their wholesale water provider, the SNWA is responsible for water treatment and delivery, as well as acquiring and managing long-term water resources for Southern Nevada.

SNWA Member Agencies:

- Big Bend Water District
- City of Boulder City
- City of Henderson
- City of Las Vegas
- City of North Las Vegas
- Clark County Water Reclamation District
- Las Vegas Valley Water District

The SNWA Cooperative Agreement calls for the adoption of a water resource plan to be reviewed annually by the SNWA Board of Directors. The 2020 SNWA Water Resource Plan fulfills this requirement, providing a comprehensive overview of projected water demands in Southern Nevada, as well as the resources available to meet those demands over time.

THE CURRENT PLANNING ENVIRONMENT

Beginning in 2000 and continuing today, several water supply and demand changes have occurred—both locally and regionally—that create uncertainty for water planning agencies across much of the western United States. Today, the most significant factors affecting Southern Nevada are increased temperatures and decreased runoff in the Colorado River Basin, resulting from drought and climate change.

Between 2000 and 2020, overall snowfall and runoff into the Basin were well below the historical average, representing one of the lowest 21-year periods on record. The persistence of decades-long drought conditions has resulted in significant water-level declines in major system reservoirs. As of late 2020, the combined water storage in the Colorado River's two primary reservoirs (Lake Mead and Lake Powell) was at just 43 percent of capacity.

In the near term, hydrologic modeling indicates a high probability that Lake Mead water levels will continue to decline. Under the Colorado River Drought Contingency Plan (DCP), water users in the Lower Basin, including Nevada, will make DCP contributions to Colorado River storage when Lake Mead is projected to be at or below 1,090 feet. These contributions are in addition to mandatory shortages and together serve to bolster Lake Mead water levels and preserve critical operations.

Climate change is expected to significantly influence the long-term availability of water supplies within the Colorado River Basin. Multiple studies project a warmer and drier future, both locally and regionally. Projected climate change impacts range from decreased snowpack, precipitation and soil moisture to increased evaporation and stronger, longer and more frequent droughts. According to the U.S. Bureau of Reclamation's 2012 Colorado River Basin Water Supply and Demand Study, the Colorado River is projected to experience a median imbalance of 3.2 million acre-feet per year (AFY) between supply and demand by the year 2060 as a result of climate change and increased demands within the Basin.

The current planning environment also includes uncertainty associated with the availability of future resources and the accuracy of long-term water demand forecasts. These considerations, as well as how they are addressed in the 2020 Plan, are detailed briefly in the following sections.

SUPPLY & DEMAND

Water resource planning is based on two key factors: supply and demand. Supply refers to the amount of water that is available or that is expected to be available for use. Water demand refers to the amount of water expected to be needed in a given year. Water demand projections are based on population forecasts and include assumptions about future water use, such as expected achievements toward water conservation goals.

Projecting future demands is uncertain, particularly during periods of significant social and economic change. Assumptions are a necessary part of the planning process and conditions are unlikely to occur exactly as assumed. Likewise, climate variations, policy changes, implementation of new regulations and other factors can influence water resource availability over time.

The SNWA has worked for more than 25 years to develop and manage a portfolio of water resource options that can be used flexibly to meet short- and long-term water demands. The portfolio approach allows the SNWA to assess water demand conditions and resource options, and make appropriate decisions regarding what resources to bring online when necessary.

The SNWA's water resource portfolio includes permanent, temporary and future resources. Some of these resources are available for immediate use, such as Nevada's Colorado River allocation, Las Vegas Valley groundwater, Intentionally Created Surplus (ICS) and banked resources. Other resource options may require changes to rules that govern Colorado River resources, agreements, and/or the construction of additional facilities.

Improving water efficiency is integral to the SNWA's resource planning efforts and conservation remains a top priority for the community over the long-term planning horizon. Conservation helps to reduce demands and extend the availability of current and future water supplies.

To promote conservation, the SNWA continues to implement one of the most comprehensive programs in the nation. The program has helped the region reduce per capita water use by approximately 52 percent between 2002 and 2019, despite the addition of approximately 730,000 new residents.

The SNWA is currently working to achieve its conservation goal of 105 GPCD by 2035. As recommended by SNWA's 2020 Integrated Resource Planning Advisory Committee (IRPAC 2020), a new conservation goal will be evaluated once the current goal is achieved. While future conservation gains are expected to occur over the planning horizon, these gains will require significant additional effort, particularly with upward pressure on water use due to climate change and system age.

The SNWA estimates that climate change and other factors could increase local water demands. When considering these factors, the community will need to reduce demands by approximately 19 gallons per capita per day to meet its current conservation goal. As further recommended by IRPAC 2020, the SNWA will work to bolster conservation gains in Southern Nevada by focusing on consumptive water use reductions associated with non-functional turf, landscape watering compliance, customer leaks, evaporative cooling and new development. This includes ensuring that wastewater associated with future development is captured, treated and returned to Lake Mead for return-flow credits, rather than losing this valuable resource to disposal processes such as evaporation ponds and septic systems (see Chapter 3).

PLANNING FOR UNCERTAINTY

While preparing the 2020 Plan, the SNWA considered other factors related to water supply and demand conditions, including:

- The potential impact of continued drought and climate change on water resource availability, particularly for Colorado River supplies; and
- The potential impact of economic conditions, climate change and water use patterns on long-term water demands.

As in prior years, the SNWA used a scenario-based planning approach for its 2020 Plan. Key factors evaluated include possible reductions of Colorado River supplies, variation in future demands, and additional conservation.

As part of its planning process, the SNWA considered the increasing likelihood that water supply reductions would be imposed for Colorado River supplies in the near-term planning horizon. Mandatory water use reductions and other contributions are based on the projected surface elevation of Lake Mead. Under federal shortage rules and the DCP, Nevada's obligation starts at 8,000 AFY when Lake Mead's elevation is at or below 1,090 feet. Contributions increase up to 30,000 AFY as the lake level declines.

For planning purposes, the SNWA assumes a further reduction of 10,000 AFY in the event Lake Mead's elevation declines below 1,020 feet. At the time of Plan publication, Lake Mead's elevation was at 1,085 feet. Additional information about Colorado River water use reductions is provided in Chapter 3.

The SNWA also considered economic growth in Southern Nevada. While Southern Nevada faces economic uncertainty related to the Covid-19 pandemic, long-term projections indicate that the region will continue to grow. However, a high level of uncertainty remains as to the magnitude and timing of population change, and what impact that change will have on associated short- and long-term water demands.

As further described in Chapter 4, the SNWA's resource planning scenarios consider these factors and bracket the range of reasonable supply and demand conditions that may be experienced over the 50-year planning horizon. This is a conservative approach that demonstrates how the SNWA plans to meet future needs, even if conditions change significantly over time.

ADAPTIVE MANAGEMENT

The SNWA has implemented several adaptation strategies to respond to the drought, climate change and other factors that affect the community's water supply. From the development of new facilities and aggressive water conservation to water banking and securing future resources, these efforts have reduced the potential for customer impacts.

Water conservation has reduced the potential for near-term supply impacts associated with mandatory shortage reductions and DCP contributions due to declining Lake Mead water levels. Nevada's Colorado River consumptive use was approximately 234,000 AFY in 2019, as described in Chapter 2. This is well below the annual basic Colorado River supply available to Nevada under current policy.

Water conservation has far-reaching benefits to the community and the Colorado River system as a whole. Locally, water conservation increases water efficiency and reduces demands. It also allows the SNWA to store or "bank" unused supplies. This, in turn, provides the SNWA with added flexibility in responding to drought conditions and meeting future demands. As of 2019, the SNWA stored more than two million acre-feet (AF) of water. This is nearly nine times Nevada's 2019 consumptive Colorado River water use.

On a larger scale, water conservation helped the SNWA to meet its commitments with interstate and federal partners to store water in Lake Mead. Together, partners have bolstered Lake Mead storage through Intentionally Created Surplus, as well as System Conservation and other initiatives that benefit the Colorado River system as a whole. Likewise, efforts by interstate and federal partners to develop and implement new Drought Contingency Plans in 2019 are helping to slow the decline of Lake Mead and Lake Powell water levels. To date, collaborations have reduced Lake Mead's water level decline by approximately 40 feet.

These efforts have provided the SNWA with time to complete essential infrastructure, helped to forestall a Colorado River shortage declaration, and allows for greater opportunities for water storage and recovery.

The SNWA completed construction of a new Low Lake Level Pumping Station at Lake Mead to help protect Southern Nevada from potential impacts of continued Lake Mead water level declines. Completed in 2020, the pumping station works in conjunction with SNWA's Lake Mead Intake No. 3 to preserve Southern Nevada's access to Colorado River water supplies to an elevation of 875 feet. These infrastructure additions have helped to ensure reliable water service, even during extremely low reservoir conditions, and provide new opportunities for the SNWA to explore water resource opportunities with Colorado River partners. Other benefits to the community include reduced pumping costs and enhanced operational flexibility.

Other adaptive management efforts include development and implementation of the SNWA's Pandemic Readiness and Response Plan. The plan was developed more than 10 years ago and has been updated to ensure operational continuity

during the Covid-19 pandemic. Southern Nevada's drinking water is treated using a combination of ozonation, filtration and chlorination, which are on the leading edge of water treatment processes and effective at removing contaminants from water.

The SNWA continuously monitors water quality to ensure water meets or surpasses drinking water standards and has plans in place to ensure ongoing reliable water delivery service to the community.

CURRENT PRIORITIES

As discussed in the chapters that follow and with continued progress toward the community's water conservation goals, the SNWA has sufficient permanent, temporary and future resources to meet all future planning scenarios described in Chapter 4. However, continued persistence will be required as the region faces prolonged drought and changing economic conditions, and as the entire Southwest region responds to hydrologic challenges related to climate change.

The SNWA's top priorities are to:

- Ensure water quality, reliability and security are maintained to the highest standards during the pandemic and throughout the long-term planning horizon.
- Reduce water demands and maximize the use of available resources through aggressive water conservation.
- Partner with SNWA's member agencies to develop agreements, policies and facilities to maximize the use of return-flow credits.
- Bank conserved resources and grow temporary supplies that can be used flexibly to meet demands and/or offset potential supply reductions.
- Work with interstate and federal partners on initiatives designed to slow the decline of Lake Mead water levels and reduce the magnitude of potential supply reductions.
- Explore collaborative water resource projects with other Colorado River partners, including emerging opportunities.
- Continue to develop and implement adaptive management strategies that proactively address new and evolving challenges.

PLAN INTRODUCTION

THIS CHAPTER PROVIDES AN OVERVIEW OF SNWA RESOURCE PLANNING EFFORTS. IT INCLUDES AN ABBREVIATED HISTORY OF WATER IN SOUTHERN NEVADA, FOCUSING ON MAJOR ISSUES AND INITIATIVES THAT OCCURRED DURING THE LAST CENTURY.

INTRODUCTION

For much of its past, the area now known as Clark County was little more than a collection of scarce watering holes for various trails through the Mojave Desert. With the coming of the railroad in 1905, the privately operated Las Vegas Land and Water Company was formed to build and operate the area's first system for conveying local spring water. In these early years, the community viewed its supply of artesian water as virtually inexhaustible and more than adequate to meet the needs of any growth that might occur.[1]

In 1922, the Colorado River Compact defined the geographic areas of the upper and lower basins of the Colorado River, apportioning 7.5 million acre-feet of water per year (AFY) to each. Of the Lower Basin's 7.5 million AFY, the Boulder Canyon Project Act authorized the apportionment of 300,000 AFY to Nevada, 2.8 million AFY to Arizona and 4.4 million AFY to California. At the time, Nevada's negotiators viewed 300,000 AFY as more than a reasonable amount; Southern Nevada had no significant agricultural or industrial users, and groundwater seemed plentiful.[2]

These conditions changed significantly over time. By 1940, local resource managers began expressing concerns about limited groundwater supplies, water waste and declining groundwater levels. While the Colorado River Compact and subsequent construction of Hoover Dam in 1936 made Colorado River water a viable future resource, the lack of infrastructure and sufficient funding for capital improvements precluded any immediate use to support development in the growing region.

In 1947, the Nevada Legislature created the Las Vegas Valley Water District (LVVWD) to help manage local water supplies. The LVVWD acquired the assets of the Las Vegas Land and Water Company and began operations in 1954 as the municipal water purveyor for Las Vegas and unincorporated Clark County.

Shortly thereafter, the LVVWD entered into agreements with what is now known as Basic Water Company (BWC) for the expansion of BWC's small industrial water line to deliver Colorado River water to the LVVWD service area.

Given the astonishing pace of growth that occurred over the next several years and the limits of the existing pipeline, the LVVWD initiated formal engineering studies for new facilities to import additional Colorado River water into the Las Vegas Valley from Lake Mead. This effort ultimately resulted in the construction of the Alfred Merritt Smith Water Treatment Facility and associated intake, pumping and transmission facilities (collectively referred to as the Southern Nevada Water System or SNWS), which became operational in 1971. The SNWS was first expanded in 1982 (and again in the years to follow) in response to increasing demands.

By the latter part of the 20th century, water planners estimated that the region would soon reach the limits of its Colorado River apportionment.[3] In 1989, as a result of profound uncertainty created by population growth and future resource availability, the LVVWD filed applications for unappropriated groundwater in eastern Nevada and began storing its remaining unused Colorado River water for future use (see Chapter 2). During this time, the community also implemented its first significant conservation effort—Operation Desert Lawn. The program resulted in ordinances by the local municipalities restricting landscape irrigation during the hottest times of the day.

CREATION OF SNWA

By the end of the 1980s, resource challenges had reached a critical point; with the new decade, local leaders began to aggressively explore different options for extending and managing water resources, while meeting the ongoing demands of the community.

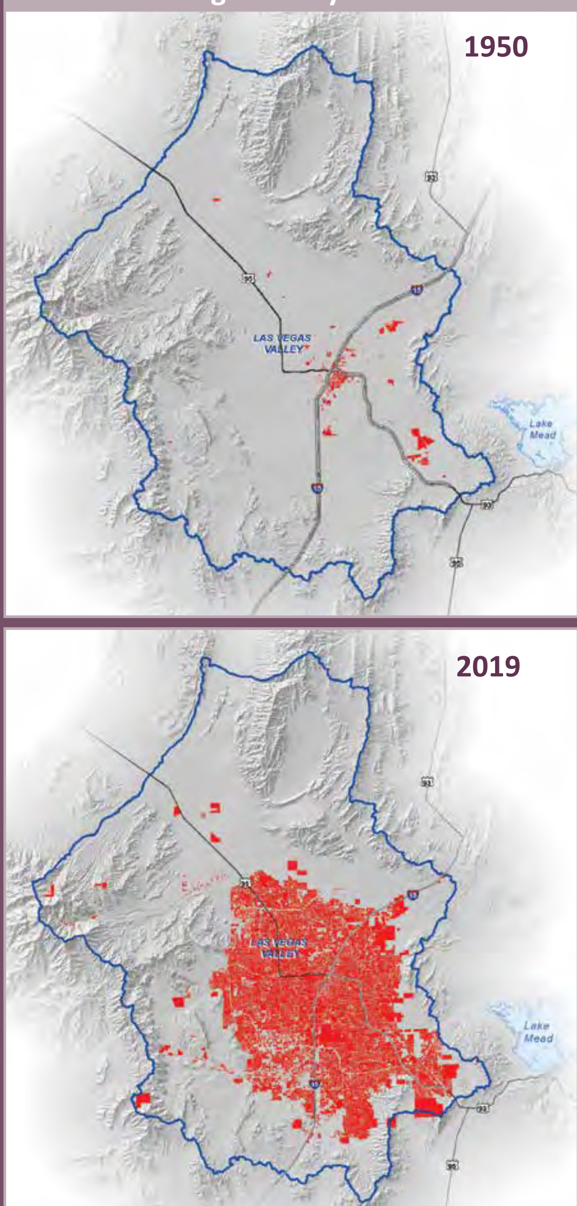
A Century of Change

With the birth of Las Vegas in 1905 as a way station for the San Pedro, Los Angeles and Salt Lake Railroad, Southern Nevada began to attract a large number of residents and businesses.

From an estimated population of more than 40,000 in 1950 to more than 2.3 million in 2019, the Southern Nevada region has experienced change faster than almost any other region in the nation during this same time. Population density in the Las Vegas area is the highest in the interior western U.S.[4]

Today, Southern Nevada is home to 74 percent of Nevada's total population. The region uses less than five percent of all water available for use in the state.

Las Vegas Valley Land Use



One of the most significant events to occur during this time was the formation of the Southern Nevada Water Authority (SNWA) in 1991 through a cooperative agreement among seven water and wastewater agencies:

- Big Bend Water District
- City of Boulder City
- City of Henderson
- City of Las Vegas
- City of North Las Vegas
- Clark County Water Reclamation District
- Las Vegas Valley Water District

Today, these seven agencies provide water and wastewater service to nearly 2.3 million residents in the cities of Boulder City, Henderson, Las Vegas and North Las Vegas, and portions of unincorporated Clark County (Figure 1). Since its inception, the SNWA has worked to acquire and manage water supplies for current and future use; construct and operate regional water facilities; and promote conservation.

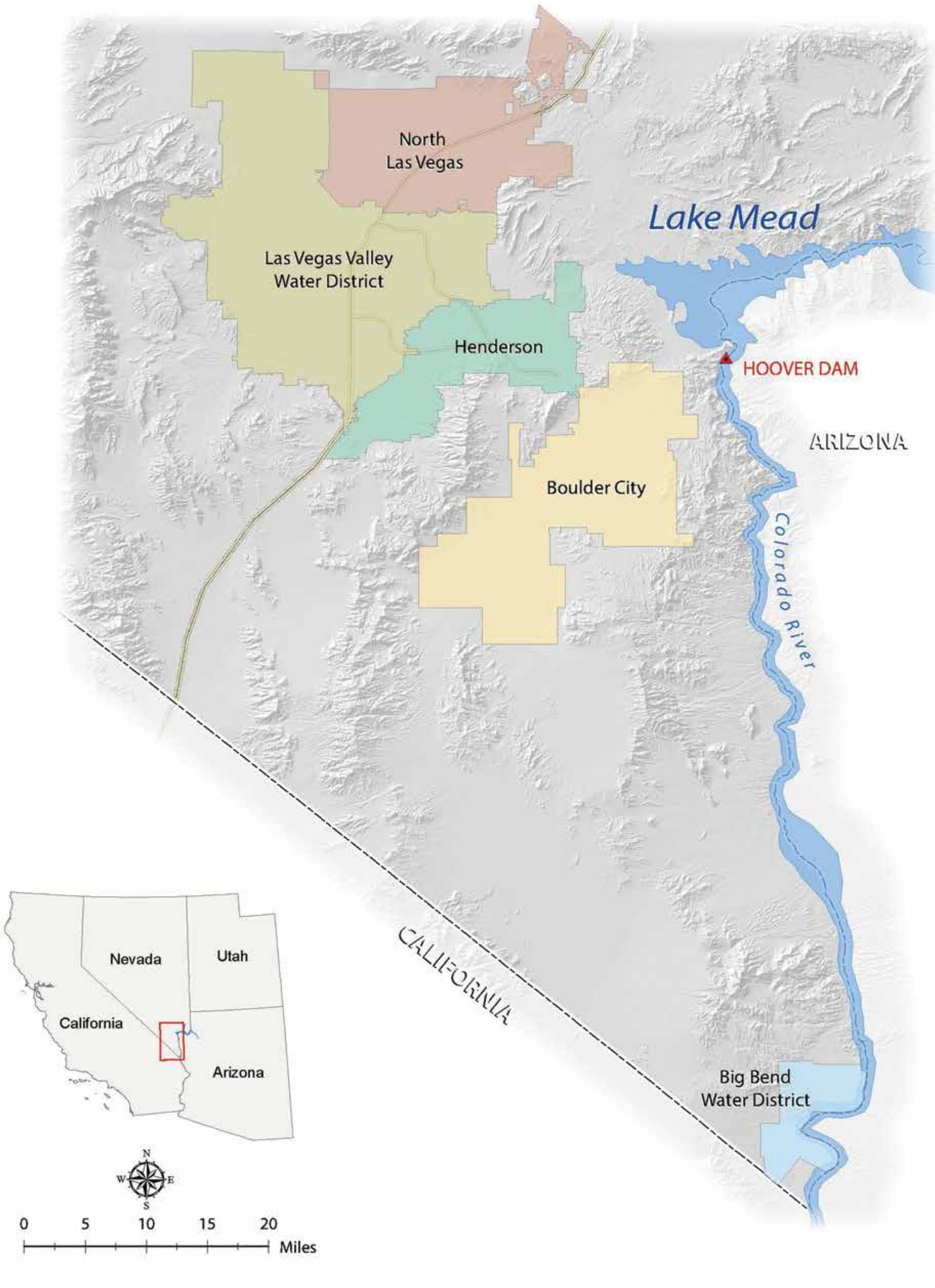
Water Supply Acquisition and Management

Since 1991, the SNWA has worked diligently to develop and manage a flexible portfolio of diverse water resource options resulting from years of in-state, interstate and international collaborations. These resources include groundwater and surface water rights in the state of Nevada, Colorado River water, as well as temporary resources that are stored in the form of storage credits. A detailed summary of the SNWA Water Resource Portfolio is provided in Chapter 3.

Construction and Operation of Regional Water Facilities

To meet the community's current and long-term water resource needs, the SNWA is responsible for constructing and operating regional water facilities, including the SNWS, which was expanded in 2002 to include the River Mountains Water Treatment Facility. The SNWA has completed several improvements and expansions to these facilities over the years to increase capacity to 900 million gallons per day (MGD). Pumping facilities and state-of-the-art treatment and laboratory facilities were also constructed and updated to ensure the availability of high-quality, reliable water supplies. These efforts were phased, coming online just in time to meet demands.

FIGURE 1 **SNWA Purveyor Service Areas**



The SNWA is responsible for managing Southern Nevada's long-term water resources, constructing and operating facilities and encouraging water conservation.

Planning for the Future

The SNWA's 2020 Plan is based on an integrated resource planning process that involved public stakeholders.

The SNWA Cooperative Agreement was amended in 1996 to require adoption of a Water Resource Plan. The SNWA adopted its first Water Resource Plan that same year.[7] The plan is reviewed annually and updated as needed to reflect changing developments in Southern Nevada's overall water resource picture.

The SNWA's 2020 Plan is based on input from public stakeholders. The SNWA has a long history of engaging the public in major planning decisions and has formed a number of citizen advisory committees over the years to make recommendations on critical issues. Committees have considered topics ranging from regional water facilities, water resources and water quality issues to capital funding and drought response.

The SNWA's latest committee process—the Integrated Resource Planning Advisory Committee 2020 (IRPAC 2020)—was formed in 2019 to evaluate and make recommendations on issues of interest to the SNWA's long-term planning efforts. The committee met nine times through mid-2020 and made recommendations on the topics of water infrastructure, water resources, water conservation and regional water rates. The SNWA Board of Directors considered and approved the committee's recommendations in September 2020 (Appendix 3).

As discussed in Chapter 2, the SNWA recently completed construction of a new raw water intake (Intake No. 3) and Low Lake Level Pumping Station (L3PS) at Lake Mead in response to extraordinary drought conditions in the Colorado River Basin. These facilities offset risk associated with future Lake Mead water level declines and preserve the community's access to available Colorado River water supplies, even under extremely low reservoir conditions. As detailed in Chapter 3, the SNWA is pursuing water projects with Colorado River partners and will use these facilities to access current and future Colorado River supplies.

Water Conservation

The SNWA and its member agencies have worked diligently over the years to maximize the availability of existing water supplies and reduce overall water demands. The community's first water conservation plan was adopted in 1995[5] and the SNWA's current plan was adopted in 2019.[6] During this time frame, the community has consistently set and achieved aggressive water conservation goals. As noted on left and described in Chapter 3, the SNWA's 2020 Integrated Resource Planning Advisory Committee (IRPAC 2020) made recommendations on additional conservation activities. These recommendations are being addressed now and will be included as part of SNWA's next Conservation Plan update.

To promote conservation efforts, the SNWA developed and implements a comprehensive water conservation program consisting of regulation, pricing, education and incentives designed to work together to improve water efficiency and reduce demands. The SNWA member agencies also implemented a number of water use and development ordinances, which have since become a permanent part of the community's overall conservation effort. Information on Southern Nevada's conservation efforts is provided in Chapter 3. Detailed program information and other conservation resources are available online at snwa.com.

2020 Water Resource Plan

The SNWA's 2020 Plan provides a comprehensive overview of water resources and demands in Southern Nevada, and discusses factors that will influence resource availability and use over a 50-year planning horizon. The plan does not intend to specifically address all aspects of water resource management and development; rather, it serves as a companion to other detailed planning documents, including:

- SNWA Major Construction and Capital Plan
- SNWA Water Conservation Plan
- Regional Water Quality Plan for the Las Vegas Valley Watershed
- Annual Operating Plan for the Las Vegas Valley Watershed
- SNWA Financial Budget and Comprehensive Annual Financial Report
- SNWS Operating Plan
- SNWA Water Budget

Integrated Resource Planning

As part of its overall water resource planning efforts, the SNWA has completed a number of integrated water resource planning processes. Integrated resource planning applies important concepts to traditional resource and facility planning, including involvement of the public early in the planning process as well as frequent reassessment, particularly as conditions change. These efforts have helped identify the appropriate combination of resources, facilities, conservation programs and funding formulas needed to meet current and future water demands in Southern Nevada.

Recommendations resulting from these integrated resource planning processes are presented to the SNWA Board of Directors for consideration and incorporated into overall water resource planning efforts as approved. The 2020 Plan incorporates the recommendations from IRPAC 2020, which were approved by the SNWA Board of Directors in September 2020. Among other things, recommendations address specific water conservation efforts needed to help the community meet its water conservation goal.

CHAPTER SUMMARY

The SNWA Water Resource Plan is an important tool designed to help the SNWA anticipate and plan for future water supply and related facility needs, which have changed significantly over the years.

Since its formation in 1991, the SNWA has worked closely with its member agencies to meet the region's long-term water demands by acquiring and managing current and future water supplies; constructing and operating necessary facilities; and promoting conservation. In addition, the SNWA has developed partnerships with other Colorado River Basin States (Basin States), working collaboratively to maximize opportunities for the flexible use of Colorado River resources.

These efforts will continue to be of paramount importance in the years to come, particularly as climate change and drought are anticipated to reduce the availability of supplies, and as changing economic conditions create new uncertainties for Southern Nevada's short- and long-term water resource needs. These challenges, as well as the SNWA's associated response efforts, are discussed in Chapter 2. The balance of this document provides a comprehensive overview of the SNWA Water Resource Portfolio (Chapter 3); a detailed discussion of how the SNWA plans to meet current and future regional water demands (Chapter 4); and a discussion on environmental initiatives underway to support water resource development and management efforts (Chapter 5).

ENDNOTES

1 "Water: A History of Las Vegas, Volume 1," 1975, Florence Lee Jones and John F. Cahlan, p.53.

2 "The Hoover Dam Documents," 1948, Ray Lyman Wilbur and Northcutt Ely.

3 "WRMI Process—Water Supply Planning for the Las Vegas Region," January 1991, published May 1992, prepared for Las Vegas Region Water Utilities by Water Resources Management, Inc.

4 Metropolitan Statistical Area Distance Profiles 2010, U.S. Census Bureau.

5 "Memorandum of Understanding Regarding Southern Nevada Water Authority's Water Conservation/Efficiency Programs," January 26, 1995, amended March 18, 1999, SNWA.

6 "Southern Nevada Water Authority Joint Water Conservation Plan," November 2019, SNWA.

7 "Southern Nevada Water Authority 1991 Cooperative Agreement," between Big Bend Water District, City of Boulder City, City of Henderson, City of Las Vegas, City of North Las Vegas, Clark County Water Reclamation District (previously Clark County Sanitation District), and Las Vegas Valley Water District. Amended 1994 and 1996.

CURRENT PLANNING ENVIRONMENT

THIS CHAPTER PROVIDES AN OVERVIEW OF CURRENT AND EMERGING ISSUES THAT ARE LIKELY TO INFLUENCE WATER SUPPLY AND DEMAND CONDITIONS IN SOUTHERN NEVADA OVER THE 50-YEAR PLANNING HORIZON.

INTRODUCTION

As discussed in Chapter 1, water supply and demand conditions have evolved significantly in Southern Nevada over the past century. As a result, resource strategies have needed to adapt. Time and again, the community rose to these challenges, developing new water resources and facilities, and significantly reducing water demands through aggressive water conservation efforts.

At the beginning of the 21st century, new issues began to emerge that have required a similar approach: close monitoring and adaptive response. Drought, climate change and changing economic conditions have become the persistent challenges of this century. Individually or combined, these factors significantly influence local water demands, as well as the resources and facilities needed to support those demands over time.

This chapter describes the challenges that exist within the current planning environment, as well as the planning and response efforts taken by the SNWA, with community support, to minimize those impacts and ensure reliable water supplies. As described in Chapter 3 (SNWA Resource Portfolio) and Chapter 4 (Meeting Future Demands), the SNWA has sufficient resources to meet the needs of the community over the 50-year planning horizon.

The SNWA is well prepared to respond to evolving conditions as they arise through close monitoring, proactive planning and adaptive management. As discussed later in this chapter, the SNWA has taken a number of actions to minimize the effects of drought and climate change in the Colorado River Basin on Southern Nevada's water supply and demand.

DROUGHT AND CLIMATE CHANGE

Colorado River water supplies are derived primarily from snowmelt and runoff from the Rocky Mountains, as well as the Wind River, Uintah and Wasatch mountains (collectively referred to as the Upper Colorado River Basin). Beginning in 2000 and continuing today, the Colorado River Basin has experienced drought conditions that quickly developed into the worst drought in the Basin's recorded history (Figure 2.1).

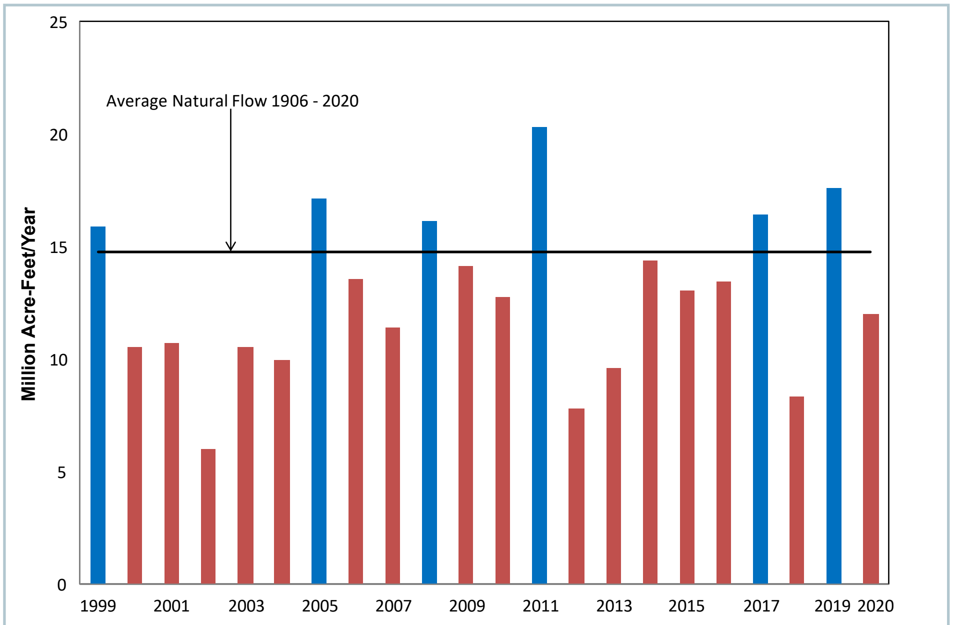


FIGURE 2.1 **Annual Colorado River Natural Flow 1999–2020**[1]

Between 2000 and 2020, overall snowfall and runoff into the Basin were well below the historical average, representing one of the lowest 21-year periods on record. While conditions in the Basin improved during 2019, the persistence of decades-long drought conditions has resulted in significant water level declines at major system reservoirs. As of late 2020, the combined water storage in the Colorado River's two primary reservoirs (Lake Mead and Lake Powell) was at just 43 percent of capacity.[2] As described in Chapter 4, further water-level declines are expected.

Recent studies provide evidence that current drought conditions, including reduced streamflows, are at least partially due to warming temperatures within the Colorado River Basin.[3] This warming is primarily a result of increased concentrations of greenhouse gases (GHGs) in the Earth's atmosphere. Since the early 20th century, observations indicate that global mean annual air temperatures have warmed 1.8°F.[4] Consistent with global trends, warming has also occurred in the southwestern United States. While climate change models project that warming trends will continue (Figure 2.2), the magnitude of change at a given location will depend in part on global mitigation efforts to reduce GHG emissions.

Locally, projections indicate that Clark County will warm between 5-10°F by the end of the century.[5] Compared to relatively uniform projected temperature increases in the Southwest, precipitation patterns are highly variable and show substantial shifts in where and how the precipitation falls. In addition, rising temperatures will cause a greater percentage of precipitation to occur in the form of rain rather than snow, and snowpack will melt earlier and be less efficient as runoff due to dry soil conditions and increasing temperatures. In some areas, this may result in significant reductions in water supply, while other areas experience greater frequency and severity of flood events.[6]

From a planning perspective, water resource managers can't afford to consider climate change and climate change impacts as something that might happen later on. Evidence supports the fact that climate change is happening now and that it will have a lasting effect on the availability of Colorado River water supplies.

Direct climate change impacts will revolve around water quantity, particularly the form and distribution of precipitation, and increasing water demands. Rising air temperatures can also affect soil moisture, and ultimately reduce the volume and timing of snowmelt runoff. In addition, changes to water quality from rising stream flow temperatures and changes in reservoir volumes are also important considerations.

There are two primary consequences for Southern Nevada associated with continued Lake Mead water level declines: possible reduction of Colorado River resources and operating limitations associated with SNWA's water facilities at Lake Mead.

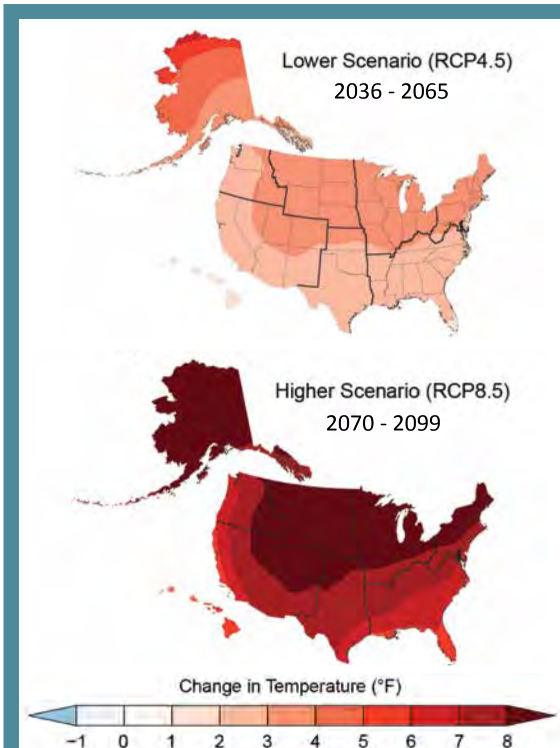


FIGURE 2.2 **Climate Change Range of Possible Future Warming in North America 2036 – 2099**
(2018) National Climate Assessment.

Potential Supply Impacts

In 2007, the Secretary of the Interior issued a Record of Decision for the Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead, also referred to as "Interim Guidelines."[7] Among other things, the Interim Guidelines established how shortages in the Lower Basin will be implemented.

According to the Interim Guidelines, the Secretary of the Interior will make a shortage declaration based on a projection of Lake Mead water levels as determined by the U.S. Bureau of Reclamation's Colorado River modeling efforts. The forecast is reviewed annually in August; if Lake Mead is forecasted to be at or below

1,075 feet on January 1 of the following year, a shortage declaration will be made.

Modeling efforts conducted by the U.S. Bureau of Reclamation in August 2020 indicate an approximate 23 to 53 percent probability of shortage annually in years 2022-2025. The probability ranges from approximately 50 to 64 percent annually in the years thereafter.[8] The model applies historical flows to simulate future conditions, representing both wet and dry years on the Colorado River. Under a shortage declaration, the amount of Colorado River water available for use to Nevada will be reduced up to 20,000 AFY. When factoring in drier hydrology assumptions related to climate change, the probability for shortage within these time frames increases.

In addition to mandatory shortage reductions defined by the Interim Guidelines, the SNWA and Lower Colorado River Basin water users in Arizona and California will make contributions as defined by the Lower Basin Drought Contingency Plan Agreement (DCP).[9] A summary of shortage amounts/DCP contributions is provided in Appendix 5.

Nevada's DCP contribution will be incurred when the projected elevation of Lake Mead is at or below 1,090 feet. As further described in this chapter, the DCP was approved in 2019 to help mitigate the impacts of drought (see also Adaptive Management). Like the Interim Guidelines, thresholds for DCP contributions are based on the U.S. Bureau of Reclamation's August projection of Lake Mead water levels on January 1 of the succeeding year.

As shown in Figure 2.3, SNWA's DCP contributions and shortage reductions are staged to increase as Lake Mead water levels decline. Nevada's obligation under these agreements ranges from 8,000 AFY to a combined maximum of 30,000 AFY. If at any time Lake Mead is projected to fall below an elevation of 1,030 feet, the Secretary of the Interior will consult with Lower Basin stakeholders to determine if additional actions are needed to protect against the potential for Lake Mead to decline below 1,020 feet.[10]

LAKE MEAD WATER LEVEL (FT)	SHORTAGE AMOUNT (AFY)	DCP CONTRIBUTION (AFY)	TOTAL (AFY)
ABOVE 1,090	0	0	0
AT OR BELOW 1,090	0	8,000	8,000
AT OR BELOW 1,075	13,000	8,000	21,000
BELOW 1,050	17,000	8,000	25,000
AT OR BELOW 1,045	17,000	10,000	27,000
BELOW 1,025	20,000	10,000	30,000

FIGURE 2.3 **SNWA Shortage/DCP Contribution**

Potential Facility Impacts

Lake Mead's surface elevation is down by approximately 129 feet since 2000. In 2016, the lake's elevation reached its lowest point since it began filling in the 1930s (Figure 2.4).[11] Lake Mead water levels have experienced some improvement due to strong snowpack and above-average runoff within the Basin during 2019, as well as benefits realized from interstate collaboration (see page 19).

As of late 2020, Lake Mead's water level was at approximately 1,085 feet. Based on current and forecasted conditions, however, there remains a high probability that Lake Mead water levels will continue to decline, potentially reaching an elevation of 1,000 feet or lower within the next decade. Protecting Lake Mead from continued water level decline is

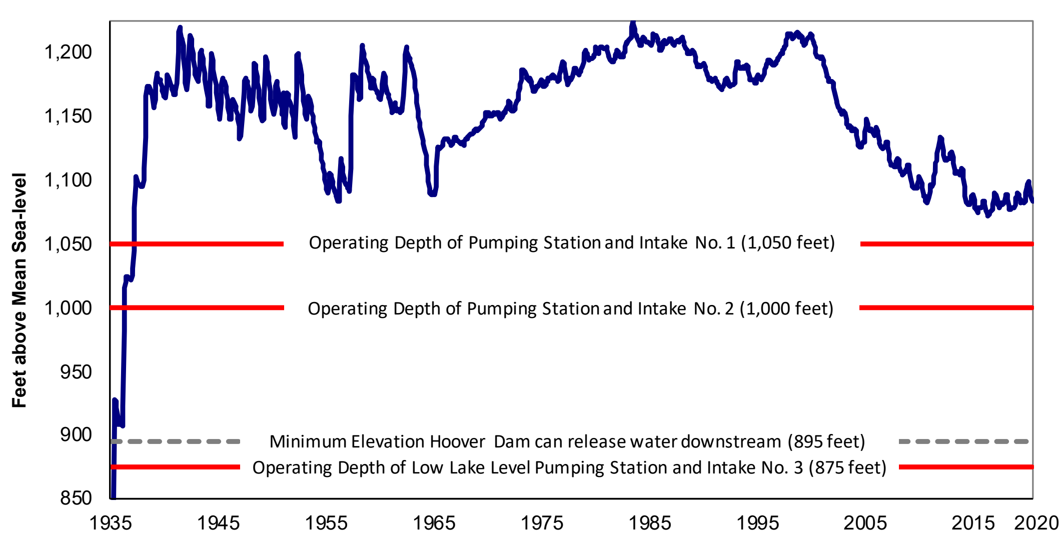


FIGURE 2.4 **Historical Lake Mead Elevations**

State of the Science Report

Increasing water demand, dry conditions and warming temperatures have impacted the Colorado River in recent years, creating greater uncertainty about the basin's future water supply availability. To more clearly understand the latest and best available science on these and related topics, the SNWA and other Colorado River Basin states and water managers pursued the creation of the Colorado River Basin Climate and Hydrology: State of the Science Report. [12]

The report integrates nearly 800 peer-reviewed studies, agency reports and other sources to assess the state of the science and the technical methods relevant to water resources in the Colorado River Basin. Further, it establishes a shared understanding of the physical setting, as well as the latest data, tools and research that underpins Colorado River water resource management.

Report findings confirm that temperature trends are increasing and precipitation, snowpack water volume and annual streamflow trends are decreasing. The SNWA and others will use the report—which identifies both challenges and opportunities—to improve the short-term and mid-term foresting and long-term projections for the Colorado River system. This information and associated work efforts will expand the SNWA's resource management and planning capacity.

Lake Mead Water Level Decline

a priority for Colorado River stakeholders. Below a Lake Mead elevation of 895 feet, Hoover Dam can no longer deliver Colorado River water to downstream users.

The SNWA has a total water treatment and transmission capacity of at least 900 MGD, consisting of raw water intakes and associated pumping facilities. Until 2020, SNWA pumping facilities were limited in their operating range relative to the elevation of Lake Mead (Figure 2.4). As detailed later in this chapter, the SNWA recently completed two major construction projects (Low Lake Level Pumping Station and Intake No.3), which together preserve full capacity under low lake level conditions, allowing the SNWA to pump from a Lake Mead elevation as low as 875 feet.

Completed in 2012, the U.S. Bureau of Reclamation released a study that projects a median imbalance of 3.2 million acre-feet per year (AFY) between supply and demand by the year 2060 due to climate change and increased demands within the Basin.[13] This study and the more recent 2020 State of the Science Report recognize the amount of water apportioned within the Colorado River Basin exceeds long-term average historic inflows, a situation that has been exacerbated over the last 20 years by drought and climate change. Average Colorado River inflows over the last two decades are about 12.5 million AFY. This is lower than the amount of water allocated to the Colorado River Basin states and Mexico (16.5 million AFY), and substantially lower than the 1909 - 1928 historical average flow that was considered in determining compact allocations (about 17.7 million AFY).

These studies recognized that climate change will not only affect the amount of water available for use but overall demands as well. As temperatures warm, water evaporation and evapotranspiration rates will increase, resulting in higher water demands for agricultural irrigation and landscaping uses. Reductions in use among those who share the Colorado River is needed to ensure supply and demand remains in balance, and that the river is sustainably managed.

Potential Demand Impacts

In Southern Nevada, the impacts of climate change are expected to be similar to that of drought. This includes extended durations of low Lake Mead elevations, water quality changes, possible reductions of Colorado River resources, and potential increases in water use to compensate for warmer and drier conditions.

Warmer and drier conditions are likely to increase local water demands, particularly for landscape irrigation and evaporative cooling systems. As described in Chapter 3, upwards pressure due to climate change and system age could increase local water demands. When considering these factors, the community will need to reduce demands by approximately 19 gallons per capita per day (GPCD) to meet its current conservation goal.[14]

LOCAL ECONOMIC CONDITIONS

Southern Nevada's economic situation changed drastically in 2007, when the national economy began to experience its (then) most significant decline since the 1930s. Southern Nevada was hit harder than almost any other region in the nation. This period of recession marked the first time in decades that the Las Vegas area experienced a sustained period of little or no growth (Figure 2.5).[15] For a few years following the downturn, gaming and tourism revenues declined. This was followed by a record spike in unemployment. Most new residential and commercial development projects came to a halt, and home foreclosures flooded the real estate market.

The economy has improved steadily in the region since 2012. However, conditions changed again in March 2020, when a global pandemic quickly spread within the community and throughout the world. Locally, Southern Nevada experienced a profound rise in unemployment due to non-essential business closures and the sudden halt to gaming and tourism activity.

While most business restrictions began to ease in May and June 2020, employment and economic activity remain far from pre-pandemic norms. It remains unclear at this time if additional restrictions will be implemented and, if so, how long they will last. The short and long-term economic impacts associated with the ongoing pandemic create tremendous economic uncertainty in communities throughout the nation and around the globe, including Southern Nevada.

According to the Center for Business and Economic Research (CBER) at the University of Nevada, Las Vegas, the short-term forecasts exhibit high uncertainty due to the current pandemic.[16] CBER forecasts that Southern Nevada population growth will continue over the long-term planning horizon, although actual growth rates will occur faster or slower than forecasted as demonstrated by Southern Nevada's unpredictable past.

While Southern Nevada has demonstrated its ability to recover from challenging economic conditions in its past., it is difficult to predict how current events will affect short and mid-term population changes, and, in turn, local water demands.

ADAPTIVE MANAGEMENT

Adaptive management relies on continuous assessment, flexible planning and action. As the region's wholesale water provider, the SNWA is responsible for anticipating future demands and taking the steps necessary to meet those demands over time. As discussed earlier in this chapter, the current planning environment contains significant uncertainties—drought and climate change have impacted water facilities, water supply availability, water quality and water demands. In addition, factors associated with Southern Nevada's local economy and its rate of growth make predicting future water

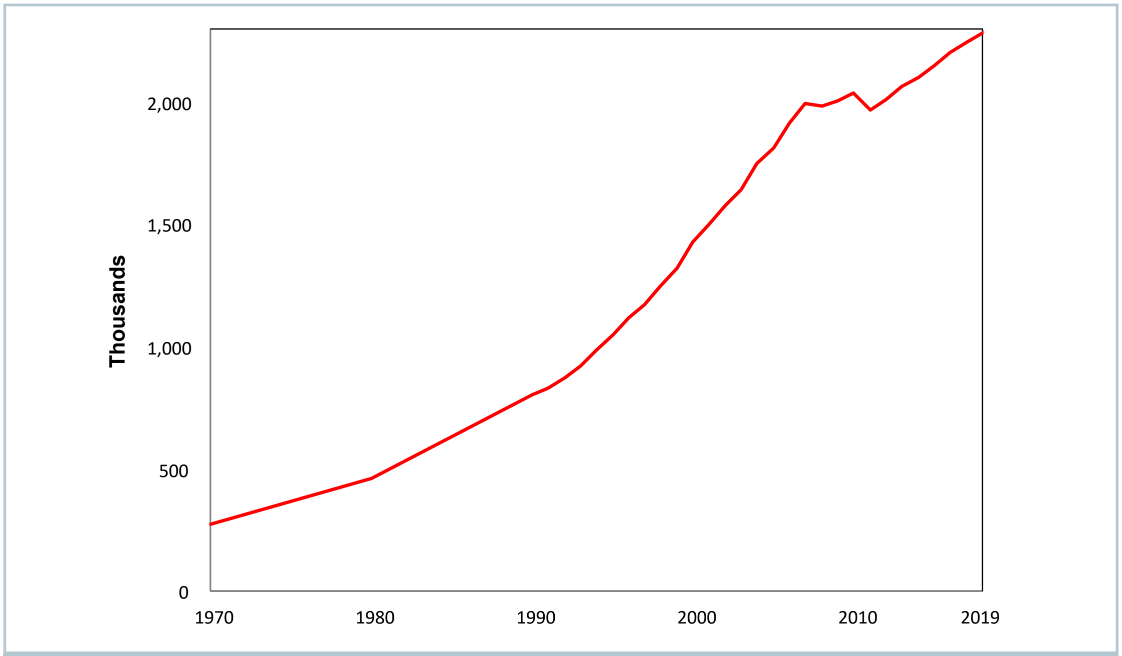


FIGURE 2.5 **Historical Clark County Population**

Adaptive Management in Action

Over the years, SNWA has taken several adaptive management steps to reduce impacts to water supplies and facilities in response to drought and climate change. These include:

- Reduced consumptive use of Colorado River supplies by approximately 108,000 AFY (approximately 35 billion gallons) between 2002 and 2019, even with the addition of more than 730,000 new residents.
- Stored nearly nine times Nevada's 2019 Colorado River consumptive use through increased water banking, storage and recharge efforts.
- Completed new Intake No. 3 and Low Lake Level Pumping Station (L3PS) to ensure continued delivery of Colorado River water supplies under low reservoir conditions.
- Acquired and developed surface water in Clark County through resource leases and purchases.
- Worked with Colorado River stakeholders to develop and implement innovative programs and agreements to improve resource management, preserve Colorado River operations for Lower Basin water users and increase the flexible use of Colorado River resources.

Low Lake Level Pumping Station Construction

demands challenging, particularly in light of the region's previous growth history.

The following sections detail how the SNWA plans to address these challenges—while some steps are being taken now to protect current water supplies from the effects of drought and climate change. Other steps are considered long-term continuous efforts that will remain a priority for many years to come.

Lake Mead Facility Improvements

To mitigate impacts associated with a potential Lake Mead water level decline below 1,000 feet and potential water quality concerns during low reservoir conditions, the SNWA constructed a new intake and pumping station at Lake Mead to ensure continued access to Colorado River resources. These facilities were developed to address drought conditions and climate change.

The SNWA put its new intake (Intake No. 3) and Low Lake Level Pumping Station into service in 2015 and 2020, respectively. Together, these facilities preserve existing capacity and allow the SNWA to pump from a Lake Mead elevation of 875 feet. This is approximately 20 feet below the minimum elevation that Hoover Dam can release water downstream. Major construction efforts were based, in part, on the recommendation of a prior Integrated Resource Planning Advisory Committee, which determined that the risk of Lake Mead's elevation falling below 1,000 feet is not acceptable for Southern Nevada due to the potential impacts on water delivery and resource availability.

These adaptive management measures help to ensure reliable water service, even during extremely low reservoir conditions, and provide new opportunities for the SNWA to explore water supply agreements with other downstream Colorado River water users.

Water Conservation

The SNWA continues to implement one of the most progressive water conservation programs in the nation and will continue to evaluate higher levels of conservation as goals are achieved. As detailed in Chapter 3, the SNWA and its member agencies utilize regulation, pricing, education and incentives to affect necessary water conservation savings.

The SNWA does not anticipate any near-term customer impacts associated with a federal shortage declaration or implementation of the DCP. This is due in large part to the success of local conservation efforts. The Southern Nevada community took both serious and sustained action as the drought took hold in the early 2000s. These efforts have provided a significant buffer against water supply impacts over the near-term planning horizon. By the end of 2019, Southern Nevada's consumptive use of Colorado River resources was 234,000 AFY. This is well below any Colorado River water supply reduction/DCP contribution that may occur under the Interim Guidelines and DCP. As further described in Chapter 3, conservation will remain an ongoing priority for Southern Nevada, and the SNWA has taken steps to enhance education, outreach and incentive programs to support continued water savings.

Interstate Collaboration

The Colorado River Basin states are collaboratively working with U.S. federal partners and Mexico to augment water supplies, improve system efficiency, and protect power generation and access to water supplies. These efforts range in nature from investing in infrastructure improvements in Mexico to system efficiency and conservation efforts that have mutual benefit to Colorado River Basin water users.

Drought Response Actions. In 2014, the SNWA entered into two agreements with federal, state, philanthropic organizations and other Colorado River water users to help mitigate the impacts of ongoing drought and bolster reservoir elevations.[17] [18] These efforts are intended to protect against critical reservoir elevations that threaten hydropower generation at Glen Canyon and Hoover dams, and access to water supplies for millions of Lower Basin water users.

As part of one agreement, the SNWA and other Colorado River partners agreed to forgo off-stream banking efforts to leave water in Lake Mead. As part of another agreement project partners paid approximately $29.8 million for conservation projects that benefit the Colorado River system as a whole. As part of this effort, partners evaluated and selected projects, and compensated users for voluntary water use reductions. Projects included land fallowing, agricultural water efficiency, wastewater effluent recovery, turf removal and other conservation projects.

Unlike water resources in the SNWA Water Resource Portfolio, water conserved as a part of these agreements benefit the entire Colorado River System by increasing reservoir elevations; these resources cannot be recovered by any individual water user.

Drought Contingency Plan. The Upper and Lower Colorado River Basin states adopted drought contingency plans in 2019 that build upon the Interim Guidelines. Authorized by Congress for immediate implementation, the plans recognize the increased potential for lakes Powell and Mead to reach critically low elevations, as well as the increasing potential for water supply interruptions. Together, the plans commit the states and federal government to additional actions designed to improve reservoir storage and preserve system operations during low lake level conditions.

Beyond the mandatory shortage reductions prescribed under the Interim Guidelines, the Lower Basin DCP requires additional water contributions by the Lower Basin states, including Nevada, Arizona and—for the first time—California. Together, the Lower Basin states will contribute between 200,000 AFY and 1.1 million AFY when Lake Mead is at or below 1,090 feet. Like the Interim Guidelines, DCP contribution amounts are based on Lake Mead water levels. Likewise, with implementation of the DCP and as part of its Water Scarcity Plan, Mexico will join the states' efforts to store additional water in Lake Mead as elevations drop.

Implementation of the DCP will help to keep more water in the Colorado River for the benefit of all water users and the environment; help slow Lake Mead water level declines to preserve critical elevations; and allow states to withdraw some of their contributions when Lake Mead water levels recover. It also expands and modifies creation and recovery provisions for Intentionally Created Surplus (ICS). The SNWA plans to meet its commitments under the Interim Guidelines and DCP with conservation savings and temporary resources as described below and in Chapter 3.

Water Banking Efforts. The Seven States have worked collaboratively over the years to store or "bank" available Colorado River water and other unused supplies through various storage efforts. As of 2019, the SNWA has banked resources in the Southern Nevada Water Bank, in the Arizona and California water banks, and Lake Mead (in the form of ICS). As noted above, the DCP builds upon the Interim Guidelines by requiring Lower Basin states to store additional water in Lake Mead and expands recovery provisions during a declared shortage. This provides increased access to banked supplies and enhances operational flexibility for the SNWA and other Colorado River water users.To the extent possible, the SNWA will continue water banking efforts to build temporary reserves and help stabilize Lake Mead water levels.

As shown in Figure 2.6, water banking and other collaborative drought response actions have reduced Lake Mead's water level decline by an estimated 40 feet in 2019.

Applying Best Available Climate Science

The SNWA continues to work with federal, state and local water agencies to enhance understanding of future water supply and demand uncertainty, and improve short and mid-term forecasts and long-term projections. A key accomplishment of these efforts is the creation of the Colorado River Basin Climate and Hydrology: State of the Science report (see page 16).

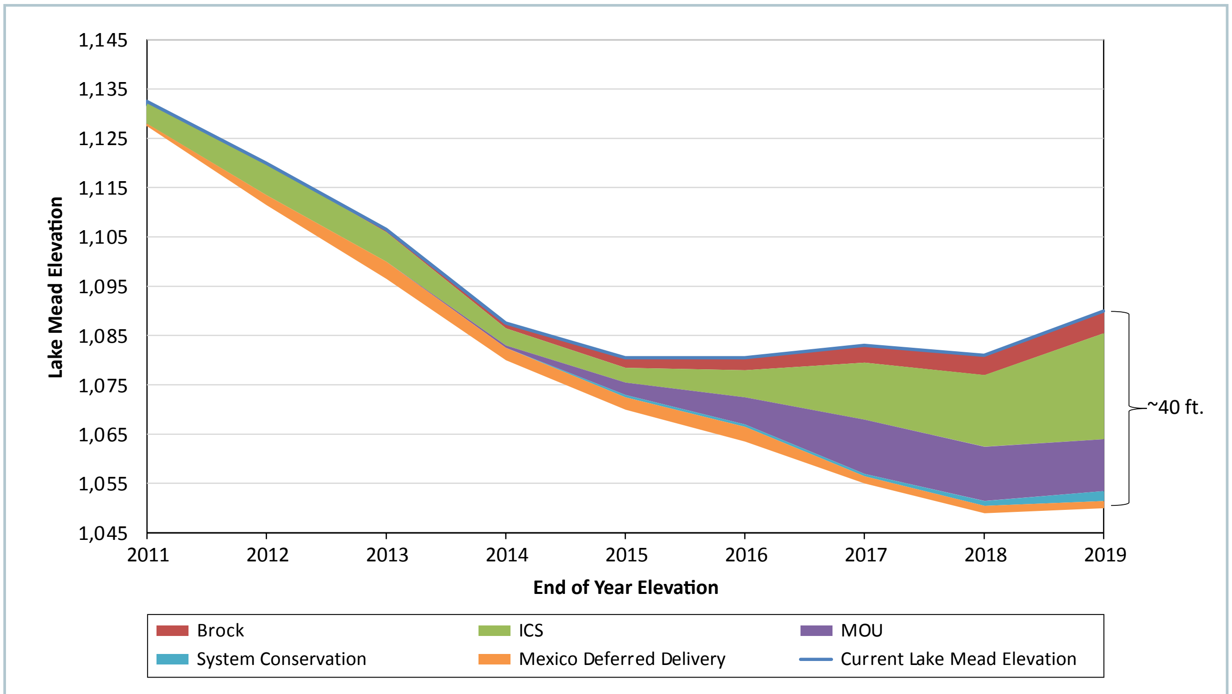


FIGURE 2.6 **Benefits to Lake Mead Storage** [19]

Likewise, to better understand and adapt to climate change effects on water-related infrastructure and water resources, the SNWA initiated collaborative efforts with both climate scientists and other water agencies. The SNWA has received funding through a WaterSMART grant from the U.S. Bureau of Reclamation to evaluate potential changes in Lake Mead water quality using SNWA's advanced Lake Mead model.[20] The Lake Mead study considered potential impacts of low lake elevations and increasing air temperatures due to climate change on a suite of water quality measures.

The SNWA is also a founding member of the Water Utility Climate Alliance (WUCA), which is comprised of 12 of the largest water agencies in the United States. WUCA is dedicated to enhancing climate change research and improving water management decision-making to ensure that water utilities will be positioned to respond to climate change and protect water supplies.

The SNWA is collaborating with other WUCA members to: advocate for climate change research that better meets the needs of the water sector; evaluate methods used to understand the influence of climate change on water providers; and identify decision and adaptation strategies employed to address long-term climate change.[21]

Supply and Demand Forecasting

As in prior years, the SNWA has taken a scenario based planning approach with its 2020 Plan to address possible changes to water supply availability and demands. As detailed in Chapter 4, the SNWA has developed a range of demands that brackets what is likely to be experienced during the planning horizon.

The plan includes a series of future planning scenarios that consider various water demand and supply conditions, including impacts of declared shortage. This is a conservative approach that recognizes that planning assumptions are generally more accurate in the near term and that the potential for change is likely to increase over time.

CHAPTER SUMMARY

The concept of uncertainty is not unique to Southern Nevada. It is a condition increasingly faced by water managers across the United States. This is particularly true in the Colorado River Basin, where climate variability (the result of drought and/or climate change) and economic conditions are influencing both water resource availability and the demand for those resources over time.

While the water supply challenges presented in this chapter need to be taken seriously, the SNWA has worked diligently to ensure both resources and facilities are available to meet the community's short- and long-term water resource needs.

By applying adaptive management—evaluating, planning and action—the SNWA is well prepared to meet whatever challenges lie ahead. Efforts include:

- Continue setting and achieving water conservation goals through aggressive water conservation efforts;
- Collaborate with Colorado River stakeholders for conservation and flexible use of Colorado River supplies (for example, water banking), as well as protect Lake Mead's elevation against future water level declines;
- Continue to secure temporary resources to offset long-term impacts associated with shortage while working to bring other permanent resources online when needed;
- Work with Colorado River partners to explore collaborative future water resource projects;
- Address uncertainty by planning to a range of future supply and demand possibilities; and
- Collaborate with climate scientists and other agencies to understand and evaluate climate change, and its potential impacts on water supplies and facilities.

ENDNOTES

1 The U.S. Bureau of Reclamation and the U.S. Geological Survey estimate the yearly "natural flow" of the Colorado River at Lees Ferry, defined as the flow of the river without reservoirs, dams or diversions. Natural flow estimates for the period 1906 to 2018 are official, while estimates for the period 2019 and 2020 are provisional, July 2020, U.S. Bureau of Reclamation.

2 August 24-Month Study - most probable forecast, U.S. Bureau of Reclamation, August 2020.

3 Lukas, J. and Payton, E., eds. 2020. Colorado River Basin Climate and Hydrology: State of the Science. Western Water Assessment, University of Colorado Boulder. DOI. https://doi.org/10.25810/3hv-w477.

4 Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, B. DeAngelo, S. Doherty, K. Hayhoe, R. Horton, J.P. Kossin, P.C. Taylor, A.M. Waple, and C.P. Weaver, 2017: Executive summary. In: Climate Science Special Report: Fourth National Climate Assessment, Volume I [Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 12-34, doi: 10.7930/J0DJ5CTG.

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7 "Record of Decision Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead, December 2007," signed December 13, 2007 by Dirk Kempthorne, Secretary of the Department of Interior.

8 The U.S. Bureau of Reclamation developed the Colorado River Simulation System (CRSS), a long-term planning and operations model. The probabilities of shortage correspond with August 2020 CRSS results, applying historical Colorado River flows, provided by U.S. Bureau of Reclamation to Southern Nevada Water Authority August, 2020.

9 "Agreement Concerning Colorado River Drought Contingency Management and Operations," 2019.

10 "Exhibit 1 to the Lower Basin Drought Contingency Plan Agreement, Lower Basin Drought Contingency Operations," 2019.

11 "Historical Reservoir Levels, Lake Mead at Hoover Dam," U.S. Bureau of Reclamation.

12 Lukas, J. and Payton, E., eds. 2020. Colorado River Basin Climate and Hydrology: State of the Science. Western Water Assessment, University of Colorado Boulder. DOI. https://doi.org/10.25810/3hv-w477.

13 "Colorado River Basin Water Supply and Demand Study," December 2012, U.S. Bureau of Reclamation.

14 "Changes in Water Use Under Regional Climate Change Scenarios," 2013, Water Research Foundation (Project #4263) prepared by Jack C. Kiefer, John M. Clayton, Benedykt Dziegielewski, and James Henderson.

15 Clark County Population data 1970-1980 are decadal counts from the U.S. Census Bureau. Clark County Population data 1990-2019 are annual estimates prepared by the Clark County Comprehensive Planning Department.

16 "Population Forecasts: Long-term Projections Clark County Nevada Population Forecast 2020-2060," June 2020, Center for Business and Economic Research at the University of Nevada, Las Vegas.

17 "Agreement among the United States of America, through the Department of the Interior, Bureau of Reclamation, the Central Arizona Water Conservation District, the Metropolitan Water District of Southern California, Denver Water, and the Southern Nevada Water Authority, for a Pilot Program for Funding the Creation of Colorado River System Water through Voluntary Water Conservation and Reductions in Use," entered into July 30, 2014 and amended August 12, 2015; March 8, 2016; and July 6, 2018.

18 "Memorandum of Understanding among the United States of America, through the Department of the Interior, Bureau of Reclamation, the Central Arizona Water Conservation District, the Metropolitan Water District of Southern California, the Southern Nevada Water Authority, the Arizona Department of Water Resources, the Colorado River Board of California and the Colorado River Commission of Nevada for Pilot Drought Response Actions," entered into December 10, 2014.

19 At the end of 2019, cumulative water storage in Lake from conservation initiatives was approximately 3.185 million AF, equivalent to approximately 40 feet in Lake Mead. Savings are attributable: 1) Water conserved by the Brock Reservoir System Efficiency ICS project (388,000 AF) and Extraordinary Conservation ICS storage (1.748 million AF); 2) Unused Colorado River saved under a 2014 Memorandum of Understanding (820,000 AF); 3) Pilot System Conservation Program water savings (129,000 AF); and 4) Deferred deliveries by the country of Mexico (100,000 AF).

20 The SNWA's Lake Mead Model was developed with Flow Science Inc., with funding from SNWA member agencies and the National Park Service. Funding for climate change model simulations was provided through a WaterSMART Grant from the Bureau of Reclamation, with matching contributions from the City of San Diego, Metropolitan Water District of Southern California and the SNWA.

21 The Water Utility Climate Alliance (WUCA) has funded and published several reports and white papers on climate change. The publications are accessible at: www.wucaonline.org/html/actions_publications.html.

SNWA WATER RESOURCE PORTFOLIO

THIS CHAPTER DISCUSSES THE DIVERSE SET OF WATER RESOURCE OPTIONS ACQUIRED BY THE SNWA TO RELIABLY MEET THE COMMUNITY'S CURRENT AND FUTURE WATER RESOURCE NEEDS.

INTRODUCTION

The SNWA has worked since 1991 to establish and manage a flexible portfolio of water resources, an approach commonly used in resource planning. Having a portfolio of resources allows the SNWA to assess its overall water resource options and to make appropriate decisions regarding which resources to develop and use when necessary. Key factors considered in determining acquisition, priority of development, and use of a resource include availability, accessibility, cost and need.

The SNWA's water resource portfolio, along with associated facility planning and permitting efforts, provides the SNWA with flexibility in adapting to changing supply and demand conditions. As detailed in Chapter 2, water resource conditions have changed significantly over the years for many western states, including Nevada. During that time, the SNWA has worked to implement innovative water resource strategies that have increased the efficiency of Colorado River water use to maximize availability of this critical supply of water. The organization has also worked to create new temporary resources that can be used flexibly to meet current and future demands. These efforts have helped to delay the development of costly water projects that may not be needed in the future.

Adaptive management has played an increasingly significant role in the SNWA's water resource and facility planning efforts, helping to reduce demands, bolster supplies and minimize risk associated with drought and climate change in the Colorado River Basin. These efforts have led to the development of new Lake Mead intake and pumping facilities and collaborative partnerships that significantly enhance the reliability of and access to Southern Nevada's Colorado River water supplies.

These accomplishments and other developments described in this chapter prompted the SNWA to make several changes relating to the composition, priority and timing of some resource options. New resource and conservation priorities have been identified for the 2020 Plan, while other resource interests have been deferred. As further detailed in this chapter, these changes are consistent with direction from the SNWA Board of Directors, as well as recommendations from the SNWA's 2020 Integrated Resource Planning Advisory Committee (IRPAC 2020).

Resources in the SNWA water resource portfolio are described in consumptive use volumes and are organized into the following categories:

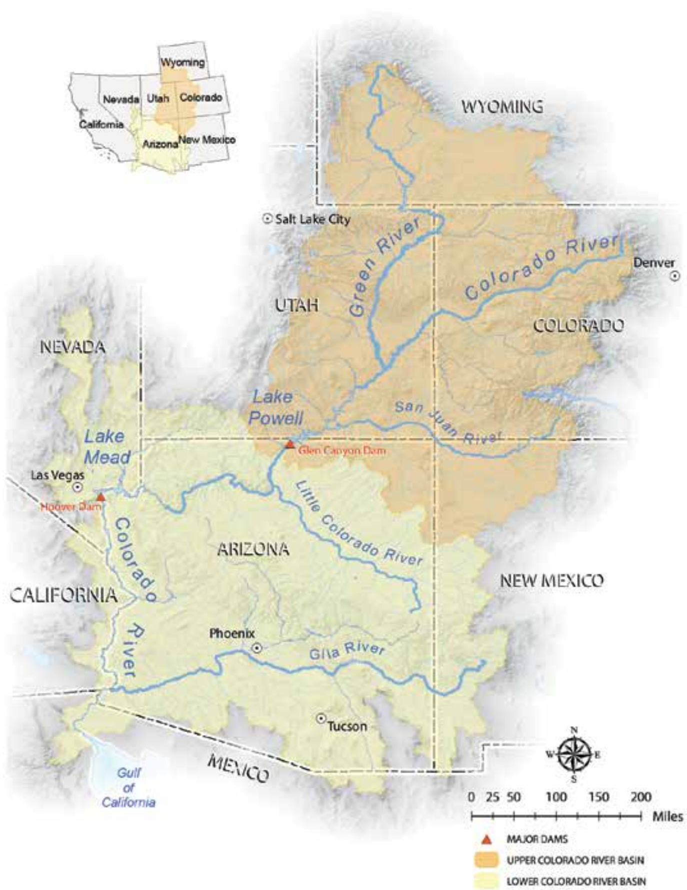
- Permanent Resources
- Temporary Resources
- Future Resources

Consistent with prior plans, water conservation remains a critical component of the SNWA's water resource portfolio. Conservation progress in reducing per capita water use remains a top priority for the SNWA. This chapter highlights new and ongoing strategies being pursued by the SNWA to build upon the community's conservation success over the last two decades.

PERMANENT RESOURCES

For the purpose of this plan, "Permanent Resources" are resources anticipated to be available for use over the 50-year planning horizon. These resources make up a base of supplies and can be used during any Colorado River operating condition, including shortage (subject to certain restrictions).

Permanent resources include Colorado River supplies, Tributary Conservation Intentionally Created Surplus (ICS), permitted groundwater rights in the Las Vegas Valley and reuse, primarily through return-flow credits. Descriptions of these resources and details regarding their availability are discussed in the following section.



The Colorado River Basin

Colorado River operations and water use are governed by a series of contracts, regulatory guidelines, federal laws, compacts, a treaty with Mexico, court decisions and decrees—collectively known as the "Law of the River." The 1922 Colorado River Compact divided the Colorado River Basin into two divisions—the Upper Division and the Lower Division, allocating 7.5 million acre-feet per year (MAFY) to each. As part of the Boulder Canyon Project Act and the 1948 Upper Colorado River Basin Compact, the Upper and Lower Divisions divided their respective share amongst individual states within each division. In addition, 1.5 MAFY was allocated to Mexico as part of a 1944 treaty.[3]

The Compact was forged in a time of abundance, during one of the wettest periods in recorded history. More recent reviews, modeling and studies of Colorado River flows have determined an imbalance in long-term Colorado River resources and future demands. State and federal partners agree that there is a strong potential for significant supply and demand challenges in coming decades, and are working together to offset potential water supply reductions.

Colorado River—Nevada Basic Apportionment

Nevada's 300,000 AFY Colorado River apportionment continues to be Southern Nevada's largest and most critical permanent resource. Nevada's right to this water was established under the 1922 Colorado River Compact and the Boulder Canyon Project Act (BCPA), which together set forth where and how Colorado River water is used.

SNWA Contract. Section 5 of the BCPA requires entities wishing to divert Colorado River water within the states of Arizona, California and Nevada to have a contract with the Secretary of the Interior for that water. Early on, the agencies that would form the SNWA contracted for most of Nevada's Colorado River allocation.

With the creation of the SNWA in 1991, these agencies agreed to collaboratively manage Southern Nevada's current and future water resources, representing a significant shift in the overall management of the region's water supply. In the years that followed, the SNWA determined that additional Colorado River water was available and contracted with the Secretary of the Interior in 1992 and 1994 to acquire these resources.[1]

The SNWA's total estimated Colorado River entitlement is 276,205 AFY of Nevada's 300,000 AFY allocation. This includes 272,205 AFY for use by SNWA member agencies and 4,000 AFY that the SNWA delivers to Nellis Air Force Base. Nevada's remaining apportionment is contracted to other users.[2] The SNWA also holds contracts for any surplus Colorado River water available to Nevada.

Unused Apportionment. As part of its 1992 Colorado River contract, the SNWA has a right to the unused apportionment of other Nevada Colorado River contract holders. The SNWA anticipates some of this water will be available for use in the planning horizon, and plans to utilize this water if and when it is available.

The SNWA's use of Colorado River resources has declined significantly since 2002 due to community water conservation efforts. As a result, Nevada is not currently using its full Colorado River apportionment. As discussed later in this chapter, the SNWA plans to store this water in Lake Mead to help alleviate the impacts of drought conditions and avoid critical Lake Mead elevations. Water also may be stored in other banking programs. In either case, Nevada will maximize the availability and use of its water conservation savings to offset risk, increase operational flexibility and help meet future demands.

Return-Flow Credits. The BCPA defines all Colorado River apportionments in terms of "consumptive use."

Consumptive use is defined as water diversions minus any water that is returned to the Colorado River. These returns are also referred to as "return-flow credits." With return-flow credits, Nevada can divert more than 300,000 AFY, as long as there are sufficient flows returned to the Colorado River to ensure the consumptive use is no greater than 300,000 AFY.[4]

Return-flow credits constitute a significant portion of Southern Nevada's Colorado River resource, expanding the SNWA's Colorado River supply. Nevada's Colorado River return-flows consist mostly of highly-treated wastewater that is returned to Lake Mead via the Las Vegas Wash.

Flood Control Surplus. If Lake Mead is full or nearly full, the Secretary of the Interior can declare a flood control surplus. This allows Lower Basin states to use Colorado River water, in excess of their apportionment, that would have been released to control potential flooding along the Colorado River system.[5]

Based on current Lake Mead water levels and climate variability in the Colorado River Basin, the SNWA does not assume that flood control surplus water will be available during the planning horizon. However, the SNWA will utilize this resource as a priority when it is available.[6]

Domestic Surplus. As discussed in Chapter 2, the Interim Guidelines defined both surpluses and shortages, and detailed provisions for water use during each condition. Under a "Domestic Surplus," the SNWA is allowed to consumptively use up to 400,000 AFY of Colorado River water when Lake Mead is above 1,145 feet. The 2020 Plan does not assume the availability or use of domestic surplus water during the planning horizon. However, the SNWA will utilize this resource as a priority when it is available.

Intentionally Created Surplus

In 2007, as part of the Interim Guidelines, the SNWA entered into a series of agreements that ensure the availability and delivery of water resources developed under provisions for ICS.[7] As discussed below, Tributary Conservation ICS and Imported ICS enable the SNWA to develop some of its surface and groundwater rights that are located in Nevada, near the Colorado River. The SNWA may develop these rights as needed by allowing them to flow into Lake Mead in exchange for Tributary Conservation ICS and Imported ICS credits.

Tributary Conservation and Imported ICS credits can be used during the year created and under any operating condition, including shortage (taken as Developed Shortage Supply or "DSS" during a declared shortage).[8] As required by the DCP, these resources are subject to a one-time deduction of 10 percent to offset evaporative loss and benefit Lake Mead system storage.

As discussed in the "Temporary Resources" section on the following pages, water that is not used in the year it is created may be converted to Extraordinary Conservation ICS. When needed, the credits will be withdrawn as Colorado River water through SNWA facilities and returned to the system for return-flow credits.

Tributary Conservation ICS. The SNWA is allowed to develop the portion of its Muddy and Virgin River surface water rights that have a priority date that precedes the BCPA (pre-1929 rights) as Tributary Conservation ICS. The SNWA can develop up to 50,000 AFY of Tributary Conservation ICS credits.

To date, approximately 14,700 AFY of permanent rights have been acquired. In addition to its permanent rights, the SNWA has acquired approximately 17,200 AFY of leased rights, with remaining terms through 2026. The SNWA anticipates acquiring and delivering a total of 36,000 AFY of Tributary Conservation ICS over the planning horizon.

Imported ICS. Under the Interim Guidelines, up to 15,000 AFY of Imported ICS can be created in an entitlement holder's state by introducing non-Colorado River water into the main stem of the Colorado River.

The SNWA has 9,000 AFY of permitted non-Colorado River groundwater rights in Coyote Spring Valley that would qualify as Imported ICS. However, these and other groundwater rights within the Lower White River Flow System are under review, subject to an ongoing process initiated by the State Engineer in 2018 to evaluate the amount of water that can be sustainably pumped. For the 2020 Plan, the SNWA assumes no use this resource.

Las Vegas Valley Groundwater Rights

All surface water and groundwater rights in the state of Nevada are administered by the Nevada State Engineer and fall under the purview of Nevada Water Law.[9]

Of the seven SNWA member agencies, the LVVWD and North Las Vegas have permanent groundwater rights totaling 40,760 and 6,201 AFY, respectively. These rights are among the most senior groundwater rights in the Las Vegas Valley. As such, they are protected even though new rights were granted to other users. Groundwater remains a critical component of SNWA's Resource Portfolio.

Water Reuse

The term water reuse generally means to recycle wastewater to support a secondary use. In the SNWA service area, nearly all water used indoors is recycled for either direct or indirect reuse. Direct reuse involves capturing, treating and reusing wastewater flows for non-potable uses such as golf course and park irrigation, and other uses. Indirect reuse consists of recycling water by way of treatment and release to the Colorado River for return-flow credits.

Boulder City, City of Las Vegas, Clark County Water Reclamation District, City of Henderson and City of North Las Vegas each operate wastewater treatment facilities that contribute to the region's direct and/or indirect reuse.

As shown in Figure 3.1, approximately 40 percent of water used in the SNWA service area results in highly-treated wastewater. Of that, approximately 99 percent is recycled.

While direct reuse of Colorado River water may have advantages over indirect reuse in terms of lower pumping cost, additional direct reuse does not extend Southern Nevada's Colorado River supply where return-flow credits are available. This is because an increase in direct reuse will reduce the amount of water available for indirect reuse through return-flow credits by a similar amount.

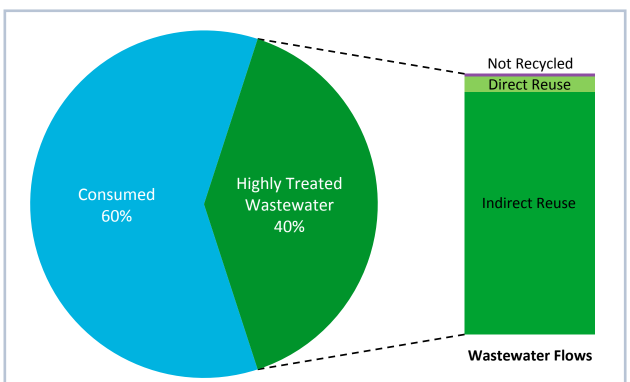


FIGURE 3.1 **SNWA Water Use and Recycling**

In 2017, SNWA adopted a policy to address water use outside the Las Vegas Valley, prioritizing the return of treated wastewater to Lake Mead for return-flow credits. IRPAC 2020 further recommended that the SNWA require out-of-valley development to return wastewater to Lake Mead and further limit consumptive uses of water outside the Las Vegas Valley.

TEMPORARY RESOURCES

Beginning in the early 1990s and continuing today, the SNWA has worked closely with other basin states to maximize opportunities for flexible use of Colorado River water. Through local and interstate arrangements, the SNWA has acquired a number of temporary resources that serve as an important management tool—these resources can be used to meet potential short-term gaps between supply and demand, serving as a bridge to meet demands while other future resources are being developed. In some cases, temporary resources can be used to offset reductions in permanent supplies due to shortages.

For the purpose of this plan, "Temporary Resources" are defined as banked resources. As part of its overall water resource strategy, the SNWA has reserved water in years when Nevada's Colorado River allocation exceeds the community's demands. To the extent possible, these resources are "banked" for future use in the form of storage credits. The volume of storage credits can change over time based on continued storage and use of supplies. As discussed below, the SNWA stores banked resources locally, as well as through banking agreements with other states.

Southern Nevada Water Bank

As of 2019, the SNWA has stored more than 346,000 acre-feet of water in the Southern Nevada Water Bank for future use through an agreement with LVVWD. The SNWA may recover water banked under this agreement in any water supply condition. This plan assumes a maximum recovery rate of 20,000 AFY.[11]

California Water Bank

Between 2004 and 2012, the SNWA entered into various agreements that allow it to store Nevada's unused Colorado River water in California. As of 2019, Nevada has banked more than 330,000 acre-feet of water in California. This plan assumes a maximum recovery up to 30,000 AFY during normal and shortage conditions, subject to agreement terms.[12]

Arizona Water Bank

In 2013, the SNWA approved an amendment to the 2001 water banking agreement with the Arizona Water Banking Authority.[13] The SNWA stored approximately 614,000 acre-feet of Colorado River water underground in Arizona's aquifers for the SNWA's future use as of 2019. Additional water can be banked on a pay-as-you-go basis up to 1.25 million acre-feet.

For the SNWA to recover this stored water, Arizona will utilize the banked water and forgo the use of a like amount of Colorado River water. The SNWA will then divert the water from facilities at Lake Mead. SNWA can recover up to 40,000 AFY during any water supply condition and may recover up to 60,000 AFY during a declared shortage. This plan assumes a maximum recovery of up to 40,000 AFY during normal and shortage conditions.

Intentionally Created Surplus

The SNWA has participated in several efforts to expand its portfolio of temporary resources under provisions specified in the Interim Guidelines and DCP.

As discussed earlier in this chapter, the Interim Guidelines created several forms of ICS: Tributary Conservation ICS and Imported ICS (discussed under "Permanent Resources"), as well as System Efficiency ICS and Extraordinary Conservation ICS. In 2012, an additional form of ICS was created as part of an international pilot program, referenced here as Bi-National ICS. Provisions for Bi-National ICS were extended through 2026 with the approval of a new agreement between the U.S. and Mexico in late 2017.

Additional provisions for the creation and delivery of ICS were authorized and implemented in 2019 under the DCP. As further described in this chapter, DCP ICS was created to provide an incentive for additional water storage in Lake Mead and, in turn, to help slow the decline of Lake Mead water levels. The SNWA can use its DCP ICS credits without penalty or payback when Lake Mead is above an elevation of 1,110 feet. The SNWA can access up to 300,000 AFY of its combined System Efficiency ICS, Extraordinary Conservation ICS, Binational ICS and may "borrow" DCP ICS during a declared shortage and when the elevation of Lake Mead is above 1,025 feet. These resources are further described below.

System Efficiency ICS. In 2007, the SNWA collaborated with the U.S. Department of the Interior and other project partners to fund construction of the Warren H. Brock Reservoir. This System Efficiency ICS project provides

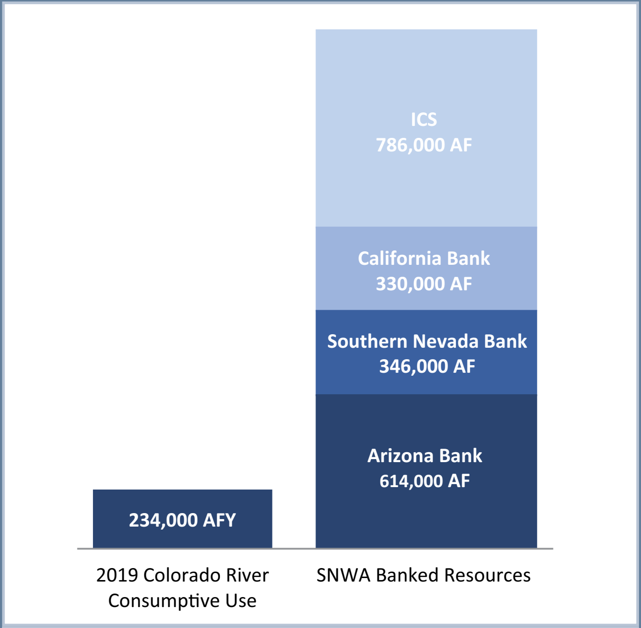
Recharge & Banking

The LVVWD began storing or "banking" water in the Las Vegas Valley in the late 1980s. In Southern Nevada, banking is accomplished through artificial recharge or in-lieu recharge.[14] Artificial recharge involves direct injection of treated unused Colorado River water into the local groundwater aquifer; in-lieu recharge is accomplished by not pumping non-revocable groundwater rights to acquire storage credits that are available for future use. Through various programs and agreements , the SNWA has expanded banking efforts to include storage in the Arizona Water Bank and California Water Bank, and in Lake Mead in the form of ICS (see sidebar on page 28).

As described later in this chapter, the 2019 DCP and associated agreements expanded Lake Mead water banking opportunities for Southern Nevada with the authorization of a new SNWA Extraordinary Conservation ICS project that allows the SNWA to leverage its past and future conservation savings and forgone banking to obtain ICS credits.

Ongoing accruals will be based on conservation achievements since 2002. Subject to certain conditions, provisions for the recovery of stored ICS credits also were expanded to allow for greater flexibility and use of ICS resources during a declared shortage.

Through 2019, the SNWA has accrued nearly 2.1 million acre-feet of water. This is nearly nine times Nevada's 2019 consumptive Colorado River water use.



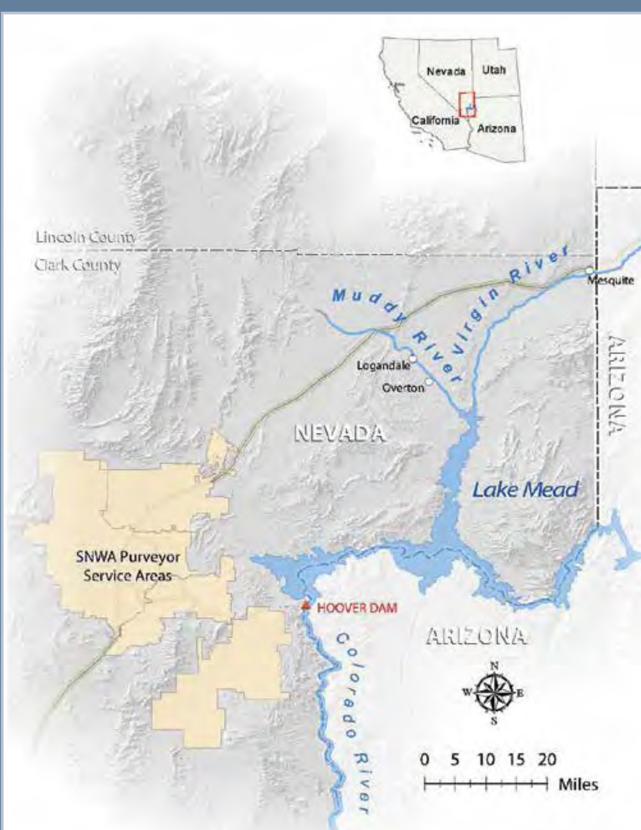
SNWA Banked Supplies Through 2019

Intentionally Created Surplus

The Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead (Interim Guidelines) were adopted in 2007 by the Secretary of the Interior. Among other things, the Interim Guidelines established requirements for the creation, delivery, and accounting for a new form of surplus called Intentionally Created Surplus.

ICS was instituted to encourage the efficient use and management of Colorado River water and to increase the water supply in Colorado River system reservoirs. The creation of ICS was designed to help reduce the likelihood, magnitude and duration of shortages in the Lower Basin. Additional provisions for the creation and recovery of ICS were authorized and are implemented under the 2019 Drought Contingency Plan.

Efforts to help stabilize Lake Mead water levels are of key importance to the SNWA – the agency has made significant investments in new intake and pumping facilities that will allow for reliable access to community water supplies in the event of low lake level conditions (below 1,000 feet).



Tributary Conservation ICS Creation

Southern Nevada with 400,000 acre-feet of ICS credits; no more than 40,000 acre-feet are available for consumptive use each year through 2036. These credits are stored in Lake Mead and are helping to bolster Lake Mead water levels.

In 2009, Nevada also collaborated with municipal water agencies in California, Arizona and the U.S. Bureau of Reclamation in a pilot operation of the Yuma Desalting Plant. The plant was constructed in 1992 to treat brackish agricultural drainage water in the United States for delivery to Mexico as part of its treaty obligation. Flood damage in 1993 caused the facility to cease operations.

As part of the 2009 collaborations, the facility was operated at one-third capacity to collect data on operational viability for long-term use. In exchange for funding the pilot test, the states received System Efficiency ICS. The SNWA's share was 3,050 acre-feet. These resources are temporarily stored in Lake Mead as System Efficiency ICS.

Extraordinary Conservation ICS. With approval and implementation of the DCP in 2019, the SNWA can create up to 100,000 AFY of Extraordinary Conservation ICS under a newly authorized project.[16] For 2017 and 2018, and through 2026, the SNWA's Extraordinary Conservation ICS account will be credited for SNWA's investments in municipal conservation and off-stream storage, which have reduced Nevada's Colorado River water use below the state's apportionment and created the opportunity for the SNWA to store this water in one of its off-stream water banks. Using an established methodology to determine water savings, the SNWA will accrue Extraordinary Conservation ICS credits when it stores these water savings in Lake Mead as ICS. Tributary Conservation and Imported ICS credits also are converted to Extraordinary Conservation ICS credits if they are not used in the year they are created.

These ICS credits are banked in Lake Mead and are subject to a one-time deduction of 10 percent for system benefit and evaporative loss. As of 2019, the SNWA has stored approximately 328,000 acre-feet of Extraordinary Conservation ICS.

DCP Contributions and ICS. The Lower Basin States will begin making DCP contributions when the elevation of Lake Mead is projected to be at or below 1,090 feet on January 1. Contribution amounts vary by state and are based on Lake Mead water levels. Nevada's DCP contribution ranges from 8,000 to 10,000 AFY. This volume of water is in addition to any mandatory reductions associated with a federally declared shortage. Mandatory shortage reductions cannot be recovered.

Subject to storage limitations, Nevada's DCP ICS account will be credited each time Nevada makes a DCP contribution. The SNWA can utilize its DCP ICS credits with no penalty or repayment obligations when Lake Mead is above 1,110 feet. Below this elevation, the SNWA can access or borrow credits, subject to repayment.

As shown in Figure 3.2, access to DCP ICS credits are not available in years when the elevation of Lake Mead is projected to be at or below 1,025 feet. Borrowed DCP ICS credits must be replenished within one to five years, depending on Lake Mead water levels. Beginning in 2027, any unused DCP ICS credits will be reduced by three percent annually to benefit the Colorado River system.

YEAR	ABOVE 1,110 FT.	1,110 TO ABOVE 1,075 FT.	1,175 TO ABOVE 1,025 FT.	1,125 FT. OR BELOW
2020 - 2026	AVAILABLE	REPAY IN 1 YEAR		NOT AVAILABLE
2027 - 2057 *	AVAILABLE	REPAY IN 5 YEARS	REPAY IN 1 YEAR	NOT AVAILABLE

*2020 Water Resource Plan assumes availability through 2071.

FIGURE 3.2 **Availability of DCP ICS Credits**

Bi-National ICS. The United States and Mexico finalized Minute 323 to the 1944 U.S./Mexico water treaty in 2017. Minute 323 extends and modifies key provisions of historic Minute 319, which enhanced Colorado River system sustainability by quantifying water deliveries to Mexico under high- and low-reservoir conditions. In addition, Minute 323 contains Mexico's commitment to a Water Scarcity Plan that requires Mexico to store additional water in the United States as Lake Mead elevations drop. With approval and implementation of the DCP, Mexico will join Arizona, California and Nevada in required storage contributions designed to mitigate the impacts of ongoing drought and slow the decline of Lake Mead water levels.

Effective through the year 2026, Minute 323 authorizes Mexico to defer its Colorado River water deliveries and to store water in the United States for later delivery to Mexico. The agreement will help maintain Lake Mead water levels, delay potential shortages, and create additional certainty for all water users, particularly during shortages.

Like Minute 319, Minute 323 allows for the SNWA to invest in conservation and infrastructure projects in Mexico in exchange for Bi-National ICS credits. Through Minutes 319 and 323 and the accompanying domestic agreements,

Drought Contingency Plan

In addition to the mandatory shortage reductions defined by the Interim Guidelines, the SNWA and other Colorado River users approved the Lower Basin DCP for Colorado River operations in 2019.[15] Authorized by Congress for immediate implementation, the agreement requires the Lower Basin states to make additional contributions designed to reduce the magnitude and likelihood of continued Lake Mead water level declines, and reduce the risks of potential water supply interruptions for Lower Basin water users.

The DCP:

- Keeps more water in the river for the benefit of all water users and the environment.
- Helps slow Lake Mead water level declines to preserve critical reservoir elevations.
- Authorizes new ICS projects and supplies that contributing states can access during a federally declared shortage and when Lake Mead water levels recover.
- Draws participation from new stakeholders, including California, and promotes continued collaboration.

Federal, state and municipal partners have worked collaboratively for years to reduce the risk of a Lake Mead water level decline below 1,000 feet, a critical elevation for operation of Hoover Dam and Lower Basin water deliveries. With implementation of the DCP and other related agreements in 2019, the risk of Lake Mead reaching this critical elevation has decreased substantially. Authorization and implementation of the DCP provides greater certainty for Lower Basin water users and represents a significant collaboration milestone among Colorado River stakeholders.

DCP Signing Ceremony at Hoover Dam, Lake Mead

Colorado River, Devil's Elbow, California

the SNWA has agreed to fund projects yielding a minimum of 51,025 and a maximum of 78,300 acre-feet of Bi-National ICS credits. As of late 2019, the SNWA has accrued 23,750 acre-feet of Bi-National ICS credits.

FUTURE RESOURCES

For the purpose of this plan, "Future Resources" are defined as those resources expected to be available to the SNWA at some point during the planning horizon. In some instances, water resources are quantified subject to water right permitting, while the availability and development of others requires further research and analysis. Some water supply options have been deferred as further described on page 31.

Development of most future resource options described in this Plan will require additional environmental permitting, as well as construction of water delivery infrastructure. Likewise, implementation of some Colorado River options may require changes to the Law of the River to provide increased flexibility.

Colorado River Transfers/Exchanges

In concept, water transfers involve moving water resources from willing sellers to willing buyers. There are a variety of ways in which this can occur: interbasin, intrastate and interstate transfers. Full-scale transfers and exchanges among Colorado River water users could involve transfers/exchanges associated with participation in desalination or agricultural fallowing projects, or through participation in other conservation and reuse initiatives. As part of Colorado River negotiations slated to begin in 2021, the SNWA will work with other Colorado River Basin states to create a more concrete framework for these types of exchanges.

Desalination. The SNWA is engaged with other Colorado River Basin states and water users, the U.S. Bureau of Reclamation and the country of Mexico to actively explore and investigate potential seawater and brackish water desalination projects in the state of California and the country of Mexico.

Other projects are being considered by a Binational Projects Work Group. These include opportunities for seawater desalination and wastewater reuse facilities in Mexico. The latter are noted as areas of interest under Minute 323. To support these efforts, the SNWA and Basin State partners funded a feasibility study to examine desalination opportunities along the Sonoran coast of the Sea of Cortez. The study was completed in 2020 and is available online.[17]

Colorado River Partnerships. The SNWA is actively exploring future resource options that may involve financial participation in major capital projects under development in other states. For example, the SNWA is exploring participation in a major reuse project currently being reviewed by the Metropolitan Water District of Southern California (MET).

MET is planning for a full scale regional recycled water program that would produce up to 150 million gallons of water daily (or about 168,000 AFY). An initial pilot project is currently underway to support planning and research efforts. While the project is still in an early phase of development, the SNWA and MET are collaborating to identify a path for the SNWA's participation and to determine what approvals might be needed to implement the partnership. The SNWA anticipates that 20,000 - 40,000 AFY will be available to the SNWA in exchange for funding participation.

The SNWA will continue to collaborate with MET and other Colorado River water users to evaluate the potential for participation in collaborative Colorado River partnerships of mutual benefit.

Colorado River Augmentation

The SNWA was permitted 113,000 AFY of Virgin River water rights in 1994. Under an agreement, the SNWA transferred 5,000 AFY to the Virgin Valley Water District. In accordance with the 2007 Seven States' Agreement, the SNWA has agreed to suspend development of these Virgin River surface water rights in exchange for agreement with the other Colorado River Basin States to cooperatively pursue the development of 75,000 AFY of permanent water supplies to augment the Colorado River for Nevada.[19]

In State Groundwater

The SNWA has permits and applications in southern and eastern Nevada based on applications filed by the LVVWD in 1989. Some of these applications have been permitted by the Nevada State Engineer in accordance with Nevada Water Law while others require further review and analysis. As described below, some resource interests have been withdrawn and/or deferred.

MET Water Project

The Metropolitan Water District of Southern California is working with Sanitation Districts of Los Angeles County on the planned development a Regional Recycled Water Advanced Purification Center. Planning efforts are currently underway, including development and operation of a demonstration facility to inform project planning and test treatment processes.

As planned, the full-scale program will recover and treat up to 150 million gallons of water per day (or about 168,000 AFY) from homes, businesses and industries within METs service area. Water will be cleaned and treated as part of a three-step purification process involving membrane bioreactors, reverse osmosis and ultraviolet/advanced oxidation processes. Treated water will be stored in groundwater basins until it is needed to meet municipal demands.

The SNWA is pursuing opportunities with MET for participation in this project. Any future agreement would likely involve a Colorado River water transfer/exchange in return for SNWA's financial participation in the project.

Once approved by regulators, the full-scale facility will take MET about 11 years to design and construct.

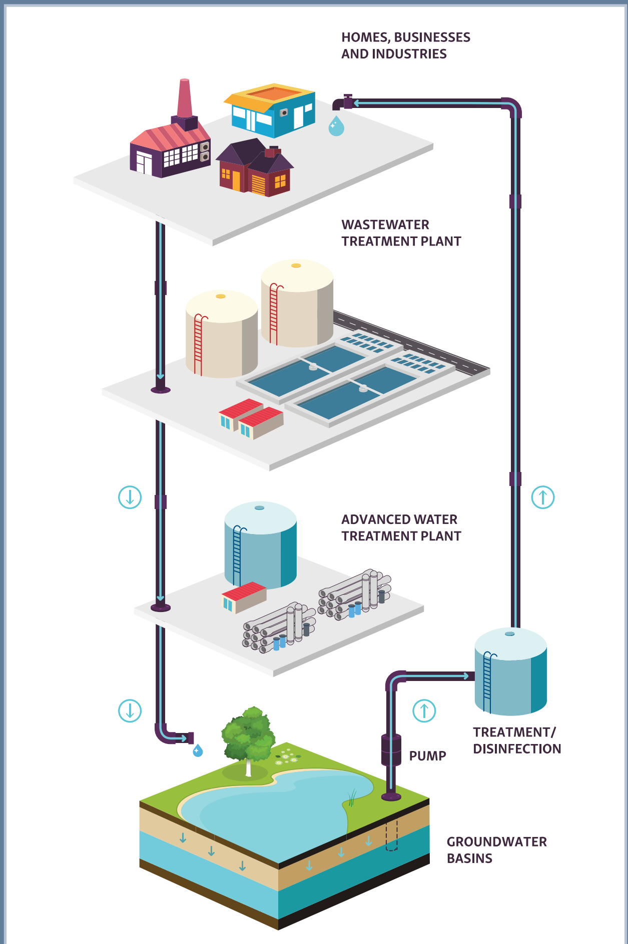


FIGURE 3.3 **Water Recovery and Treatment Process**

Garnet and Hidden Valleys. The SNWA has permitted rights to 2,200 AFY of groundwater in Garnet and Hidden valleys. The majority of these rights have been leased to dry-cooled power plants located in Garnet Valley. [18] As noted earlier in this chapter, these and other groundwater rights within the Lower White River Flow System are subject to an ongoing process initiated by the State Engineer in 2018 to evaluate the amount of water that can be sustainably pumped from the system.

Three Lakes Valley (North and South) and Tikaboo Valley (North and South). Between 2003 and 2006, the Nevada State Engineer issued a series of rulings granting the SNWA rights to 10,605 AFY of groundwater in these basins. The SNWA is working to develop options for delivery of 8,018 AFY of the groundwater rights from Three Lakes Valley North and South and Tikaboo Valley South into the northwest portion of the Las Vegas Valley. Remaining applications for groundwater not acted upon by the Nevada State Engineer were withdrawn by the SNWA in 2020.

Delamar, Dry Lake, Cave, Spring and Snake Valleys. The SNWA placed its Clark, Lincoln and White Pine Counties Groundwater Development Project into deferred status in 2020. Consistent with this decision, the SNWA terminated federal permitting processes associated with the project, including the withdrawal of pending water right applications, right-of-way grant and federal stipulations for water resource development activities in Delamar, Dry Lake, Cave, Spring and Snake valleys. These actions were made possible due to conservation advancements and the completion of new Lake Mead infrastructure. These new facilities offset risk associated with ongoing drought and climate change, and allow the SNWA to pursue collaborative future resource opportunities with Colorado River partners in the Lower Basin.

WATER CONSERVATION

Water conservation is a resource. However, unlike typical "wet" resources, which are acquired and conveyed to meet demands, conservation reduces existing and future demands, and extends available supplies.

Gallons Per Capita Per Day (GPCD) is a metric used by many communities to measure water uses. It also is an effective tool to measure efficiency over time. GPCD varies across communities due to several factors, including differences in climate, demographics, water-use accounting practices and economic conditions.

The SNWA's conservation progress and goal is stated in consumptive use terms. This approach reflects water resource implications associated with conservation progress. SNWA GPCD is calculated by dividing all SNWA water sources diverted (excluding off-stream storage less corresponding Colorado River return-flow credits by total SNWA resident population served per day (GPCD = water diverted - return- flow credits / resident population / 365 days). This approach recognizes that not all water that is delivered is consumed. This is because the SNWA recycles nearly all indoor water use, primarily through return-flow credits.

Approximately 60 percent of all water delivered by the SNWA is consumed, primarily for landscape irrigation and cooling. Unlike water used indoors, water used outdoors and for cooling is lost to the system as it cannot be treated and reused. As a result, outdoor uses continue to be a primary focus area for future conservation gains.

Conservation Goals

Since its inception in 1991, the SNWA and its member agencies have worked collaboratively to set and achieve aggressive water conservation goals. These efforts have yielded a 52 percent decrease in per capita water use between 2002 and 2019, even as growth within the SNWA service area increased by approximately 48 percent during that same timeframe (Figure 3.5).

The SNWA is currently working to achieve its conservation goal of 105 GPCD by 2035. As recommended by IRPAC 2020, a new conservation goal will be evaluated once the current goal is achieved. Chapter 4 provides an illustrative look at how additional conservation—beyond the current goal—might impact long-term (50-year) water demands, as well as short- and mid-term water supply needs.

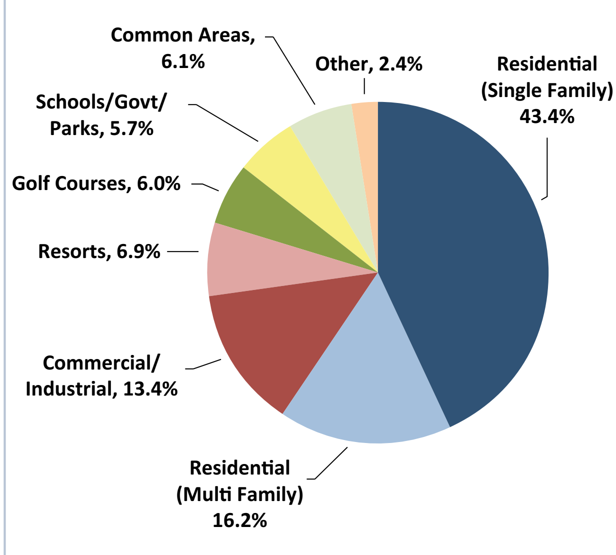


FIGURE 3.4 **Municipal Metered Use (2019)**

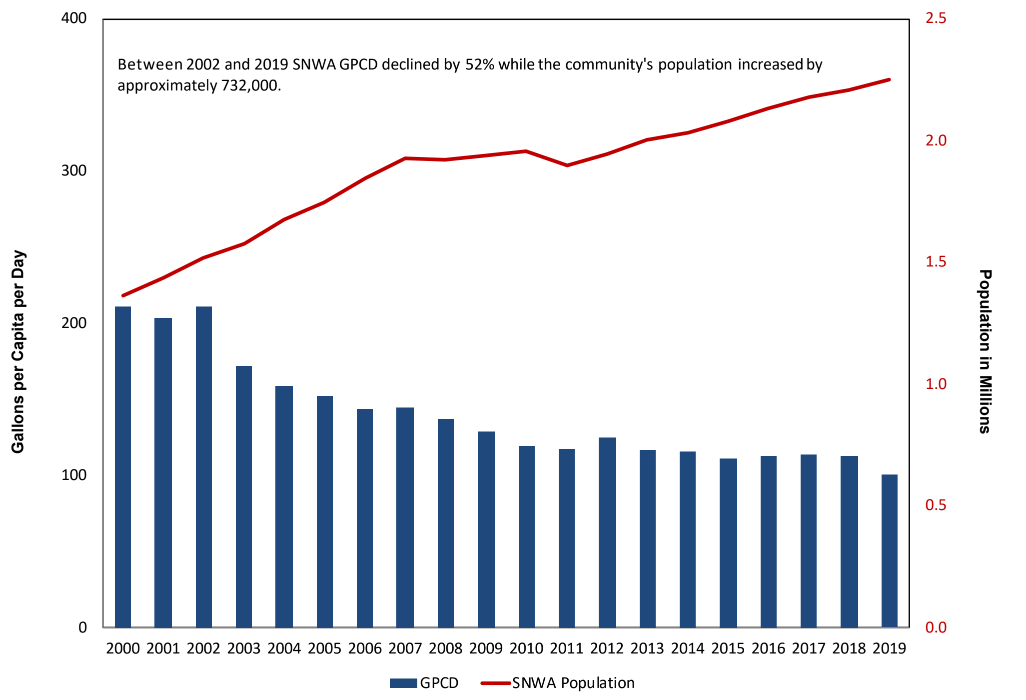


FIGURE 3.5 **Population & Per Capita Water Use**

While the SNWA has expanded education, outreach and incentive programs to support water conservation and efficiency gains, meeting our current conservation goal (and even higher levels of efficiency thereafter) will require the implementation of new strategies and tactics. IRPAC 2020 considered this and other supply and demand challenges as part of its review process. The committee also considered impact of upward pressure on water use due to climate change and system age.

Key Focus Areas

Above and beyond the continued implementation of existing conservation tools (see sidebar on page 34), IRPAC 2020 recommended specific actions, that if implemented, will help the SNWA to achieve its current conservation goal and support the achievement of additional conservation gains thereafter. Among other things, these recommendations specifically address major consumptive uses of water in Southern Nevada (see Appendix 3). Key focus areas are described in the balance of this chapter.

Non-Functional Turf. As of 2019, approximately 5,000 acres of non-functional turf remain in the SNWA member agency service area, predominantly located in streetscapes, common areas and commercial frontage (Figure 3.6). As recommended by IRPAC 2020, the SNWA is working to reduce existing non-functional turf acreage by 50 percent by 2035. The SNWA assumes that achieving this target could save up to 365 million gallons of water annually. The SNWA is currently working with its member agencies to update service rules, codes and ordinances to consistently implement the SNWA's 2019 non-functional turf resolution, which prohibits new non-functional turf installations. Other efforts will include outreach and collaboration with developers and master planned communities, and other potential changes to municipal codes.

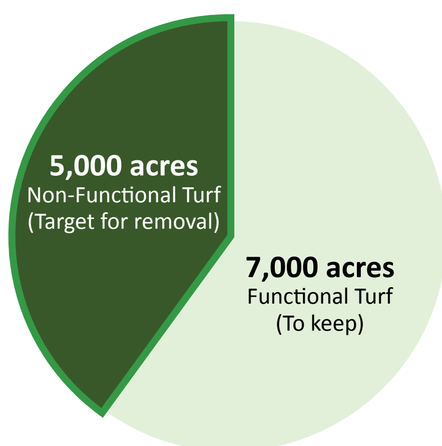


FIGURE 3.6 **Remaining Turf Acreage**

Conservation Tools

The SNWA uses several demand management tools to promote conservation and reduce overall water use, including water pricing, incentives, regulation and education. As described below, these measures are designed to work in conjunction with one another to promote efficient water use. Likewise, the SNWA has deployed new strategies to promote continued conservation and efficiency gains. These include increased water management measures, targeted education and outreach initiatives and increases to financial incentive programs. New incentives and offerings have also been introduced.

- Education: Education is an integral element of the SNWA's water conservation strategy. It includes both formal and informal education, from tips and tutorials to improve efficiency, to class offerings on water-smart landscaping practices for both residents and landscape professionals.
- Incentives: The SNWA operates one of the largest incentive programs in the nation. Since 2000, SNWA has invested more than $230 million in incentive programs, reducing demand by more than 12.6 billion gallons annually.
- Regulation: Through collaboration, SNWA member agencies and Clark County have adopted a suite of land use codes, ordinances and water use policies to ensure more efficient use of water in Southern Nevada. These include time-of-day and day-of-week watering restrictions, water waste restrictions and limitations on the installation of new turf in residential and commercial development.
- Water Pricing: SNWA member agencies implement conservation rate structures that charge higher rates for water as use increases. These rate structures encourage efficiency, without jeopardizing water affordability for essential uses.

Cool Season Turf. Limiting future installations of cool-season turf in public spaces and expediting the conversion of cool-season turf to warm-season turf at existing public facilities will help reduce consumptive use associated with turf irrigation while preserving functional turf in recreational spaces. The SNWA is working with the its member agencies to identify conversion opportunities and is providing support through its incentive programs. Future efforts to limit new cool-season turf installations may include changes to service rules, codes and ordinances. The estimated water savings is 21 gallons per square foot of turf converted.

Landscape Watering Compliance. Improving compliance with landscape watering restrictions and preventing water waste is a high priority for reducing consumptive water use in Southern Nevada. Current restrictions allow customers to water on three assigned days per week in spring and fall, one assigned day per week in winter and six assigned days per week in summer. Sunday watering is prohibited year-round. The SNWA maintains an active information and outreach campaign to promote landscape watering compliance and SNWA's member agencies conduct water waste enforcement. The SNWA is currently working to develop a pilot program to examine water savings associated with smart controllers, which can automatically adjust for seasonal watering schedule changes and weather factors. Other strategies to improve compliance include enhanced water waste investigations and more direct-outreach to violators.

Water Efficient Development. While Southern Nevada has some of the nation's most progressive water efficiency standards, the implementation of additional policies, products and practices can significantly reduce consumptive water use in new development. Meaningful opportunities for efficiency gains exist within the commercial and industrial sectors, particularly for new development. As recommended by IRPAC 2020, the SNWA is working to embed the principals of the SNWA's Non-Functional Turf Resolution in municipal codes and service rules; require out-of-valley development to return wastewater to Lake Mead for return-flow credits and further limit consumptive uses of water in out-of-valley areas; and establish an efficiency review policy and process for new large water users that encourages efficient development and disincentivize consumptive uses.

Leak Resolution. Customers are responsible for repairing leaks that occur on their property and downstream of the utility's water meter. Residential leaks are typically the result of damaged irrigation systems, cracked supply lines or faulty fixtures (such as faucets, toilets, appliances

Cooling Tower

and water heaters). Slow leaks aren't always visible and can generate significant water loss. As recommended by IRPAC 2020, SNWA member agencies, including the Las Vegas Valley Water District, City of Henderson and City of North Las Vegas, are working to deploy advanced metering infrastructure (AMI) that will significantly enhance their ability to notice customers of suspected leaks for faster leak resolution. The Big Bend Water District is currently using this technology. AMI provides high-resolution data in near real-time. Other efforts may include the development of new programs and services, as well as the deployment of other new technologies that can help customers to identify and resolve leaks faster.

Cooling Efficiency. Evaporative cooling is the second-largest consumptive use of water in Southern Nevada and deployment of alternative cooling technology represents a significant opportunity for water savings. In Southern Nevada, evaporative cooling is predominantly used to cool commercial and industrial buildings. Water consumption primarily occurs through evaporation and drift loss which comprise about 70 percent of total cooling water demand. As recommended by IRPAC 2020, the SNWA is evaluating changes necessary to reduce current and future consumptive water losses associated with evaporative cooling technology. Near-term efforts include research and pilot projects to inform best management practices, incentive programs and other policy changes.

Infrastructure investments. IRPAC 2020 recommended making continued investments to maintain and improve the existing water loss rate among wholesale and retail water purveyors. Non-revenue water losses are typically associated with leaks in transmission or distribution pipelines, variations in meter accuracy and water theft. The SNWA and its member agencies implement several strategies to minimize water loss within their water distribution systems, but investments will be required as systems age. Other related efforts include deploying and testing innovative technologies that can improve leak detection and speed leak repairs, as well as prioritizing system optimization and making proactive retrofits and repairs to system facilities.

CHAPTER SUMMARY

A number of factors can influence the timing, use and availability of water resources. Having a diverse portfolio of resources allows the SNWA to assess its overall water resource options and make appropriate decisions regarding which resources to bring online when necessary. This approach provides flexibility in adapting to changing supply and demand conditions, and helps ensure that community water demands can be met reliably.

The SNWA Water Resource Portfolio includes a mix of resources that will be used in tandem with continued conservation efforts to meet demands over the 50-year planning horizon. Some of these resources can be used under any Colorado River operating condition, while others are subject to limitations.

The SNWA continues to make water conservation a priority and the community is currently working to achieve its 105 GPCD conservation goal by 2035. Additional targets will be evaluated once the current goal is achieved. The SNWA has taken a number of steps to increase conservation gains and is aggressively pursuing opportunities and recommendations identified by the SNWA's 2020 Integrated Resource Planning Advisory Committee. Priority areas include:

- Targeting the reduction of non-functional turf and limiting turf installation in new development.
- Limiting cool-season turf installation in public spaces and expediting conversions in public facilities.
- Enhancing landscape watering compliance through implementation of smart controller technology.
- Speeding customer leak repairs through implementation of advanced metering infrastructure.
- Reducing consumptive water losses associated with evaporative cooling by promoting advanced technology.
- Encouraging efficient development and discouraging consumptive water use for new large water users.
- Continuing to achieve reductions in water loss through infrastructure investments.

With ongoing support from the community, conservation will maximize the use and availability of existing supplies, help protect Lake Mead water levels from continued decline, offset potential climate change supply and demand impacts, delay the need for new resources and facilities, and provide opportunities to increase temporary storage reserves.

Likewise, the SNWA continues to work with other Colorado River water users to pursue flexible use of Colorado River supplies, including augmentation and storage projects that are designed to increase supplies and bolster Lake Mead water levels, as well as other water resource initiatives that could provide permanent supply benefits to Southern Nevada.

ENDNOTES

1 "Contract with the Southern Nevada Water Authority, Nevada for the Delivery of Colorado River Water," effective March 2, 1992; between Secretary of Interior, Colorado River Commission and Southern Nevada Water Authority." The contract was amended in 1994: "Amended and Restated Contract with the Southern Nevada Water Authority, Nevada for the Delivery of Colorado River Water," effective November 17, 1994.

2 Nevada Colorado River consumptive use entitlement available for SNWA and the SNWA purveyor members is estimated to be 272,205 AFY plus 4,000 AFY for Nellis Air Force Base with 23,795 AFY allocated for use by Nevada non-SNWA contractors. "Listing of Individual Water Entitlements in the State of Nevada," listing as of May 2020, U.S. Bureau of Reclamation, http://www. usbr. gov/lc/region/g4000/contracts/entitlements/NVentitlements.pdf.

3 The 1944 United States-Mexico Treaty for Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande. The treaty guarantees Mexico the delivery of 1.5 million AFY of Colorado River water plus 200,000 AFY of any surplus Colorado River water. In 1974, an international agreement interpreting the 1944 Treaty guaranteed Mexico water of the same quality as that being used in the United States.

4 Nevada receives credits for Colorado River return flows from the Las Vegas Wash based upon a procedure originally agreed to by the U.S. Bureau of Reclamation (BOR) and the Colorado River Commission of Nevada in 1984. This procedure has been updated periodically through consultation with the BOR, SNWA and Colorado River Commission of Nevada; the most recent update in 2007 allows full consumptive use of water imported to the Las Vegas Valley.

5 The 1964 Supreme Court Decree in Arizona v. California defines "surplus" as follows: "If sufficient mainstream water is available for release as determined by the Secretary, to satisfy annual consumptive use [in the Lower Division states of Arizona, California and Nevada] in excess of 7,500,000 acre-feet, such excess consumptive use is surplus."

6 Under the Interim Guidelines, Extraordinary Conservation ICS credits accumulated in ICS accounts will be reduced by the amount of the Flood Control Surplus on an acre-foot for acre-foot basis until no Extraordinary Conservation ICS remains. The reductions to the ICS accounts will be shared on a pro-rata basis among all contractors that have accumulated Extraordinary Conservation ICS credits.

7 According to the Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations of Lake Powell and Lake Mead (Interim Guidelines), Lower Basin States of Arizona, California and Nevada can create credits for Colorado River or non-Colorado River water that has been conserved by users in the Lower Basin (known as intentionally created surplus or ICS). ICS credits can be used in the year they are created or be stored in Lake Mead and made available for release from Lake Mead at a later time, subject to Operating (Shortage) conditions at the time of release.

8 "Developed Shortage Supply ("DSS")" shall mean water available for use by a contractor under the terms and conditions of a Delivery Agreement and Section 4 of Interim Guidelines in a Shortage Condition, under Article III(B)(3) of the Consolidated Decree. During a year when the Secretary has determined a shortage condition, the Secretary shall deliver DSS available in a contractor's DSS Account at the request of the contractor, subject to the provisions of Interim Guidelines' Section 4.C.

9 Nevada Revised Statutes, Chapters 532, 533, and 534.

10 "Policy Regarding Out-of-Valley Water Reuse," 2017, SNWA.

11 "Cooperative Agreement for the Banking of Water in the Las Vegas Valley Groundwater Basin between the Southern Nevada Water Authority and the Las Vegas Valley Water District," effective February 21, 2006. The artificial recharge program in the Las Vegas Valley was initiated in 1987 by the Las Vegas Valley Water District.

12 "Third Amended Operational Agreement among the Metropolitan Water District of Southern California (Metropolitan), Colorado River Commission of Nevada and the Southern Nevada Water Authority (SNWA)," effective October 19, 2015 and "Storage and Interstate Release Agreement among the United States of America, the Metropolitan Water District of Southern California, the Southern Nevada Water Authority, and the Colorado River Commission of Nevada," effective October 27, 2004. The amount of developed and released water stored in Metropolitan's SNWA Interstate Account to SNWA depends on timing of SNWA's request and Colorado River operating conditions at the time of such request.

13 "Third Amended and Restated Agreement for Interstate Water Banking among the Arizona Water Banking Authority and the Southern Nevada Water Authority and the Colorado River Commission of Nevada," effective May 20, 2013 and "Storage and Interstate Release Agreement among the United States of America, the Arizona Water Banking Authority, the Southern Nevada Water Authority, and the Colorado River Commission of Nevada," effective December 18, 2002.

14 "In-Lieu Recharge Order," Order No. 1176, December 10, 2004,State of Nevada, Office of the Nevada State Engineer.

15 "Lower Colorado River Basin Drought Contingency Plan Agreement" among the U.S., State of Arizona, Metropolitan Water District of Southern California, Coachella Valley Water District, Palo Verde Irrigation District, City of Needles, Colorado River Commission of Nevada and SNWA. May 20, 2019.

16 "Lower Basin Drought Contingency Operations, ICS Exhibit W - Southern Nevada Water Authority – Extraordinary Conservation Intentionally Created Surplus using Municipal Conservation and Offstream Storage for implementation under the Lower Basin Drought Contingency Plan," May 20, 2019.

17 Black & Veach, "Binational Study of Water Desalination Opportunities in the Sea of Cortez," 2000, prepared for Minute 323 Desalination Work Group (ibwc.gov/Files/TMs_All_Portfolio.pdf).

18 SNWA has 2,200 AFY of groundwater permits in Garnet and-Hidden valleys as a combined duty. SNWA is currently leasing a maximum of 1,450 AFY, not to exceed 13,000 acre-feet over any ten year rolling period, for power generation in Garnet Valley. The leases therefore commit 1,300 AFY over a ten year rolling period. In addition, the City of North Las Vegas is permitted to divert 300 AFY from their wells in Garnet Valley, and the remaining 600 AFY is available for future uses.

19 "Agreement Concerning Colorado River Management and Operations," effective April 23, 2007; between Arizona Department of Water Resources, Colorado River Board of California, Colorado Water Conservation Board, Governor's Representative for the State of Colorado, Colorado River Commission of Nevada, Southern Nevada Water Authority, New Mexico Interstate Stream Commission, Utah Division of Water Resources, Utah Interstate Streams Commissioner, and Wyoming State Engineer.

20 Southern Nevada Water Authority Joint Water Conservation Plan," November 2019, SNWA.

21 J. Kiefer, J. Clayton, B. Dziegielewski and J. Henderson, "Changes in Water Use Under Regional Climate Change Scenarios," 2013, Water Research Foundation (Project #4263).

MEETING FUTURE DEMANDS

THIS CHAPTER ADDRESSES HOW SNWA PLANS TO RELIABLY MEET PROJECTED WATER DEMANDS UNDER A RANGE OF SUPPLY AND DEMAND CONDITIONS.

INTRODUCTION

As described in the preceding chapters, water supply conditions and demands can be influenced by several factors that can change in unpredictable ways, including changes associated with economic conditions, water conservation progress and climate variability. As the SNWA prepared its 2020 Plan, the organization considered two overriding issues related to water supply and demands:

- The potential impact of continued drought and climate change on water resource availability, particularly for Colorado River supplies; and
- The potential impact of economic conditions, climate change and water use patterns on long-term water demands.

To address these uncertainties, the SNWA developed a series of planning scenarios that represent Southern Nevada's future water resource needs under variable supply and demand conditions. This approach helps inform water resource planning and water resource development efforts and demonstrates how the SNWA plans to meet future needs, even if conditions change significantly over time.

Water demands and resource volumes are presented in consumptive use terms, consistent with the water resource descriptions in Chapter 3 and illustrating the supply related impacts of SNWA shortage reductions and DCP contributions. As described in the following sections, all of the planning scenarios presented in this chapter demonstrate the SNWA's ability to meet the community's long-term projected water needs through adaptive use of its Water Resource Portfolio.

SUPPLY AND DEMAND

Water resource planning is based on two key factors: supply and demand. Supply refers to the amount of water that is available or that is expected to be available for use. Demand refers to the amount of water expected to be needed in a given year.

Water demand projections are based on population forecasts and include assumptions about future water use, such as expected achievements toward water conservation goals. Precise accuracy from year to year rarely occurs in projecting demands, particularly during periods of significant social and economic changes. While making assumptions is a necessary part of the planning process, assumptions are unlikely to materialize exactly as projected. Likewise, climate variations, policy changes and/or the implementation of new regulations can also influence water resource availability over time.

The scenarios presented in this chapter address these uncertainties by considering a wide range of supply and demand possibilities. Rather than considering a single forecast, the scenarios bracket the range of reasonable conditions that may be experienced over the 50-year planning horizon. Key factors evaluated include possible reductions of Colorado River supplies, as well as variation in future demands. This is a conservative approach that reflects the uncertainties presented in the current planning environment.

The following describes the water supply conditions and demand projections that were considered as part of scenario development.

Water Supply

Figure 4.1 summarizes the water resources planned for development and use as part of the SNWA's Water Resource Portfolio. As previously described, some permanent and temporary resources are subject to restrictions for use based on Lake Mead water levels (when Lake Mead is at an elevation of 1,090 feet or lower), while other resources will require the development of facilities for use.

Ultimately, the timing and need for resources will depend significantly on how supply and demand conditions materialize over the long-term planning horizon.

	SUPPLY	CONSUMPTIVE USE	AVAILABLE IN SHORTAGE
PERMANENT	Colorado River (SNWA and Nellis Air Force Base) [1]	276, 205 AFY	Yes. Subject to shortage reductions
	Nevada Unused Colorado River (Non-SNWA)	13,132 (2020) to 0 AFY in 2031	Yes. Subject to availability
	Tributary Conservation ICS	28,700-36,000 AFY	Yes
	Las Vegas Valley Groundwater Rights	46,961 AFY	Yes
TEMPORARY	Southern Nevada Groundwater Bank	345,777 AF (20,000 AFY max.)	Yes
	Interstate Bank (Arizona)	613,846 AF (40,000 AFY max.)	Yes
	Interstate Bank (California)	330,225 AF (30,000 AFY max.)	Yes
	Intentionally Created Surplus (storage in Lake Mead)	785,913 AF (300,000 AFY max.)	Yes. Varies by Lake Mead elevation
FUTURE	Colorado River Transfers/Exchanges Permanent Future Supply (Desalination and Colorado River Partnerships)	20,000-40,000 AFY	Yes
	Colorado River Transfers/Exchanges Virgin River/Colorado River Augmentation	Up to 108,000 AFY	To be determined
	Garnet and Hidden Valleys Groundwater	2,200 AFY	Yes
	Tikaboo and Three Lakes Valley North and South Groundwater	10,605 AFY	Yes

FIGURE 4.1 **SNWA Water Resource Portfolio**

Water Demand Projections

The planning scenarios developed as part of this Plan include three water demand projections (Figure 4.2 and Figure 4.3). These include: an upper water demand projection, a lower water demand projection and an additional conservation demand projection. The lower water demand projection was derived from a population forecast and expected conservation achievements. The Clark County population forecast was obtained from the University of Nevada Las Vegas Center for Business and Economic Research (CBER).

YEAR	2020	2045	2071
LOWER DEMAND	281,000	334,000	353,000
UPPER DEMAND	283,000	393,000	441,000
ADDITIONAL CONSERVATION	282,000	365,000	406,000

FIGURE 4.2
SNWA Demand Projection, (AFY)

This forecast is also used in local planning, including transportation planning by the Regional Transportation Commission. The forecast is based on CBER's working knowledge of the economy and the nationally recognized Regional Economic Model Incorporated (REMI).

The lower water demand projection was derived using the 2020 CBER population forecast through 2060 and trending through the year 2071. The historical share of Clark County population attributable to the SNWA service area was multiplied by 2019 water-use levels and reduced over time to represent expected achievement of the community's water conservation goal of 105 GPCD by 2035. The projection assumes a further reduction in total demand (100 GPCD) by 2055 to reflect the potential for additional conservation once the current goal has been met.

The upper demand projection was developed for planning purposes to reflect increased uncertainties related to possible changes in demands that are associated with the economy, climate, population and water use variability.

The upper demand projection represents a 15 percent increase over the lower projection at the midpoint of the planning horizon (2040), increasing to 25 percent in the latter part of the planning horizon (2071). The SNWA also considered one variant of the upper demand projection that includes assumptions about additional levels of conservation.

The additional conservation demand projection was developed for planning purposes to illustrate how additional conservation might reduce water demands, extend permanent and temporary resources and delay the need for future resources. The projection assumes the community meets its conservation goal of 105 GPCD and further reduces water use to 98 GPCD by 2035 and 92 GPCD by 2055.

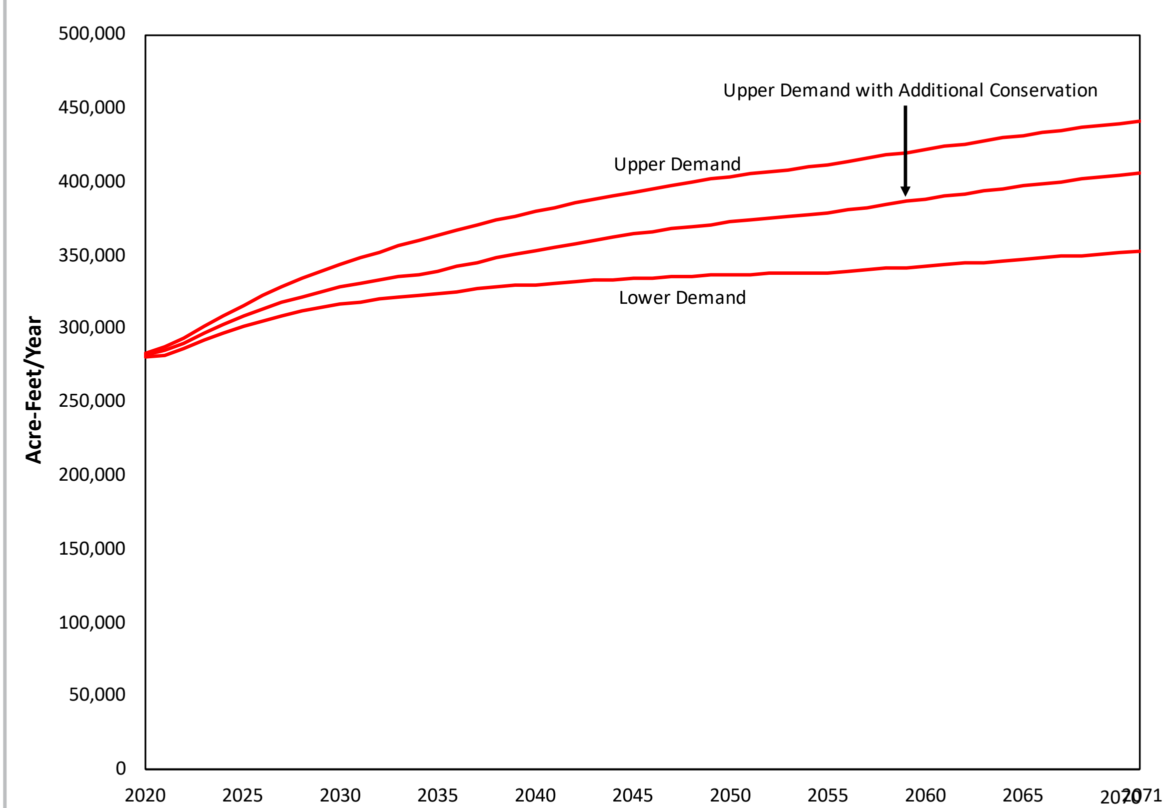


FIGURE 4.3 **SNWA Historical and Projected Water Demand**

Water Supply Conditions

The SNWA also made assumptions about future water supply conditions as part of its long-range planning efforts. As detailed in Figure 4.4 and Figure 4.5, the SNWA evaluated four water supply conditions that are based on historic Colorado River inflows since 1906 (when record-keeping began) to 2020. While several planning scenarios presented in this Plan consider historical average flows for Colorado River supplies, drier hydrology is expected based on current trends and forecast conditions (see Chapter 2). As a result, the Dry, Extremely Dry and Climate Change water supply conditions as shown on right provide a more likely range for planning purposes.

As noted earlier in this Plan, Colorado River inflows are highly variable with occasional and extended periods of extremely wet and extremely dry inflows. By incorporating historical water supply conditions into long-term planning efforts, the SNWA can make better-informed decisions about future Lake Mead water levels and associated restrictions on Colorado River supplies, as well as the timing and volume of resources needed to meet future demands.

Under the Interim Guidelines, shortage volumes are defined for Lake Mead elevations between 1,075 and 1,025 feet. Likewise, the DCP defines Lower Basin contributions when Lake Mead is at or below

WATER SUPPLY CONDITION	SUMMARY
AVERAGE	Repeats Colorado River inflows over the combined 50-year period from 1915 to 1964; assumes an average annual Colorado River inflow of 14.8 million AFY. This is representative of the river's historic long-term average inflow of 14.7 million AFY.
DRY	Repeats Colorado River inflows over the 50-year period from 1924 to 1973; assumes an average annual Colorado River inflow of 14.1 million AFY.
EXTREMELY DRY	Repeats Colorado River inflows over the 50-year period from 1929 to 1978; assumes an average annual Colorado River inflow of 13.7 million AFY.
CLIMATE CHANGE	To simulate the effects of drier and hotter conditions represented in climate change projections, the Colorado River inflows over a 25-year period from 1953 to 1977 are repeated to form an average annual inflow of 12.9 million AFY. Projections of inflows under the Colorado River Basin study for climate change ranged from roughly 10 to 17 million AFY. While this does not represent the driest scenario, it is drier than approximately 70 percent of the climate scenarios (see Appendix 4).

FIGURE 4.4 **Water Supply Conditions Summary**

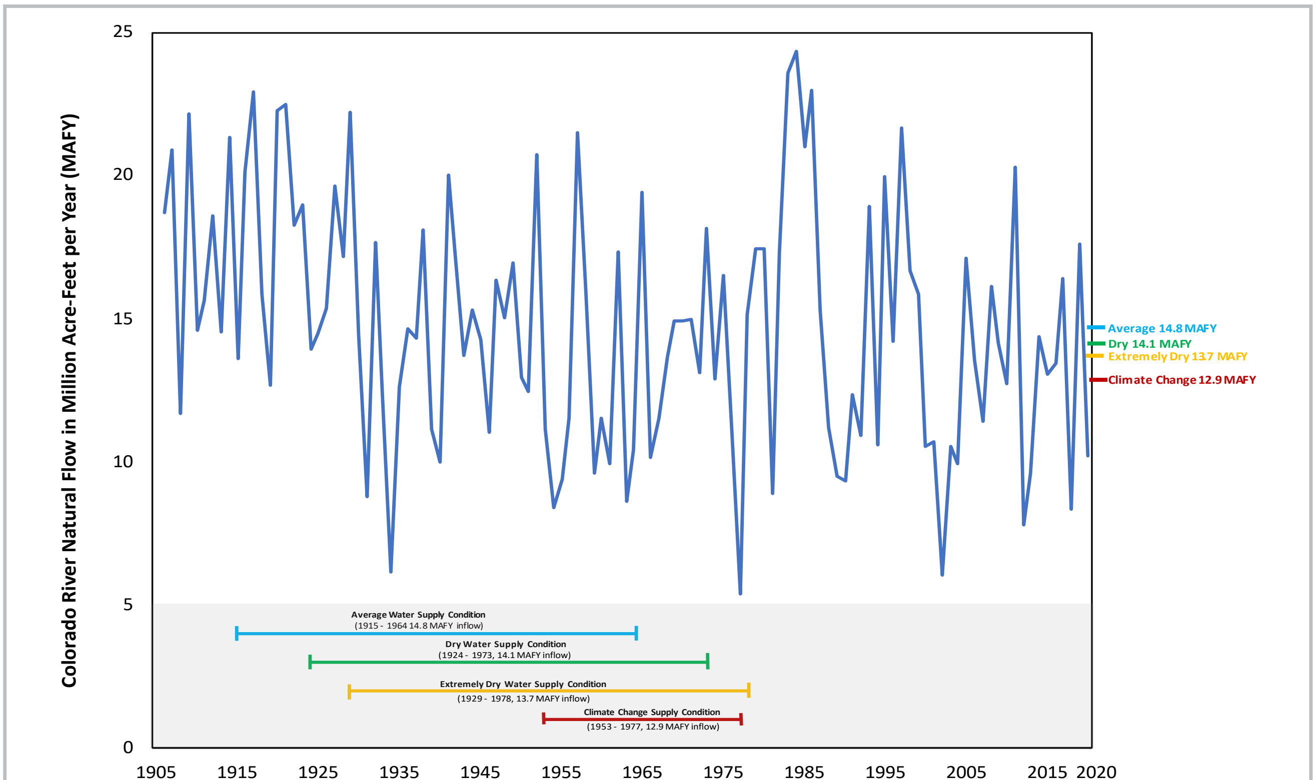


FIGURE 4.5 **Water Supply Conditions Evaluated in Planning Scenarios 1906 - 2020**

Hoover Dam

The Interim Guidelines and Lower Basin DCP work to reduce the decline of Lake Mead water levels and protect Colorado River operations. If modeling projects Lake Mead to be at or below 1,030 feet, the U.S. Secretary of the Interior will work with Lower Basin states to determine what additional actions may be needed to avoid and protect against the potential for Lake Mead to decline below 1,020 feet.

1,090 feet. Both agreements expire in 2026. While some provisions extend further, operational certainty decreases with time.

If Lake Mead is projected to be at or below 1,030 feet, the U.S. Secretary of the Interior will consult with the Colorado River Basin States to determine what additional measures are needed to avoid and protect against the potential for Lake Mead to decline to below 1,020 feet. If this were to occur, future negotiations and consultation with the U.S. Secretary of the Interior may establish additional shortage volumes and/or DCP contribution amounts. As a result, Nevada may be required to assume reductions greater than 30,000 AFY (Nevada's combined maximum shortage and contribution volume under the Interim Guidelines and DCP). This Plan assumes a maximum reduction of 40,000 AFY as described later in this chapter.

Colorado River modeling performed by the Bureau of Reclamation in 2020 projects an approximate 23 to 53 percent probability that Lake Mead will reach an elevation of 1,075 feet or lower in the years 2022 to 2025, triggering a federal shortage declaration. The probability of shortage ranges between approximately 50 to 64 percent in the years following.

SUPPLY AND DEMAND SCENARIOS

The water supply conditions and demand projections on pages 39 and 40 have been combined into a series of planning scenarios (Figure 4.6 through Figure 4.23) that depict the volume and type of resources planned for use to meet the range of possible future supply and demand conditions discussed in this chapter. Each set of planning scenarios is accompanied by a more detailed description of water supply conditions, as well as assumptions about resource availability and use.

The 2020 Plan assumes the Interim Guidelines and DCP continue through the planning horizon. Resource volumes may vary within scenario groupings based on assumptions for how SNWA DCP commitments are met. The SNWA can meet this obligation by reducing the use of Colorado River supplies, by utilizing other resources, or converting eligible forms of ICS to meet DCP contributions.

All planning scenarios consider combinations of permanent, temporary and future resources as described in Chapter 3. Having a portfolio of resource options provides the SNWA with the flexibility to adjust the use of some resources if the development of other resources is delayed or revised, or if changes in demands occur. If other options become available sooner, the priority and use of resources may change.

AVERAGE HYDROLOGY SCENARIOS
(14.8 Million AFY Natural Flow)

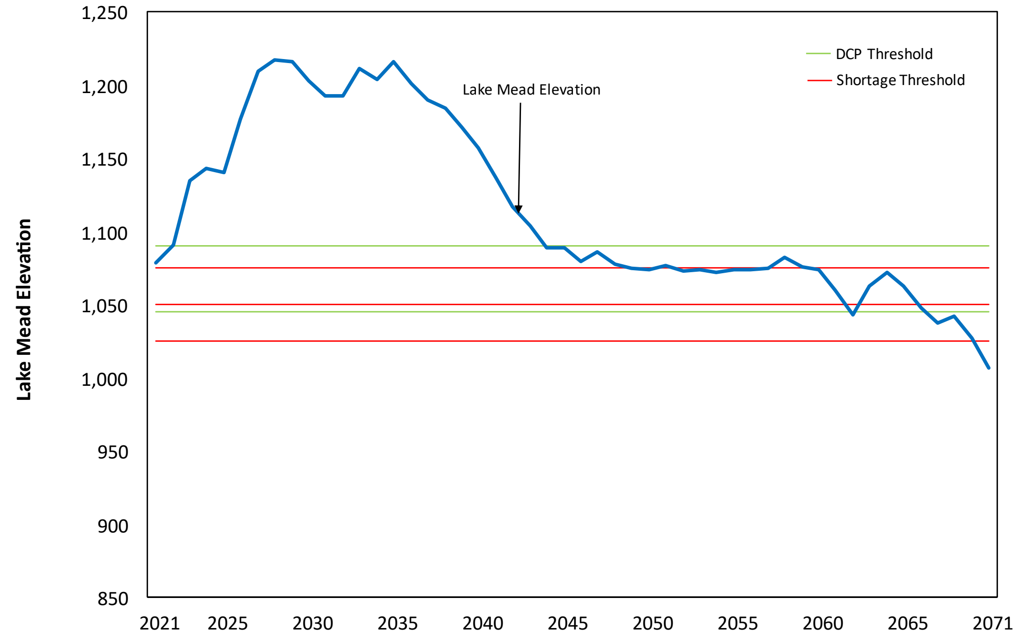


FIGURE 4.6 **Lake Mead Elevation, Average Hydrology**

Figure 4.6 depicts the projected Lake Mead elevation if Colorado River hydrology over the combined 50-year period from 1915 to 1964 repeats through 2071.

This forecast assumes Lake Mead will decline intermittently over the long-term planning horizon, triggering DCP contributions in 2021 and 2022 . This is followed by intermittent DCP contributions and shortage conditions between 2045 and 2071. Increased reductions up to 40,000 AFY are assumed in later years based on demand and when Lake Mead falls below 1,020 feet.

Figure 4.7 - Figure 4.9 reflect SNWA planning adjustments and water resources available to meet average hydrology demand projections.

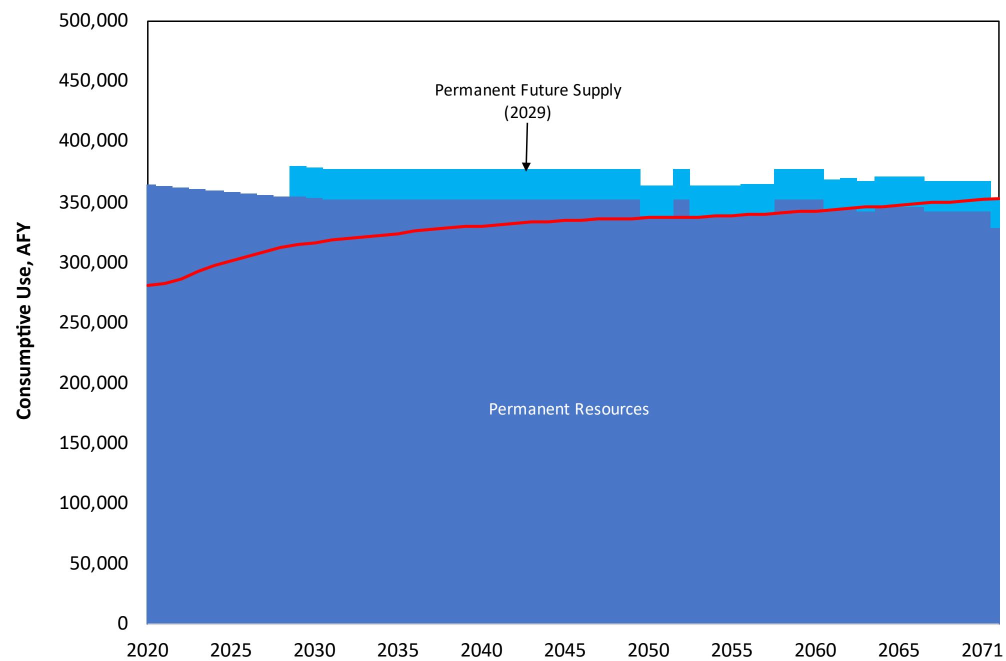


FIGURE 4.7 **Average Hydrology, Lower Demand**

As shown in Figure 4.7, permanent and future resources are sufficient to meet demands through 2071 Permanent future supplies (25,000 AFY) are available in 2029 with deliveries beginning in 2063.

Under this scenario, temporary and other future resources are not anticipated for use during the planning horizon.

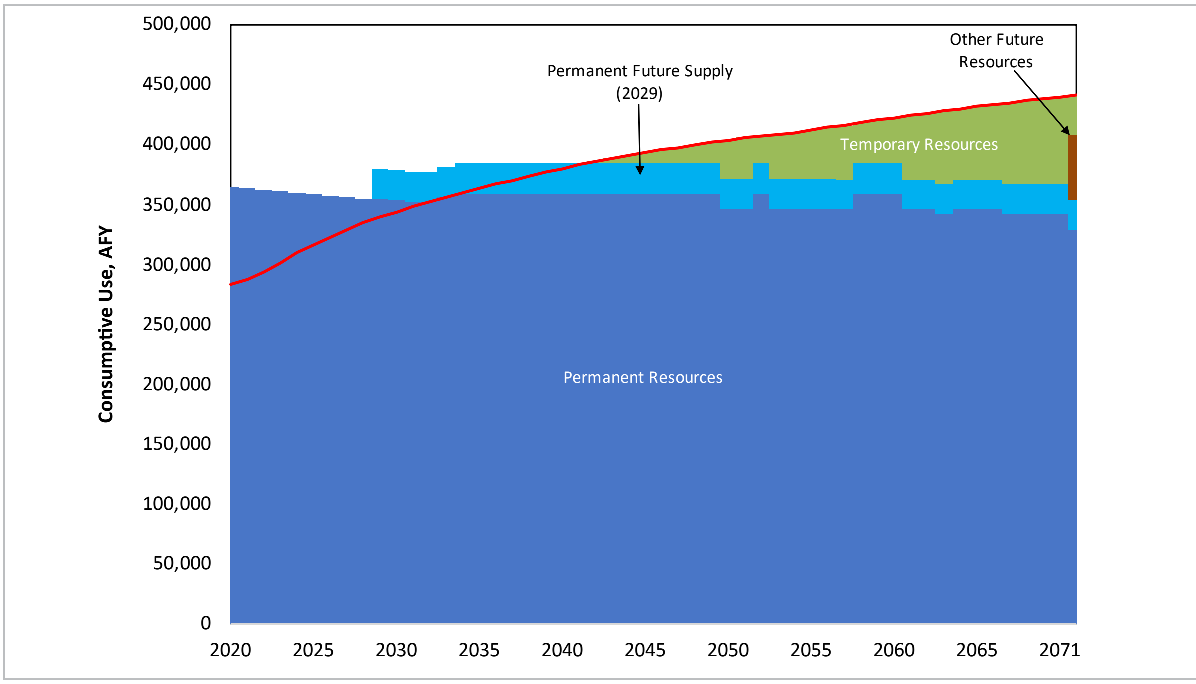


FIGURE 4.8 **Average Hydrology, Upper Demand**

As shown in Figure 4.8, permanent, temporary and future resources are needed to meet demands through the 50-year planing horizon. Under this scenario, permanent future supply (25,000 AFY) is available in 2029 with deliveries beginning in 2034. Temporary resources are needed in 2042 and other future resources are needed in 2071. The volume of other future resources needed at the end of the planning horizon is estimated at 54,000 AFY.

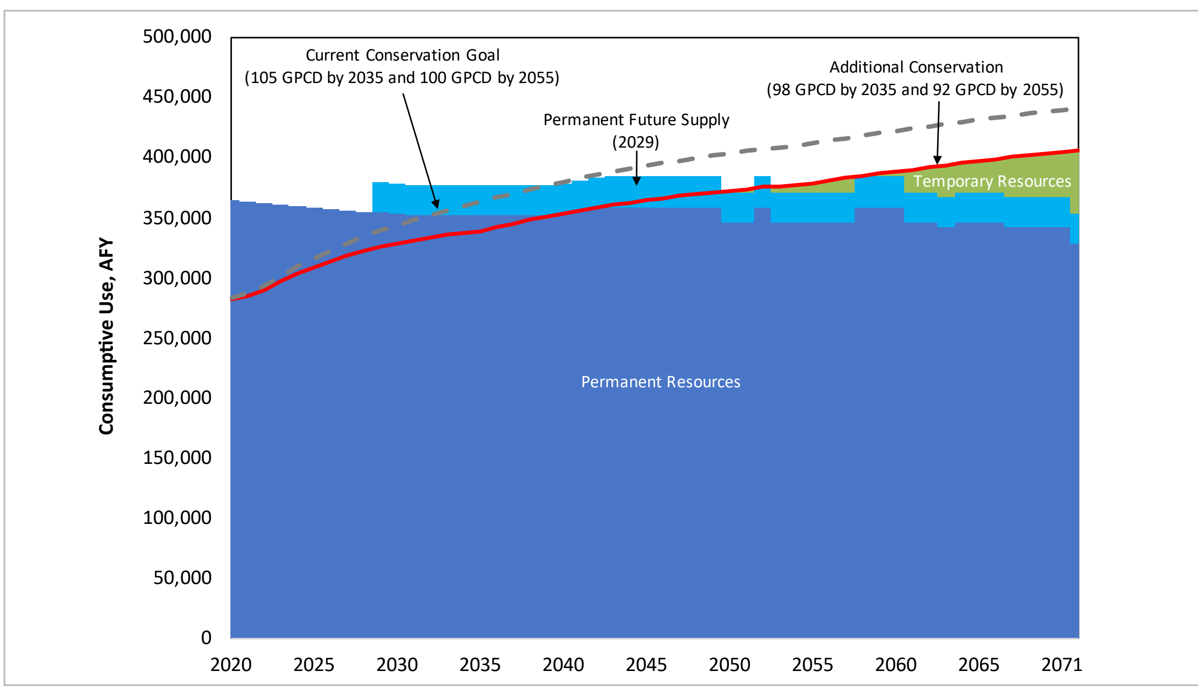


FIGURE 4.9 **Average Hydrology, Additional Conservation**

Figure 4.9 illustrates the impact of additional conservation on the timing and need of temporary and future resources. This scenario assumes future water use at 98 GPCD by 2035 and 92 GPCD by 2055. Under this scenario permanent, temporary and future resources resources are sufficient to meet water demands through 2071. Permanent future supply (25,000 AFY) is available in 2029 with deliveries beginning in 2043 and temporary resources are needed in 2050. Other future resources are not anticipated for use during the planning horizon.

DRY HYDROLOGY SCENARIOS
(14.1 Million AFY Natural Flow)

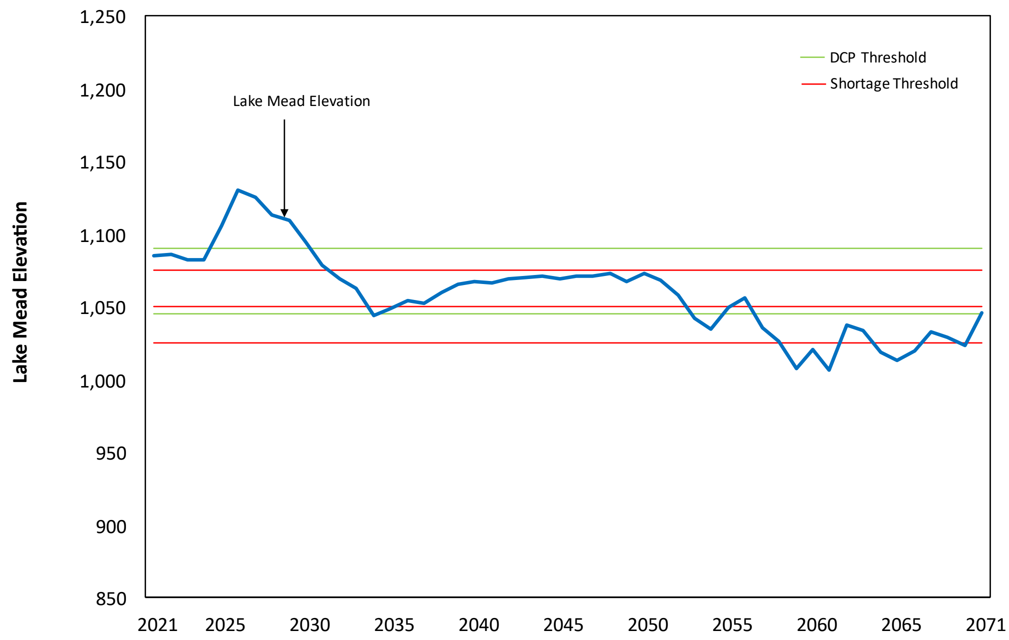


FIGURE 4.10 **Lake Mead Elevation, Dry Hydrology**

Figure 4.10 illustrates the projected elevation of Lake Mead if Colorado River hydrology experienced between 1924 and 1973 repeats through 2071.

This forecast assumes Lake Mead will decline between 2021 and 2025, triggering DCP contributions. A period of sustained decline follows after 2031, triggering defined shortage reductions and DCP contributions for the balance of the planning horizon. A maximum annual reduction of 40,000 AFY is assumed in later years based on demand and when Lake Mead water levels are below 1,020 feet.

Figures 4.11 – 4.13 reflect SNWA planning adjustments and water resources available to meet dry hydrology demand projections.

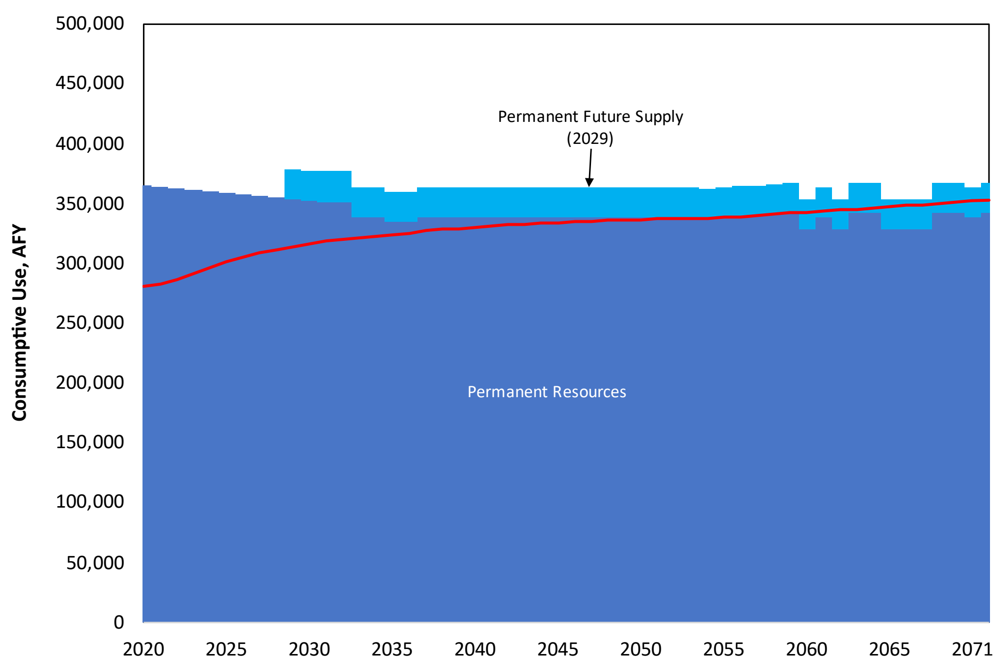


FIGURE 4.11 **Dry Hydrology, Lower Demand**

As shown in Figure 4.11, permanent and future resources are sufficient to meet demands through 2071. Permanent future supplies (25,000 AFY) are available in 2029 with deliveries beginning in 2060.

Under this scenario, temporary and other future resources are not anticipated for use during the planning horizon.

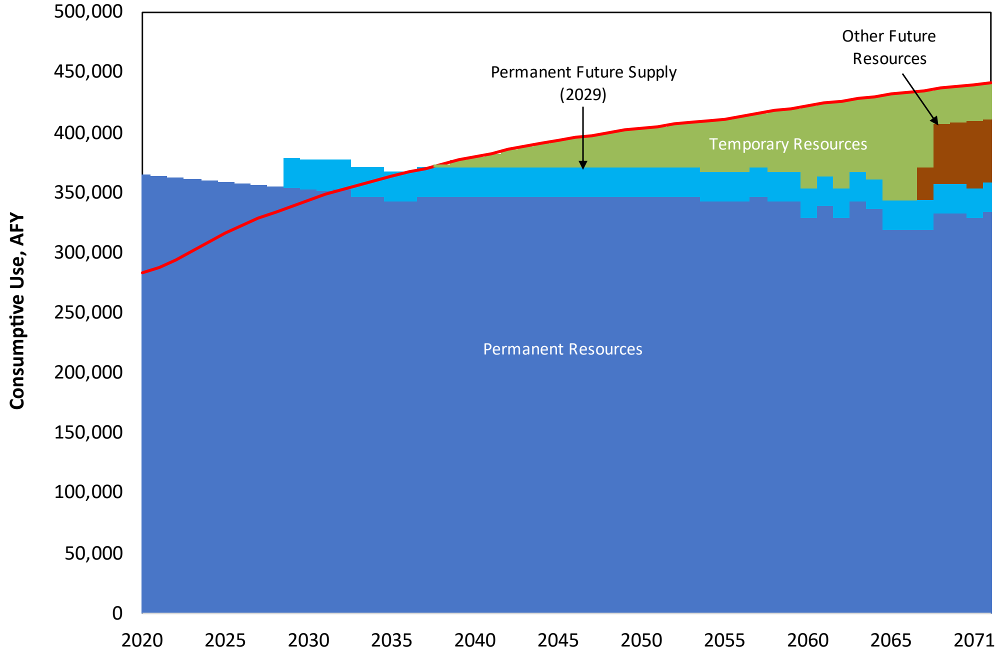


FIGURE 4.12 **Dry Hydrology, Upper Demand**

As shown in Figure 4.12, permanent, temporary and future resources are needed to meet demands through the 50-year planing horizon. Under this scenario, permanent future supply (25,000 AFY) is available in 2029 with deliveries beginning in 2033. Temporary resources are needed in 2038 and other future resources are needed in 2067. The volume of other future resources needed at the end of the planning horizon is estimated at 52,000 AFY.

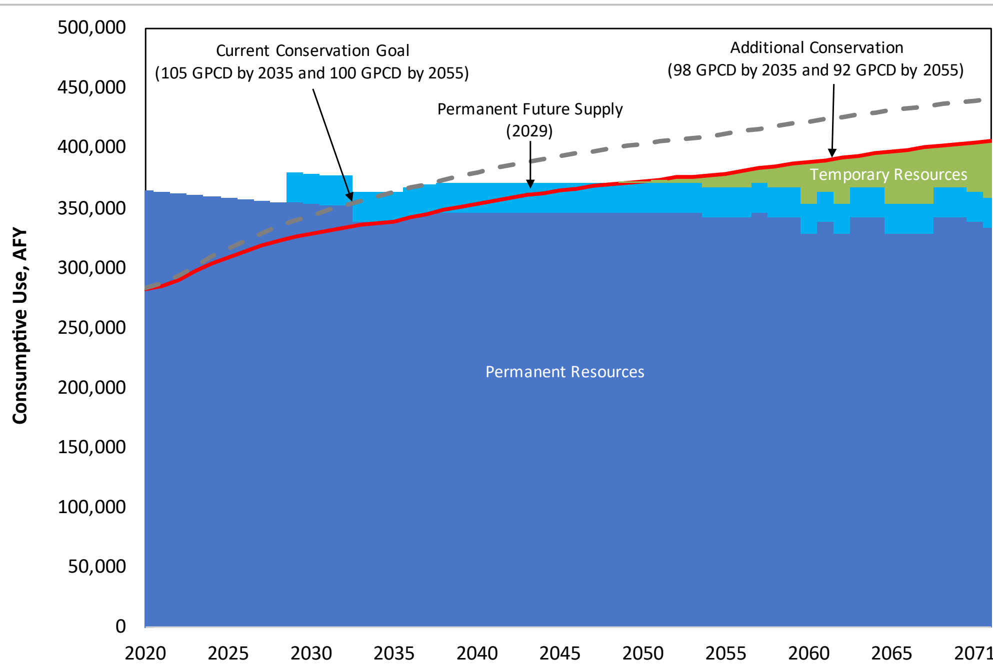


FIGURE 4.13 **Dry Hydrology, Addtional Conservation**

Figure 4.13 illustrates the impact of additional conservation on the timing and need for temporary and future resources. This scenario assumes future water use at 98 GPCD by 2035 and 92 GPCD by 2055. Under this scenario permanent, temporary and future resources resources are sufficient to meet water demands through 2071. Permanent future supply (25,000 AFY) is available in 2029 with deliveries beginning in 2038 and temporary resources are needed in 2049. Other future resources are not anticipated for use during the planning horizon.

EXTREMELY DRY HYDROLOGY SCENARIOS
(13.7 Million AFY Natural Flow)

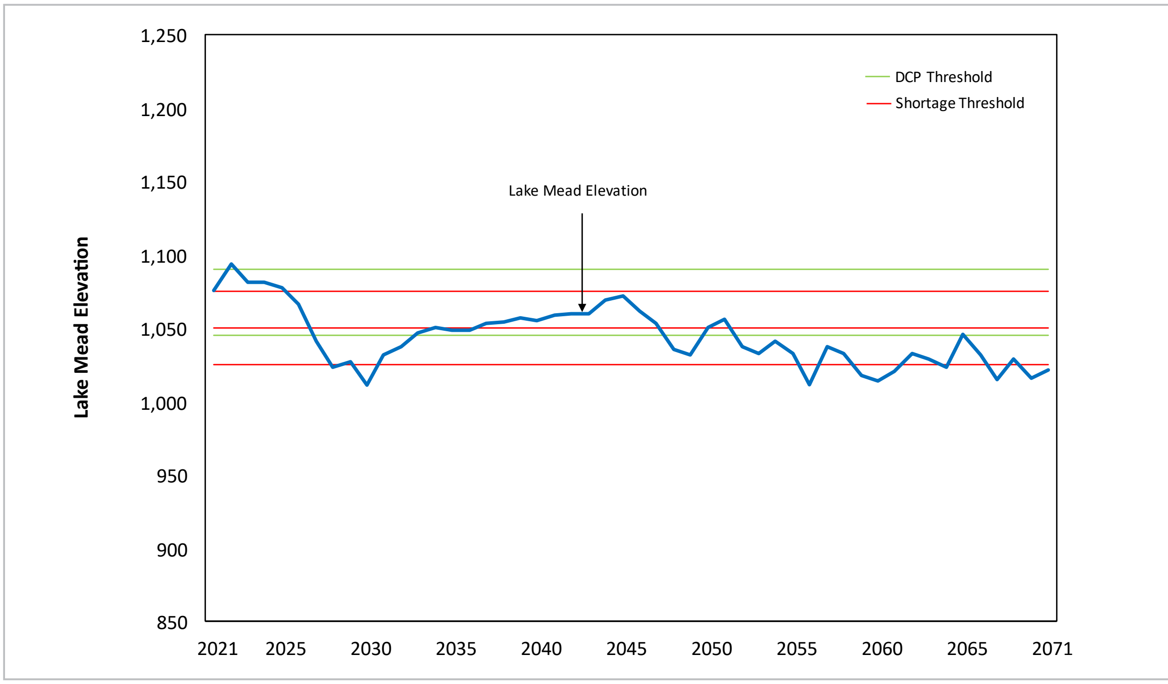


FIGURE 4.14 **Lake Mead Elevation, Extremely Dry Hydrology**

Figure 4.14 illustrates the projected elevation of Lake Mead if Colorado River hydrology experienced between 1929 and 1978 repeats through 2071.

This forecast assumes Lake Mead will decline between 2021 and 2026, triggering DCP contributions. A period of sustained decline follows in years thereafter, triggering defined shortage reductions and DCP contributions.

Increased reductions up to 40,000 AFY are assumed in later years based on demands and when Lake Mead is below 1,020 feet.

Figures 4.15 – 4.17 reflect SNWA planning adjustments and water resources available to meet the three water demand projections with extremely dry hydrology.

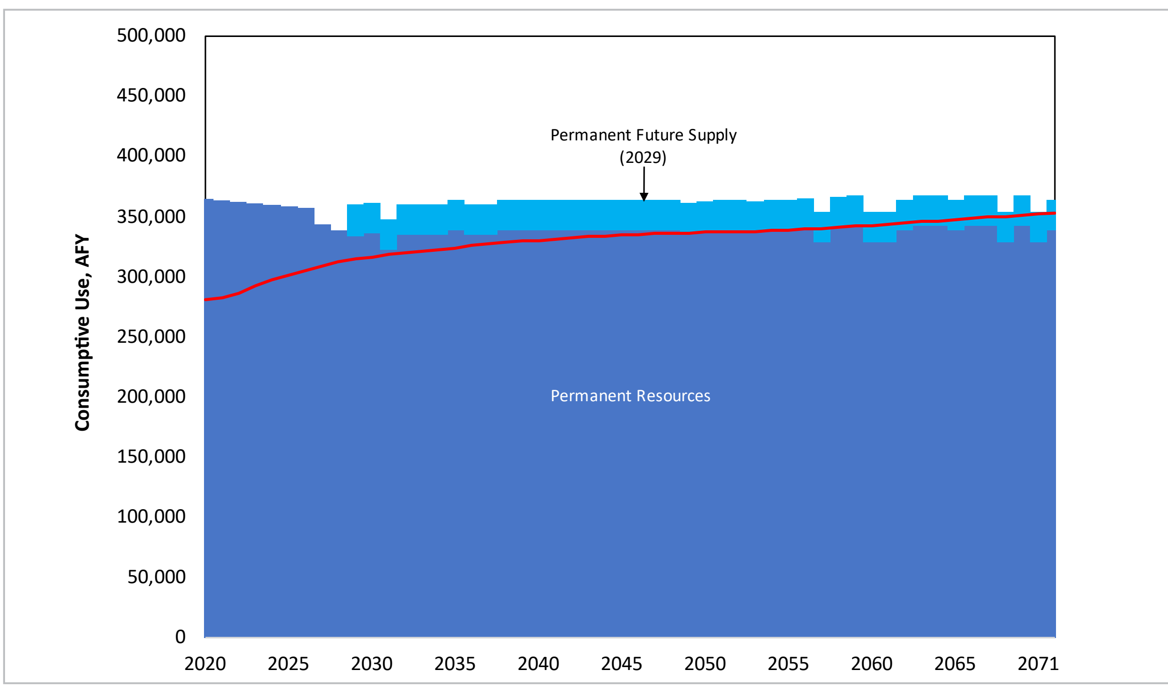


FIGURE 4.15 **Extremely Dry Hydrology, Lower Demand**

As shown in Figure 4.15, permanent and future resources are sufficient to meet demands through 2071. Permanent future supplies (25,000 AFY) are available in 2029 with deliveries beginning in 2057.

Under this scenario, temporary and other future resources are not anticipated for use during the planning horizon.

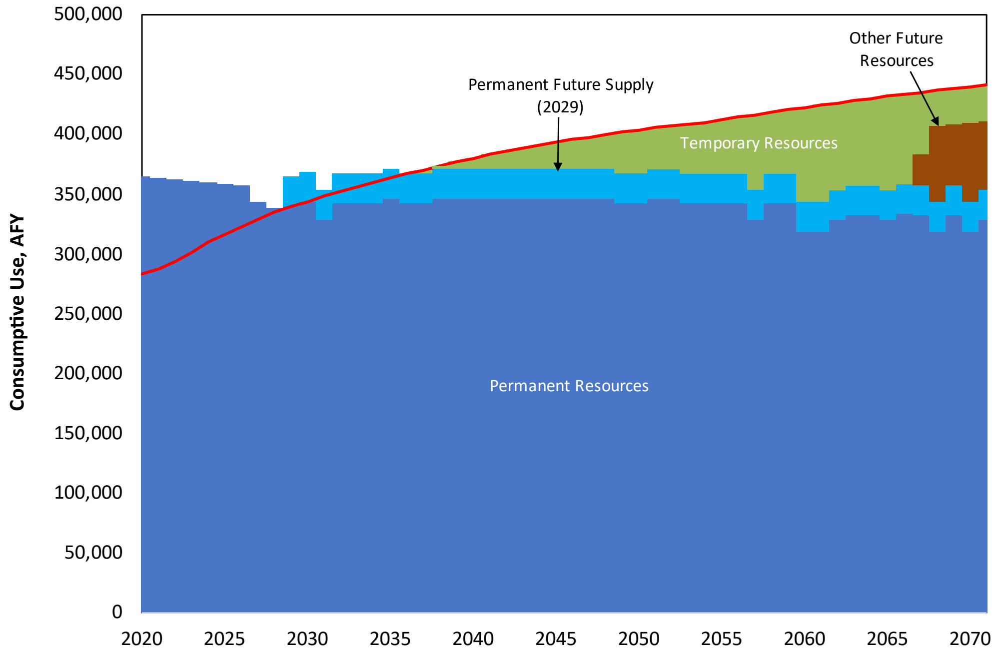


FIGURE 4.16 **Extremely Dry Hydrology, Upper Demand**

As shown in Figure 4.16, permanent, temporary and future resources are needed to meet demands through the 50-year planing horizon. Under this scenario, permanent future supply (25,000 AFY) is available in 2029 with deliveries beginning in 2030.

Temporary resources are needed in 2037 and other future resources are needed in 2067. The volume of other future resources needed at the end of the planning horizon is estimated at 57,000 AFY.

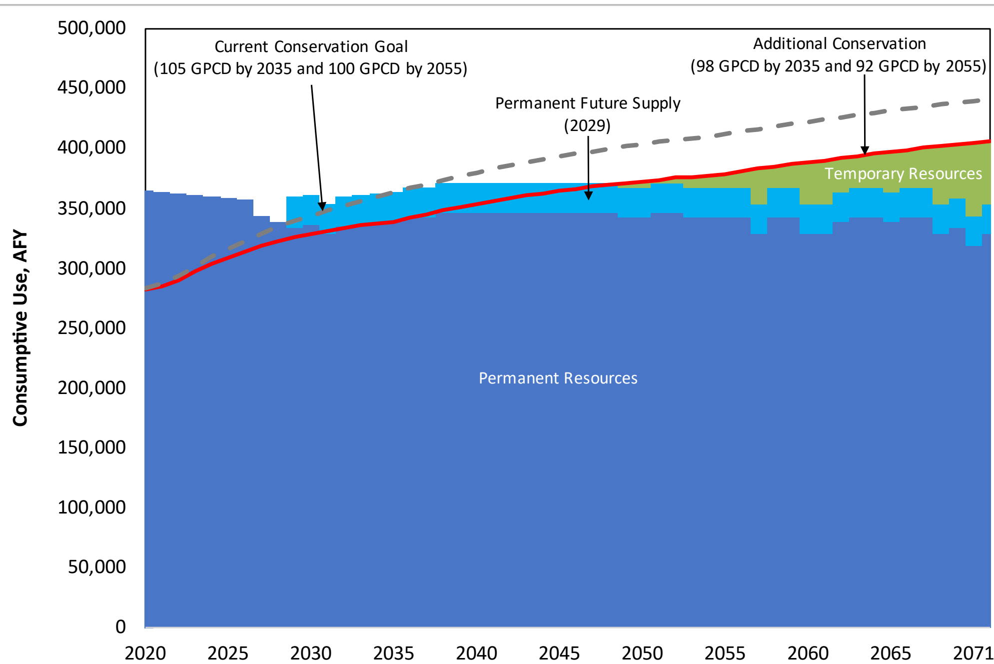


FIGURE 4.17 **Extremely Dry Hydrology, Additional Conservation**

Figure 4.17 illustrates the impact of additional conservation on the timing and need for temporary and future resources. This scenario assumes future water use at 98 GPCD by 2035 and 92 GPCD by 2055. Under this scenario permanent, temporary and future resources are sufficient to meet water demands through 2071. Permanent future supply (25,000 AFY) is available in 2029 with deliveries beginning in 2031 and temporary resources are needed in 2049. Other future resources are not anticipated for use during the planning horizon.

CLIMATE CHANGE SCENARIOS
(12.9 Million AFY Natural Flow)

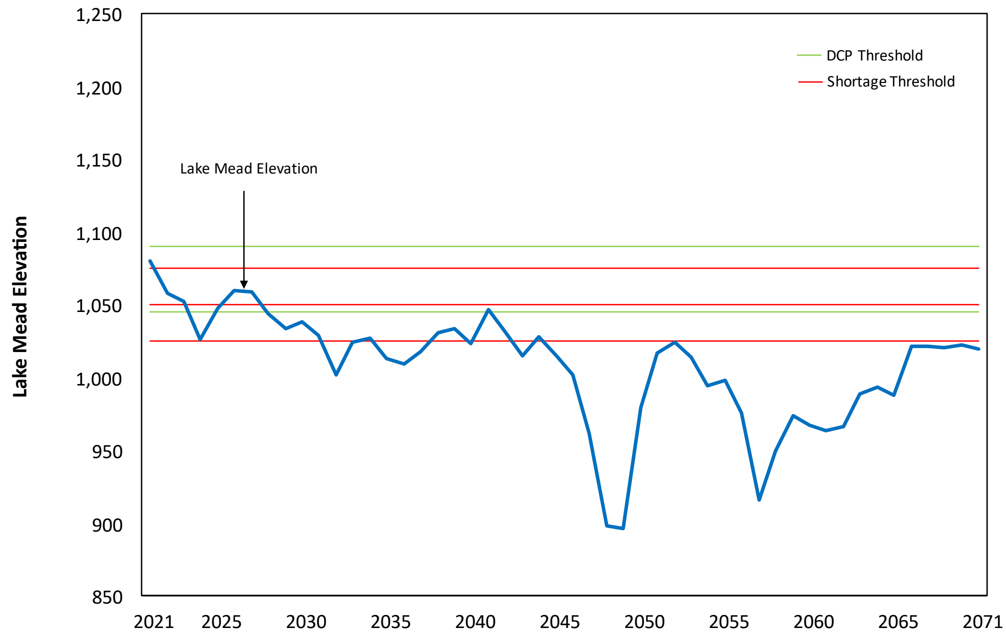


FIGURE 4.18 **Lake Mead Elevation, Climate Change Hydrology**

Figure 4.18 illustrates the projected elevation of Lake Mead if Colorado River hydrology experienced between 1953 and 1977 repeats through 2071. Under this scenario, Lake Mead falls below 1,090 feet and declines between 895 and 1,000 feet in 2048.

Shortage reductions and DCP contributions are assumed throughout the planning horizon. Increased reductions up to 40,000 AFY are assumed based on demands and when Lake Mead water levels are below 1,020 feet.

Figures 4.19 – 4.23 reflect SNWA planning adjustments and water resources available to meet the climate change hydrology water demand projections.

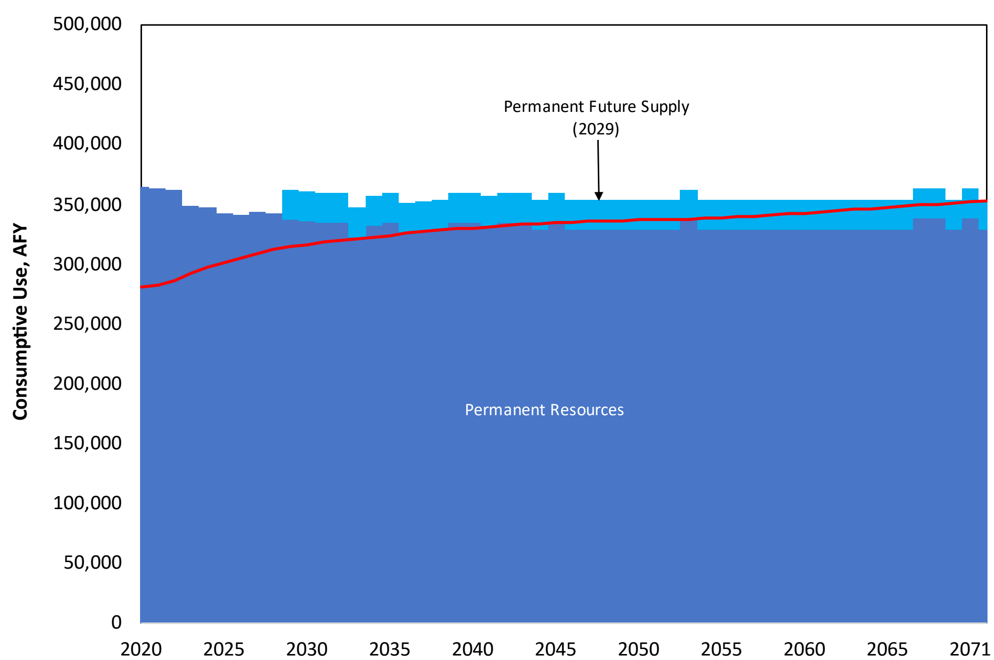


FIGURE 4.19 **Climate Change Hydrology, Lower Demand**

As shown in Figure 4.19, permanent and future resources are sufficient to meet demands through 2071. Permanent future supplies (25,000 AFY) are available in 2029 with deliveries beginning in 2044. Under this scenario, temporary and other future resources are not anticipated for use during the planning horizon.

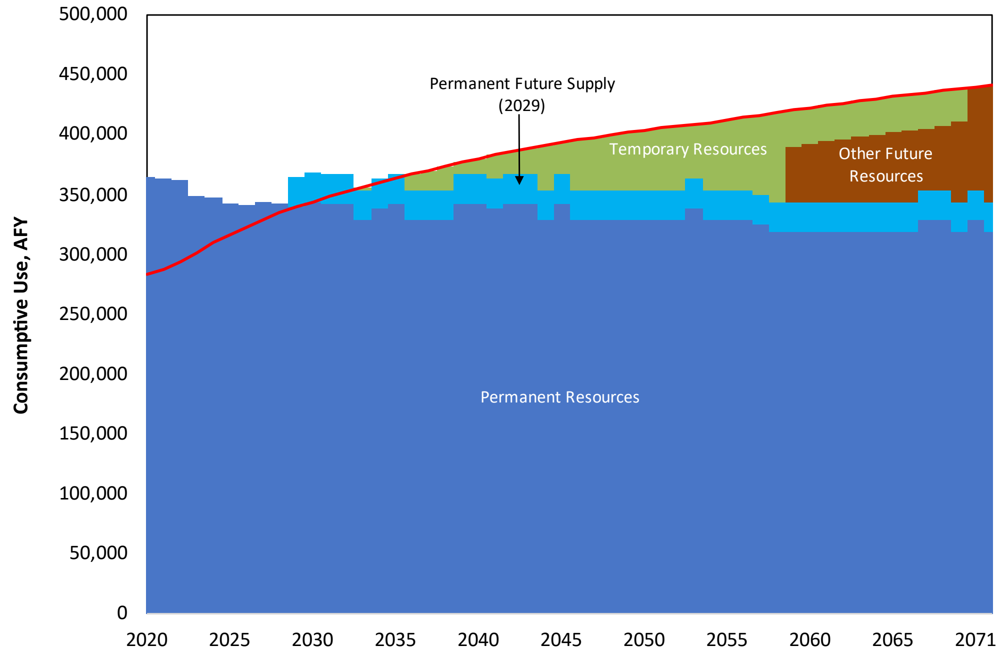


FIGURE 4.20 **Climate Change Hydrology, Upper Demand (2029)**

As shown in Figure 4.20, permanent, temporary and future resources are needed to meet demands through the 50-year planing horizon. Under this scenario, permanent future supply (25,000 AFY) is available in 2029 with deliveries beginning in 2030.

Temporary resources are needed in 2033 and other future resources are needed in 2059. The volume of other future resources needed at the end of the planning horizon is estimated at 97,000 AFY.

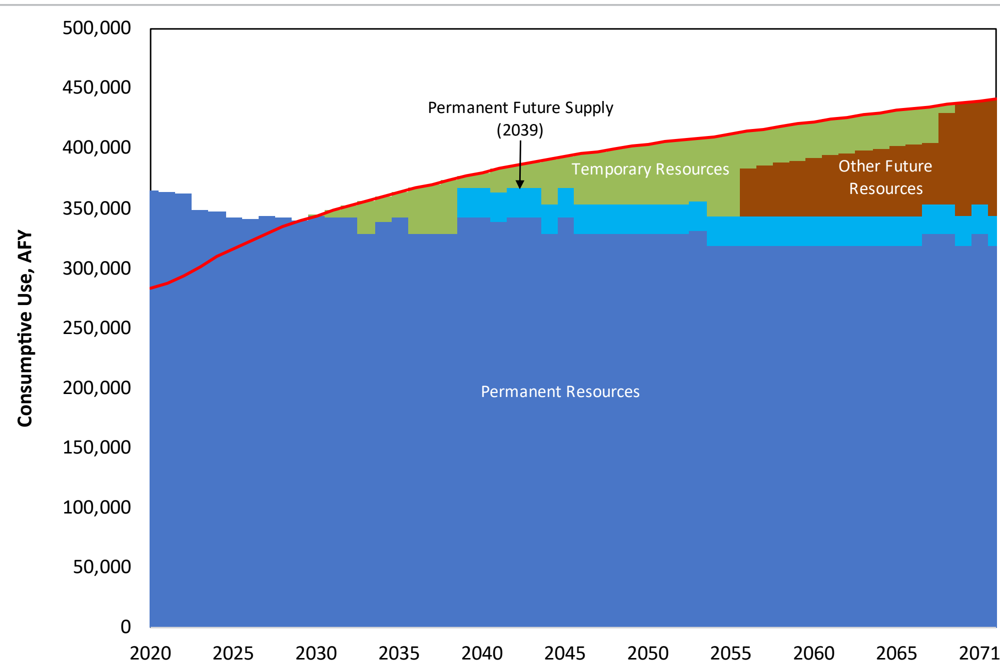


FIGURE 4.21 **Climate Change Hydrology, Upper Demand (2039)**

As shown in Figure 4.21, permanent, temporary and future resources are needed to meet demands through 2071. Under this scenario, permanent future supply (25,000 AFY) is available and needed in 2039.

Temporary resources are needed in 2030 and other future resources are needed in 2056. The volume of other future resources needed at the end of the planning horizon is estimated at 97,000 AFY.

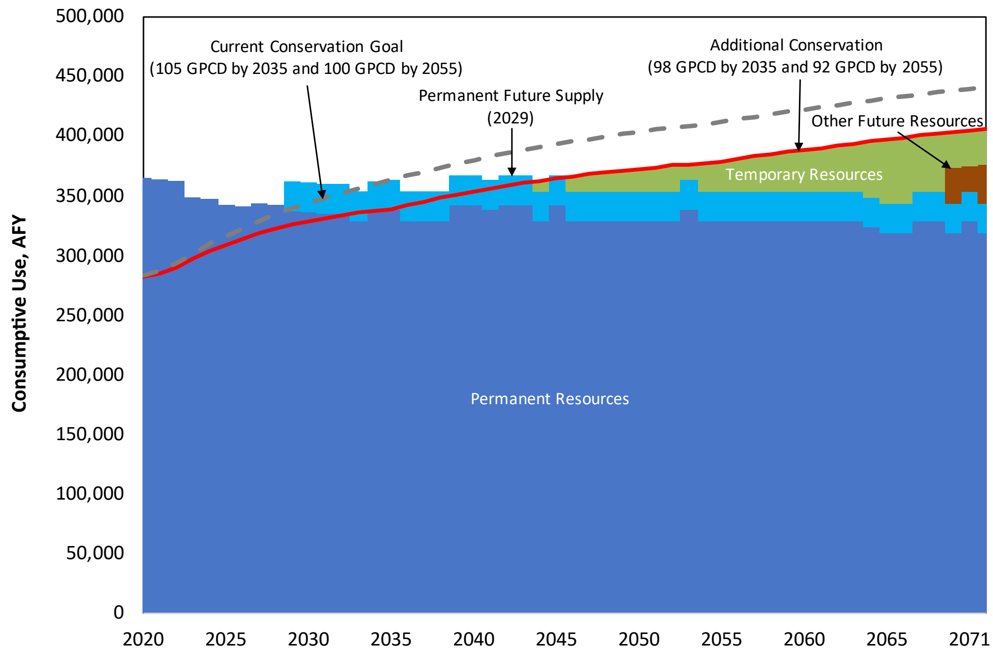


FIGURE 4.22 **Climate Change Hydrology, Additional Conservation (2029)**

Figure 4.22 illustrates the impact of additional conservation on the timing and need for temporary and future resources. This scenario assumes future water use at 98 GPCD by 2035 and 92 GPCD by 2055. Under this scenario permanent, temporary and future resources resources are sufficient to meet water demands through 2071. Permanent future supply (25,000 AFY) is available in 2029 with deliveries beginning in 2033. Temporary resources are needed in 2044 and other future resources are needed in 2069. The volume of other future resources needed at the end of the planning horizon is estimated at 32,000 AFY.

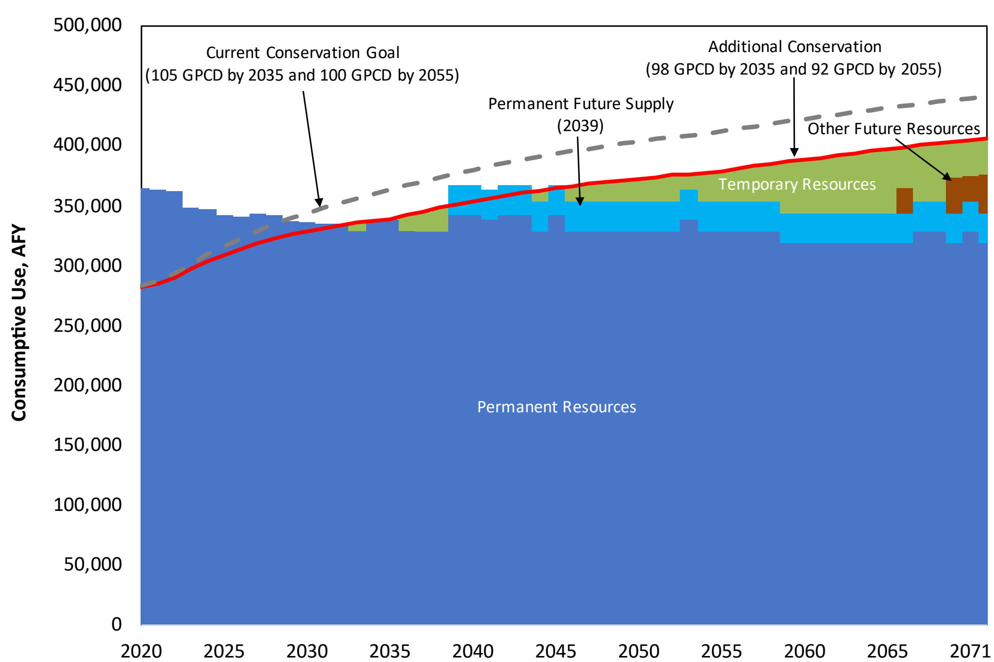


FIGURE 4.23 **Climate Change Hydrology, Additional Conservation (2039)**

As shown in Figure 4.23, permanent, temporary and future resources are needed to meet demands through 2071. Under this scenario, permanent future supply (25,000 AFY) is available and needed in 2039. Temporary resources are needed in 2033 and other future resources are needed in 2066. The volume of other future resources needed at the end of the planning horizon is estimated at 32,000 AFY.

CHAPTER SUMMARY

Water supply and demand conditions are influenced by a number of factors, including economic conditions, water use patterns, conservation progress and climate variability. To account for these variables, the SNWA's 2020 Plan considers several water supply and demand scenarios that bracket the range of plausible conditions to be experienced over the 50-year planning horizon.

The scenarios assume that Southern Nevada will continue to make progress towards its current water conservation goal, as well as achieve increased levels of efficiency over the long-term planning horizon. Likewise, the scenarios assume that unused Nevada Colorado River water will continue to be stored for future use and that this and other temporary resources will be used to meet demands until future resources are needed and developed. Meanwhile, the SNWA will continue to work with its Colorado River partners to explore emerging resource development opportunities, including participation in desalination projects in the U.S. and Mexico, and/or conservation and reuse projects in the state of California.

Colorado River modeling performed by the U.S. Bureau of Reclamation in 2020 projects an approximate 23 to 64 percent probability that Lake Mead will reach an elevation of 1,075 or lower over the 50-year planning horizon. This would trigger a federal shortage declaration. Under the Interim Guidelines and DCP, the maximum supply reduction prescribed to Nevada is 30,000 AFY; however, this amount could potentially increase. If modeling projects Lake Mead to be at or below 1,030 feet, the Secretary of the Interior will work with Lower Basin states to determine what additional actions may be needed to avoid and protect against the potential for Lake Mead to decline below 1,020 feet.

The SNWA is not currently using its full Colorado River allocation and near-term shortage declarations are not anticipated to impact current customer use. Additionally, and as illustrated in the planning scenarios, the SNWA is prepared to meet long-term demands and future Colorado River supply limitations by adaptively managing its resource portfolio and by bringing future resources online when needed.

Subject to necessary authorizations, the amount of resources available for use as described in the SNWA Water Resource Portfolio is more than sufficient to meet the range of projected demands through the planning horizon. Maintaining this portfolio provides flexibility and enables the SNWA to use an appropriate mix of resources as needed to meet demands. Through this and other adaptive management strategies, the SNWA is better prepared to address factors that can influence resource availability over time such as permitting, policy changes, climate variability and/or new regulations.

As part of its long-term water planning efforts, the SNWA will:

- Continue to assess factors influencing water demands and the outlook for future demands;
- Continue to assess its overall water resource options and make informed decisions on which resources to use when needed;
- Consider the factors of availability, accessibility, cost and need a when determining priority of resources for use;
- Maintain a diverse water resource portfolio to ensure future resources are available to meet projected long-term demands and to replace temporary supplies such as banked resources; and
- Work proactively with other Colorado River water users to explore emerging future resource options of mutual benefit, and support ongoing efforts to increase the elevation of Lake Mead to preserve system operations.

ENDNOTES

1 The U.S. Bureau of Reclamation developed the Colorado River Simulation System (CRSS), a long-term planning and operations model. The probabilities of shortage correspond with August 2019 CRSS results, applying historical Colorado River flows, provided by U.S. Bureau of Reclamation to Southern Nevada Water Authority, August, 2019.

PROTECTING THE ENVIRONMENT

THE SNWA'S ENVIRONMENTAL STEWARDSHIP EFFORTS HELP CONSERVE AND PRESERVE NATURAL RESOURCES FOR FUTURE GENERATIONS WHILE MINIMIZING CONFLICTS WITH WATER RESOURCE MANAGEMENT.

The SNWA works cooperatively with federal, state and local agencies as part of its long-term water resource management and planning efforts. This work helps to ensure avoidance, mitigation or minimization of impacts during development and delivery of water resources, including the construction, operation and maintenance of regional water facilities. In addition to the organization's proactive efforts, the SNWA adheres to strict environmental laws and regulations that govern its use and development of resources and facilities. These include the Endangered Species Act (ESA), National Environmental Policy Act (NEPA) and Clean Water Act.

By complying with environmental laws and regulations, working cooperatively with others, and by implementing the latest best management practices, the SNWA minimizes its footprint and protects valuable environmental resources for generations to come.

The SNWA participates in several environmental programs that contribute to species recovery and habitat conservation and protection in areas where its facilities or resources are located. The following summarizes specific activities that are currently planned or underway:

COLORADO RIVER

Human alterations on the Colorado River, including changes to riparian, wetland and aquatic habitats, have affected the river's ecosystem, both in the United States and in Mexico. Today, there are several native fish, birds and other wildlife species listed as threatened or endangered under the ESA.

Lower Colorado River Multi-Species Conservation Program

Environmental issues are being addressed cooperatively by Colorado River water users, primarily through the Lower Colorado River Multi-Species Conservation Program (LCRMSCP).

Finalized in 2005, the LCRMSCP provides ESA coverage for federal and non-federal operations in the Lower Colorado River under a Biological Opinion and a Habitat Conservation Plan.[1]

The SNWA is a non-federal partner in the LCRMSCP, which is being implemented by the Bureau of Reclamation over a 50-year period. The program area extends more than 400 miles along the lower Colorado River, from Lake Mead to the southernmost point of the U.S./Mexico border. Lakes Mead, Mohave and Havasu, as well as the historical 100-year floodplain along the main stem of the lower Colorado River, are all included. The program area also supports implementation of conservation activities in the lower Muddy, Virgin, Bill Williams and Gila rivers. The plan will benefit at least 26 species, most of which are state or federally listed endangered, threatened or sensitive species.

Some of the LCRMSCP projects being conducted in Nevada include razorback sucker studies in Lake Mead, southwestern willow flycatcher surveys and habitat protection at the Big Bend Conservation Area.

In 2005, the SNWA purchased the 15-acre Big Bend Conservation Area site along the Colorado River to protect backwater habitat for native fish. In 2008, the LCRMSCP and the U.S. Fish and Wildlife Service (USFWS) funded wildlife habitat improvements on the property. The SNWA continues to maintain the property and habitat.

By taking a proactive role in the health of the river and its native species, the SNWA and other Colorado River users are working to help ensure the long-term sustainability of this critical resource.

Colorado River Basin Water Supply and Demand Study

An Environmental and Recreational Flows Workgroup was one of three workgroups established following completion of the Colorado River Basin Water Supply

and Demand Study.[2] The SNWA is a member of this workgroup, which identified opportunities that would provide multiple benefits to improve flow and water-dependent ecological systems, power generation and recreation.

Binational Collaboration

Through interpretive minutes to the 1944 Treaty for the Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande, the United States and Mexico have established a framework for cooperation on environmental issues in Mexico. This includes studies related to the riparian and estuarine ecology of the Colorado River limitrophe and Delta.

The SNWA is a member of the Environmental Work Group that was established in 2010. The work group provides a forum where the two countries can explore and evaluate potential areas of cooperation. The SNWA continues to collaborate with the work group to consider opportunities for environmental improvements such as those identified in minutes 319 and 323 regarding environmental flow deliveries in the limitrophe and Delta.

Adaptive Management Work Group

The SNWA participates in the Adaptive Management Work Group (AMWG) for the operations of Glen Canyon Dam. This multi-agency work group helps balance the needs and interests of the endangered humpback chub, recreational interests, Native American perspectives, hydropower generation, water deliveries and downstream water quality. Active participation in the AMWG and its subcommittees helps ensure the SNWA's interests in protecting water deliveries, downstream water quality and the endangered humpback chub are adequately addressed.

MUDDY RIVER

The Muddy River and its tributaries and springs provide habitat for a unique array of rare species, including the federally endangered Moapa dace (*Moapa coriacea*), southwestern willow flycatcher (*Empidonax trailii extimus*), and Yuma Ridgway's rail (*Rallus obsoletus yumanensis*) (formerly Yuma clapper rail), and the federally threatened western yellow-billed cuckoo (*Coccyzus americanus occidentalis*). It is also habitat for the Virgin River chub (*Gila seminuda*), which although not listed on the Muddy River is listed as endangered on the Virgin River.

The SNWA has conducted and supported environmental studies on the Muddy River since 2004, including population and habitat surveys for these and other native, sensitive species. The SNWA is also working with federal and state agencies, environmental organizations and local stakeholders to implement conservation and recovery actions.

Warm Springs Natural Area

Located approximately 7 miles northwest of the town of Moapa, the Warm Springs Natural Area contains more than two dozen warm water springs that form the headwaters of the Muddy River. The springs and river provide habitat for the federally endangered Moapa dace, a small fish that is endemic to the area. The river and surrounding riparian areas also provide habitat for 27 other listed and sensitive species, including fish, birds, bats, invertebrates and amphibians.

In 2007, the SNWA purchased the former 1,220-acre "Warm Springs Ranch," using funding secured under the Southern Nevada Public Lands Management Act. Working with federal, state and local stakeholders, the SNWA completed a Stewardship Plan for the Warm Springs Natural Area in 2011.[3] The Stewardship Plan provides a framework for use and management of the property that preserves the integrity of natural resources and allows for management of water resources.

Since acquisition of the property, the SNWA has focused on restoration of aquatic fish habitat, control and eradication of invasive species, fire prevention and general property maintenance. A public use trail system with interpretive signage also was developed to allow for low-impact public use of the property. These conservation actions help to provide mitigation benefits for water development. For more information, including hours of operation for public exploration, visit warmspringsnv.org.

VIRGIN RIVER

The Virgin River is one of the largest riparian corridors in the desert southwest; within Nevada, the lower Virgin River is home to the federally endangered woundfin, Virgin River chub, southwestern willow flycatcher, and Ridgway's rail and the federally threatened western yellow-billed cuckoo.

CLARK COUNTY

The SNWA participates in a number of environmental initiatives in Clark County to help protect and restore the environment, including the Clark County Multiple Species Habitat Conservation Plan and Las Vegas Wash Comprehensive Adaptive Management Plan. These efforts directly affect the SNWA's ability to operate facilities in Clark County and deliver high quality water to the community.

Clark County Multiple Species Habitat Conservation Plan

The Clark County Multiple Species Habitat Conservation Plan (MSHCP)[4] was approved in 2001, and provides ESA coverage for 78 species, including the threatened desert tortoise (*Gopherus agassizii*). The key purpose of the MSHCP is to achieve a balance between the conservation and recovery of listed and sensitive species in Clark County and the orderly beneficial use of land to meet the needs of the growing population in Clark County. The SNWA actively participates in the MSHCP, which provides ESA coverage for its projects and facilities located on non-federal lands within the county.

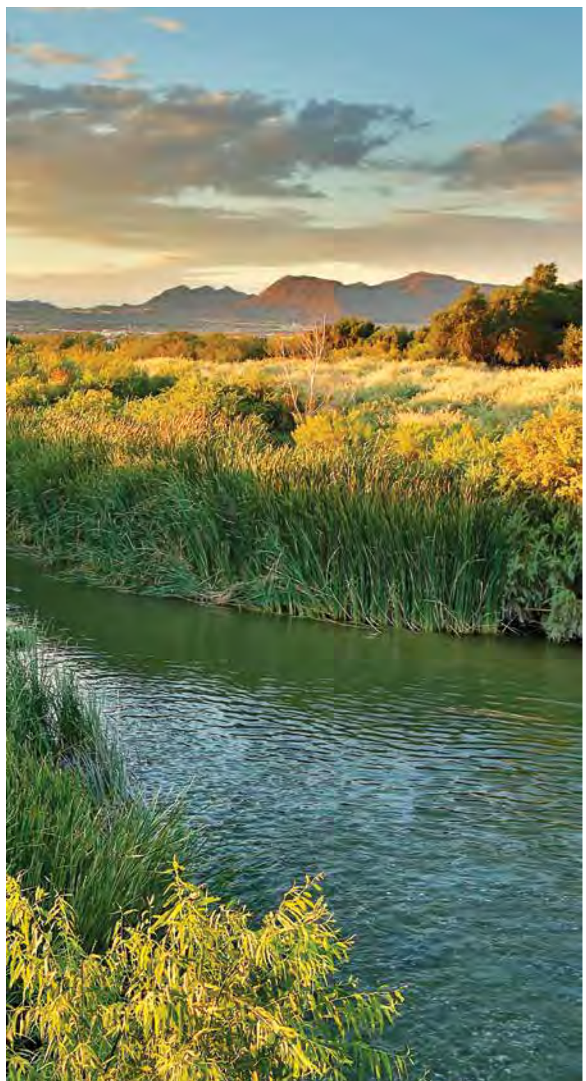
Las Vegas Wash

The Las Vegas Wash is the primary channel through which the SNWA member agencies return water to Lake Mead for return-flow credits. These flows account for less than two percent of the water in Lake Mead and consist of urban runoff, shallow groundwater, storm-water and highly treated wastewater from the valley's four water reclamation facilities. Decades ago, the flows of the Wash created more than 2,000 acres of wetlands, but by the 1990s, only about 200 acres of wetlands remained. The dramatic loss of vegetation reduced both the Wash's ability to support wildlife and serve as a natural water filter.

In 1998 at the request of its citizen's advisory committee, the SNWA reached out to the community in an effort to develop solutions to the problems affecting the Wash. This led to the formation of the Las Vegas Wash Coordination Committee (LVWCC), a panel representing more than two dozen local, state and federal agencies, businesses, an environmental group, the University of Nevada Las Vegas and private citizens. The committee quickly developed a Comprehensive Adaptive Management Plan for the Wash.[5]

Over nearly 20 years of working together, the LVWCC and its member agencies have taken significant strides toward improving the Las Vegas Wash. Early efforts focused on reducing the channelization of the Wash, reducing erosion and increasing the number of wetlands. Accomplishments to date include:

- Completed construction of 21 identified erosion control structures or weirs.
- Stabilized more than 13 miles of the Wash's banks
- Removed more than 565 acres of non-native tamarisk


Mature Vegetation Along the Wash

Dace on the Rise

The Moapa dace is endemic to the Muddy River.

The Moapa dace only occurs in the warm springs, tributaries and upper main stem of the Muddy River, and was listed as an endangered species in 1967. The USFWS recovery plan for the Moapa dace set a goal to delist the fish when the adult population reaches 6,000 in five spring systems for five consecutive years.[6]

The SNWA has worked with its partners to implement a number of activities to benefit the Moapa dace. Efforts include improving connectivity between springs and streams, eradicating invasive fish species, and restoring natural streamflow dynamics and riparian vegetation.

These actions have helped the overall Moapa dace population to increase substantially. The population increased from a low of 459 individuals in 2008 to more than 2,340 in 2020.

- Revegetated more than 515 acres with native plants
- Removed more than 550,000 pounds of trash from adjacent areas
- Organized more than 16,000 volunteers
- Completed extensive wildlife and water quality monitoring programs
- Identified more than 933 species of wildlife
- Identified more than 270 species of vegetation
- Built or improved more than two miles of trails
- Implemented an invasive species management program

Today, the Wash carries about 200 million gallons of water a day to Lake Mead. The efforts to stabilize the Wash have resulted in a greater than 60 percent reduction in the amount of total suspended solids in the water, and the removal of the Wash from Nevada Division of Environmental Protection's list of impaired waters.

SUSTAINABILITY

Sustainability transcends resource boundaries, but it is inseparably linked to the conservation of vital resources such as water and energy. This concept forms the framework for SNWA's sustainability initiatives, which focus on four main areas:

- Water
- Energy
- Environment
- Personal responsibility

As a water provider and educator in one of the region's driest communities, living a conservation ethic is an essential part the organization's work practices. The SNWA strives to provide sufficient water to the community while promoting conservation, utilizing reliable, renewable water resources and maintaining water quality with minimal impact on the environment.

The SNWA has undertaken a broad range of initiatives to help ensure conservation and preservation of water resources. The SNWA's Water Smart Landscape program has averted nearly 41,000 metric tons of carbon dioxide discharge (more than 90 million pounds) through avoided water pumping, treatment and transmission activities. That is equivalent to taking 8,900 cars off the road every year. On an annual basis, program participants reduce our carbon dioxide footprint by 900 metric tons.

Water Smart streetscape

As the state's largest energy user, the SNWA strives to reduce energy consumption and reduce environmental pollution through efficient energy use and incorporating use of renewable resources such as solar energy and hydropower. Following the passage of new renewable energy standards by the Nevada Legislature in 2019, the SNWA is working to achieve 20 percent renewable energy by 2019 and 50 percent by 2030. The SNWA's current energy portfolio consists of approximately 18 percent derived from renewable resources.

The SNWA's solar and small hydropower facilities generate more than 44 million kilowatt hours of clean energy, enough to power nearly 3,500 average Southern Nevada homes annually. The SNWA's fleet is nearing its goal of becoming 100 percent alternative fueled, replacing standard-fueled vehicles with alternative-fueled models when appropriate.

The SNWA continues to identify ways to minimize the environmental impacts of operations and create a greener way of working. Reducing, reusing and recycling are key components of waste reduction efforts. SNWA facilities are designed to be environmentally conscious, including certification under U.S. Leadership in Energy and Environmental Design green building program.

CHAPTER SUMMARY

The SNWA adheres to strict environmental laws and regulations that govern its use and development of resources and facilities. In addition, the SNWA proactively integrates environmental stewardship into facility operations and resource management. To support its long-term water resource planning and development efforts, the SNWA will:

- Continue its environmental planning, monitoring and mitigation efforts to minimize its footprint and protect community water supplies;
- Participate in environmental programs to enhance regulatory certainty for the flexible and adaptive use of resources;
- Work with partners to conserve habitat and work towards the recovery of threatened and endangered species, as well as reducing the likelihood of additional species listings; and
- Meet the community's current and long-term water resource needs while promoting conservation, utilizing reliable, renewable water resources and maintaining water quality with minimal impact on the environment.

ENDNOTES

1 Lower Colorado River Multi-Species Conservation Program, 2004. Lower Colorado River Multi-Species Conservation Program, Volume II: Habitat Conservation Plan. December 17, 2004.

2 "Colorado River Basin Water Supply and Demand Study," December 2012, U.S. Bureau of Reclamation.

3 SNWA, 2011. "Warm Springs Natural Area Stewardship Plan," June 2011, SNWA.

4 Clark County Multiple Species Habitat Conservation Plan and Environmental Impact Statement for Issuance of a Permit to Allow Incidental Take of 79 Species in Clark County, Nevada, September, 2000, Clark County Department of Comprehensive Planning and U.S. Fish and Wildlife Service.

5 "Las Vegas Wash Comprehensive Adaptive Management Plan," December 1999, Las Vegas Wash Coordination Committee.

6 "Recovery Plan for the Rare Aquatic Species of the Muddy River Ecosystem," May 16, 1996, U.S. Fish and Wildlife Service Region 1, Portland, Oregon.

APPENDIX 1

CLARK COUNTY POPULATION FORECAST AND ASSUMPTIONS USED IN 2020 WATER RESOURCE PLAN DEMAND PROJECTIONS

Year	Lower Demand Population	Upper Demand Population
2020	2,341,000	2,361,000
2025	2,555,000	2,682,000
2030	2,731,000	2,968,000
2035	2,847,000	3,189,000
2040	2,936,000	3,376,000
2045	3,008,000	3,537,000
2050	3,067,000	3,675,000
2055	3,119,000	3,795,000
2060	3,161,000	3,893,000
2065	3,203,000	3,980,000
2070	3,245,000	4,056,000
2071	3,253,000	4,070,000

Endnotes:

1 “Population Forecasts: Long-Term Projections for Clark County, Nevada 2020–2060,” June 2020, Center for Business and Economic Research at the University of Nevada, Las Vegas (projected through 2071).

2 Adjusted “Population Forecasts: Long-Term Projections for Clark County, Nevada 2020–2060,” June 2020, Center for Business and Economic Research at the University of Nevada, Las Vegas (projected through 2070 with a 15 percent increase by 2040 and a 25 percent increase by 2071).

APPENDIX 2

Year	Lower Demand (105 GPCD Conservation goal)	Upper Demand (105 GPCD Conservation goal)	Upper Demand (Add'l Conservation Scenario)
2020	281,000	283,000	282,000
2025	301,000	316,000	309,000
2030	317,000	344,000	329,000
2035	324,000	363,000	339,000
2040	330,000	380,000	353,000
2045	334,000	393,000	365,000
2050	337,000	404,000	373,000
2055	338,000	412,000	379,000
2060	343,000	422,000	389,000
2065	347,000	432,000	397,000
2070	352,000	440,000	405,000
2071	353,000	441,000	406,000

APPENDIX 3

IRPAC 2020 RECOMMENDATIONS

The SNWA Board of Directors established the 11-member Integrated Resource Planning Advisory Committee (IRPAC 2020) in 2019 to evaluate and develop recommendations on various issues critical to the SNWA's mission. As detailed below, the committee's deliberations resulted in 22 recommendations that were accepted by the SNWA Board of Directors in September 2020. Major topics include water resources, water conservation, facilities and rates.

GENERAL RECOMMENDATIONS

1. Work with community stakeholders to implement IRPAC recommendations.

MCCP AND FACILITIES

2. Maintain current asset management funding levels and practices to ensure reliable water treatment and transmission in Southern Nevada.

3. Pursue projects to meet Nevada's Renewable Portfolio Standard.

4. Include the candidate projects presented to IRPAC 2020, totaling $3.166 billion, in the SNWA's Major Construction and Capital Plan (MCCP).

WATER RESOURCES

5. Pursue emerging water resource opportunities with Colorado River partners to increase Nevada's water supplies, as presented to IRPAC on December 18, 2019.

6. Require out-of-valley development to return wastewater to Lake Mead and embed the principles of the SNWA's Out-of-Valley Water Use Policy within municipal codes and Las Vegas Valley Water District (LVVWD) Service Rules.

CONSERVATION

7. Pursue changes necessary to achieve the SNWA's current water conservation goal of a minimum of 105 GPCD by 2035 and further efforts to achieve additional conservation thereafter.

8. Reduce existing non-functional turf acreage by 50 percent by 2035.

9. Embed the principles of the SNWA's Non-Functional Turf Resolution in municipal codes and LVVWD Service Rules.

10. Limit future installations of cool-season turf in public spaces and expedite the conversion of cool season turf to warm-season turf at existing public facilities.

11. Implement smart controller technology to automate landscape watering compliance and increase outreach and enforcement efforts.

12. Pursue implementation of advanced metering infrastructure and develop partnerships and programs to improve the speed of customer leak repairs.

13. Evaluate changes necessary to reduce current and future consumptive water losses associated with evaporative cooling technology.

14. Establish an efficiency review policy and process for new large water users to encourage efficient development and disincentivize consumptive use.

15. Continue to make investments that will maintain or improve the existing water loss rates among wholesale and retail water purveyors.

16. Continue outreach efforts to engage the public and effectuate the changes needed to meet the community's regional conservation goal.

FUNDING

17. Fund the MCCP with a combination of debt capital and pay-go to manage unrestricted reserve balances at adequate levels consistent with the Reserve Policy.

18. Implement a six-year annual increase to SNWA charges effective January 2022 to: 1) Phase-in an inflationary catch up, and 2) Adjust for subsequent annual inflation within the six-year period: – Increase the Connection Charge by 9.5% annually for six years effective Mar. 2022 – Increase the Infrastructure Charge by 4.6% annually for six years effective Jan. 2022 – Increase the Commodity Charge by 4.8% annually for six years effective Jan. 2022.

19. Implement an indexed rate component to the SNWA Infrastructure and Commodity charges annually, effective January 2028, and limit future increases to a floor of 1.5% and a ceiling of 4.5% each year. – Infrastructure Charge in accordance with Engineering News Record (ENR) index – Commodity Charge in accordance with the Consumer Price Index (CPI) Do not implement inflationary increases in a year in which the five-year forecast unrestricted reserve balance is projected to be greater than 150% of targeted reserve balances.

20. Implement an indexed rate component to the SNWA Connection Charge annually in accordance with the ENR index, effective March 2028.

21. Eliminate the $16.1 million Connection Charge threshold, require SNWA Connection Charge revenues to fund the pay-go portion of capital expenditures and related debt service, and exclude from funding recurring operating expenses.

22. Provide IRPAC 2020 with an annual update of the funding model and convene the committee as necessary.

APPENDIX 4

SCENARIO DETAIL

Figure A-1 from the Colorado River Basin Study illustrates the range of Colorado River inflows considered under observed hydrology and climate change projections, providing useful detail to compare the water supply conditions presented in Chapter 4.2 The graph on the left was developed using observed resampled average annual Colorado River natural flow at Lees Ferry. It shows the variability of future hydrology based on observed records, with a range of Colorado River inflow between approximately 13.7 MAFY and 16.3 MAFY. Mean inflow is approximately 15 MAFY.

The graph on the right considers how climate change might impact Colorado River inflows and flow variability. It was developed using Downscaled General Circulation Model (Downscaled GCM) projections and simulated hydrology, which project the climate will continue to warm in the future. The range of inflow for the Downscaled GCM projection is between approximately 10 MAFY and 17 MAFY. The mean inflow is approximately 13.7 MAFY.

The water supply conditions presented in Chapter 4 are within range of the average and below average observed natural flow, and within mid-range of the Downscaled GCM projections.

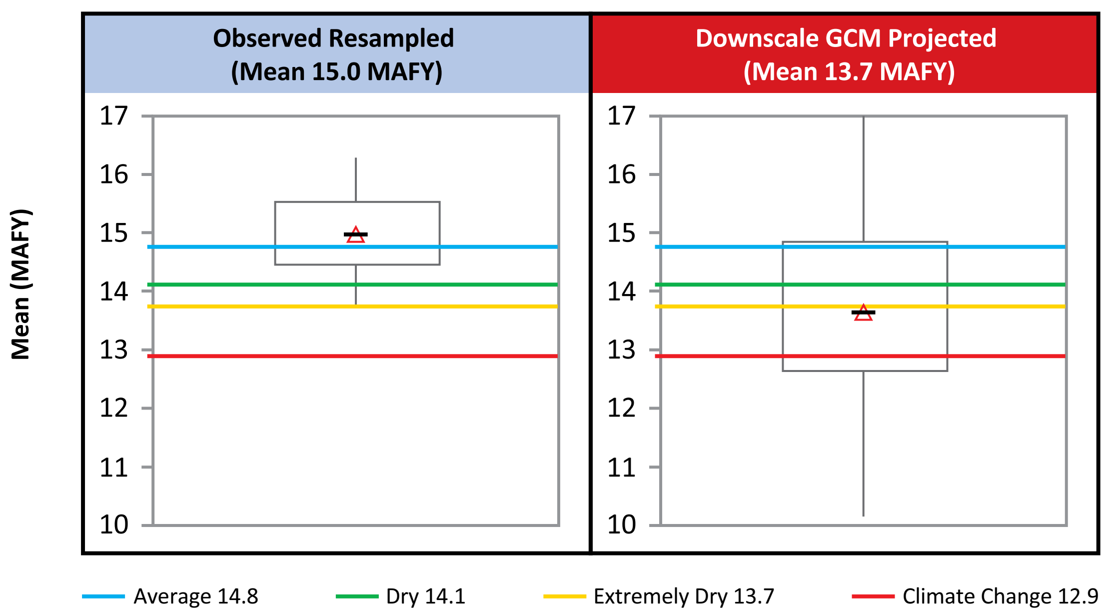


FIGURE A-1 **Average Annual Colorado River Natural Flows at Lees Ferry in Million Acre-Feet per Year (MAFY)**

ENDNOTES

1 "Colorado River Basin Water Supply and Demand Study Technical Report B – Water Supply Assessment," December 2012, U.S. Bureau of Reclamation.

2 The lower and upper borders of each box in the graph represent the 25th and 75th percentile values (lower quartile Q1 and upper quartile Q3). The band within each box denotes the median (dash) and the mean (triangle) values. The value Q3-Q1 is the interquartile range or IQR. Thus, 50 percent of the values reside within the box and the IQR is the height of the box. The upper and lower vertical lines, or whiskers, cover the points outside of the box. Each of the whiskers covers 25 percent of the values. The colored lines in the graphs represent average annual flow for the water supply conditions used in Chapter 4.

APPENDIX 5

VOLUME BY STATE AND COUNTRY

The following table summarizes shortages, delivery reductions, DCP contributions and other water savings by volume under the 2007 Interim Guidelines, Minute 323, Lower Basin DCP and the Binational Water Scarcity Contingency Plan. Participants include Arizona (AZ), Nevada (NV), California (CA) and Mexico (MX). Volumes are represented in thousands of acre-feet (kaf).

Lake Mead Elevation (ft. above mean sea level)	**2007 Interim Guidelines Shortages**		**Minute 323 Delivery Reductions**	**Total Combined Reductions**	**DCP Water Savings Contributions**			**Binational Water Scarcity Contingency Plan Savings**	**Combined Volumes by States and Country**					
	AZ	NV	MX	**Lower Basin & Mexico Total**	AZ	NV	CA	MX	AZ Total	NV Total	CA Total	Lower Basin Total	MX Total	**Lower Basin & Mexico Total**
1,090-1,075	0	0	0	**0**	192	8	0	41	192	8	0	200	41	**241**
1,075-1,050	320	13	50	**383**	192	8	0	30	512	21	0	533	80	**613**
1,050-1,045	400	17	70	**487**	192	8	0	34	592	25	0	617	104	**721**
1,045-1,040	400	17	70	**487**	240	10	200	76	640	27	200	867	146	**1,013**
1,040-1,035	400	17	70	**487**	240	10	250	84	640	27	250	917	154	**1,071**
1,035-1,030	400	17	70	**487**	240	10	300	92	640	27	300	967	162	**1,129**
1,030-1,025	400	17	70	**487**	240	10	350	101	640	27	350	1,017	171	**1,188**
<1,025	480	20	125	**625**	240	10	350	150	720	30	350	1,100	275	**1,375**

JOINT WATER
CONSERVATION PLAN

City of Henderson | City of Las Vegas | City of North Las Vegas
City of Boulder City | Clark County Water Reclamation District
Big Bend Water District | Las Vegas Valley Water District


Photo: Southern Nevada

SOUTHERN NEVADA WATER AUTHORITY

BOARD OF DIRECTORS

Photo: Landscape Conversion

MISSION

Our mission is to provide world class water service in a sustainable, adaptive and responsible manner to our customers through reliable, cost effective systems.

GOALS

Assure quality water through reliable and highly efficient system.

Deliver an outstanding customer service experience.

Anticipate and adapt to changing climatic conditions while demonstrating stewardship of our environment.

Develop innovative and sustainable solutions through research and technology.

Ensure organizational efficiency and manage financial resources to provide maximum customer value.

Strengthen and uphold a culture of service, excellence and accountability.

The Southern Nevada Water Authority (SNWA) is a cooperative, not-for-profit agency formed in 1991 to address Southern Nevada's unique water needs on a regional basis.

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Photo: Mojave Desert

A Message from the General Manager

The Southern Nevada Water Authority and its member agencies work diligently to maximize the availability of existing water supplies and reduce overall water demands in Southern Nevada through aggressive water conservation programs and policies. Our community has made great strides in water efficiency over the years and these efforts will continue to be of paramount importance, particularly as drought and climate change are anticipated to reduce the availability of water supplies, and as our economy continues to thrive.

I believe the challenges we face today will follow us into the future. The Southwest is getting warmer and soil conditions are getting dryer, which means less water is flowing into the Colorado River and Lake Mead – our primary water source. As we face an increasingly water-scarce future, there is more our community can and must accomplish. I am asking all Southern Nevada residents to join me with increased resolve to protect our community's limited water supply and help to meet our water conservation goals.

Increased water efficiency remains a critical step towards the long-term prosperity of our desert community. This plan describes the importance of ongoing conservation in Southern Nevada and details the steps we've taken to increase water efficiency. It also provides insights and results for our past success, discusses the tools and resources we're implementing to support achievement of our water conservation goal, and explores the steps we are asking residents and businesses throughout the region to take to help ensure the long-term sustainability of Southern Nevada.

While hard work remains, I have tremendous confidence in our collective ability to do more with less and to take actions that will sustain Southern Nevada for current and future generations.

John J. Entsminger
General Manager

Photo: Lake Mead National Recreation Area

Photo: Southern Nevada landscape

Plan Introduction

The Southern Nevada Water Authority (SNWA) is a regional, not-for-profit agency. Formed in 1991 by a cooperative agreement among seven water and wastewater agencies, SNWA works to address Southern Nevada's unique water needs on a regional basis. Collectively, the SNWA member agencies serve more than 2.2 million residents in the cities of Boulder City, Henderson, Las Vegas, North Las Vegas, Laughlin and areas of unincorporated Clark County.

AUTHORITIES

As the region's wholesale water provider, the SNWA is responsible for managing current and future water resources. This includes managing all water supplies available to Southern Nevada through an approved water resource plan and water budget; managing regional conservation programs; ensuring regional water quality meets or exceeds state and federal standards; and building and operating regional facilities to provide a reliable drinking water delivery system to its member agencies.

Although the SNWA plays a critical role in managing water, it does not have the authority to regulate water use by end-users or to establish customer rates. Such policies, codes and regulations are implemented through its member agencies. In terms of regulatory issues, the SNWA plays an important role in facilitating information sharing and collaboration. Past efforts have resulted in the creation of successful community-wide water-efficiency policies, such as permanent mandatory watering restrictions and limitations on lawn installation in new construction (see Chapter 4).

Education, outreach and incentive programs as described in Chapters 5 and 6 are largely developed and managed by the SNWA through committed involvement from its member agencies.

STATE AND FEDERAL REQUIREMENTS

This Joint Water Conservation Plan (Plan) meets state and federal conservation plan requirements prescribed under Nevada Revised Statutes (NRS) and the Reclamation Reform Act (RRA). It addresses the regional conservation initiatives of the following wholesale and municipal water agencies:

- Southern Nevada Water Authority
- City of Las Vegas
- City of North Las Vegas
- City of Boulder City
- City of Henderson
- Big Bend Water District
- Las Vegas Valley Water District
- Clark County Water Reclamation District

Nevada Revised Statutes

NRS 540.121 through 540.151 requires all water suppliers in Nevada to prepare and adopt a water conservation plan that is based on the climate and living conditions of its service area, and to update the plan every five years. As outlined in NRS 540.141, the plan must include a drought contingency plan, water management measures, standards for efficiency in new development, conservation water rates, conservation measures, public education initiatives, a schedule for carrying out the plan, measures for evaluating plan effectiveness and a conservation savings estimate.

As required, the plan was submitted to the Nevada Department of Conservation and Natural Resources, Division of Water Resources for review and approval prior to its adoption. The plan also was made available for public inspection during regular business hours, both at SNWA's public offices and online at snwa.com. The next plan update is scheduled for August 2024.

Reclamation Reform Act

In addition to NRS, RRA Section 210(b), requires the SNWA to maintain a five-year conservation plan with the U.S. Bureau of Reclamation. This Plan meets these requirements and is effective for a period of five years from the date of SNWA Board approval.

PLANNING GUIDANCE

In addition to NRS and RRA, the SNWA reviewed other conservation guidance documents in preparation of its 2019-2024 Plan. These include the U.S. Environmental Protection Agency (EPA) Advanced Guidelines for Preparing Water Conservation Plans (for systems serving greater than 100,000 customers)[i] and the American Water Works Association's (AWWA) G480-13 Water Conservation Program Operation and Management Standards.[ii]

These tools were designed to assist water suppliers in developing effective water conservation plans. While compliance with EPA and AWWA guidance is voluntary, the SNWA has informed its 2019-2024 Plan with these valuable tools. Although additional information on facilities and resource planning has been included, this plan does not intend to specifically address all aspects of water resource management and development. Instead, it serves as a companion to other detailed planning documents as described in Chapter 2.

CONSERVATION PHILOSOPHY

The SNWA has a long history of setting and achieving its water conservation goals. Since its first plan was adopted in 1995, the agency's philosophy towards conservation has centered on important practical and principled considerations.

For many communities, including ours, conservation is a sensible approach that can extend the availability and use of limited water supplies. The SNWA's planning approach recognizes the intrinsic value of water for life and livelihood in our desert community.

Implementation of the conservation planning goals and strategies detailed within this plan will help to:

- Prolong the life and improve utilization of existing facilities, reduce variable operating costs, and delay new source water development costs.
- Extend the use of permanent resources and help grow temporary resources or banked supplies that can be used when needed to improve operational flexibility.
- Reduce the likelihood of federally imposed shortage declarations for Colorado River supplies and reduce the magnitude of curtailments.
- Build and maintain strong relationships among the public, other stakeholders and the river community with whom we share resources.
- Protect Southern Nevada's economy and jobs by ensuring short- and long-term water demands can be met sustainably.
- Demonstrate our deep understanding of the value of water and model responsible, innovative approaches for the stewardship of Southern Nevada's limited water supplies.

Public Involvement in Goal Setting

Since its inception, the SNWA has consistently relied upon public input. Citizen advisory committees convened by the SNWA Board of Directors have explored and deliberated a range of issues – from water quality and environmental initiatives to water conservation goals, and the development of water sources and infrastructure for Southern Nevada's future.

Image: SNWA's 2017 ethics campaign emphasizes the value of water for life, family, jobs and our future.

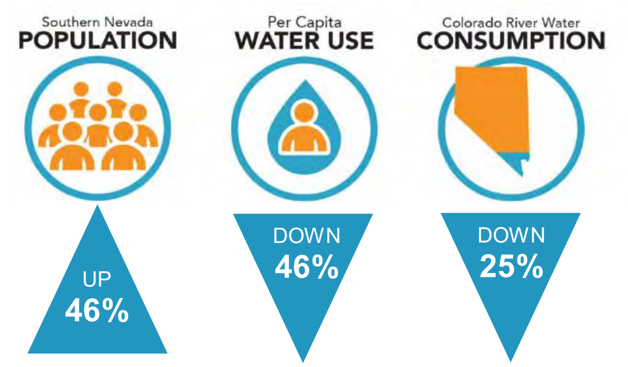
Water Conservation Goal

The SNWA is working to achieve its conservation goal of 105 gallons of water per capita per day (GPCD) by 2035.[iii] As recommended by SNWA's 2015 Integrated Resource Planning Advisory Committee, a new conservation goal will be evaluated once the current goal is achieved. The SNWA's Water Resource Plan (visit snwa.com) provides an illustrative look at how additional conservation – beyond the current goal – might impact long-term (50-year) water demands, as well as short- and long-term water supply needs.

GPCD is a metric used by many communities to measure water use. It also is an effective tool to measure efficiency over time. GPCD varies across communities due to several factors, including differences in climate, demographics, water-use accounting practices and economic conditions. As such, it is difficult to compare GPCD rates for different communities for the purpose of evaluating efficiency.

For the 2019-2024 SNWA Conservation Plan, the SNWA has restated its conservation progress and goal in consumptive use terms to more accurately reflect the water resource implications associated with conservation progress.[iv] SNWA GPCD is calculated by dividing all SNWA water sources diverted (excluding offstream storage) less corresponding Colorado River return-flow credits by total SNWA resident population served per day (GPCD = water diverted - return-flow credits / resident population / 365 days). This approach recognizes that not all water that is diverted is consumed. This is because the SNWA recycles nearly all indoor water use, either through return-flow credits or direct reuse (see Chapter 2).

Southern Nevada has made significant progress towards its water conservation goal as detailed in Appendix 3. Between 2002 and 2018, per capita and Colorado River water use has decreased by about 46 percent and 25 percent, respectively. Meanwhile, population has increased by more than 46 percent.



Infographic: SNWA Conservation Progress (2002-2018)

Over the years, the SNWA has made several significant changes to its Water Conservation Plan and associated strategies to promote continued conservation and efficiency improvements. These include increased water management measures, financial increases to incentive programs, and targeted education and outreach initiatives as detailed in Chapters 4-6.

CONSERVATION STRATEGIES

The SNWA uses several demand management tools to promote conservation and reduce overall water use, including water pricing, incentives, regulations and education. These measures work in conjunction with one another to promote efficient water use. For example, water pricing (including water rates and water waste fees) provides a financial signal for customers to reduce water use, which, in turn, may lead some customers to improve efficiency.

Through passive and active education, customers learn about regulations (such as day-of-week watering restrictions and incentive programs), which, when acted upon, help the customer save water and reduce the impact of rates. Ideally, these measures yield higher levels of efficiency. A table of estimated water savings by specific conservation measures over the planning horizon is included in this Plan as required (Appendix 3). However, the complex and inter-related nature of these conservation tools makes it difficult to attribute specific water savings to any single measure.

As detailed later in this Plan, the SNWA maintains a suite of conservation programs for both indoor and outdoor water uses, while deliberately focusing its staff and financial resources on programs and efforts designed to reduce consumptive water use, such as water waste, landscape irrigation and evaporative loss. While significant funding is directed to reduce consumptive water uses, the SNWA maintains consistent water conservation messaging and program support to reduce all types of end uses. This is an important strategy that helps to build upon the community's strong and growing conservation ethic.

Other conservation strategies include:

- Engaging our community with information and programs that help individuals and organizations change their water use (retrofit).
- Building in future conservation savings by ensuring new development is water efficient.
- Transforming demand through new products and technologies that reduce water demand.
- Curtailing waste and losses by minimizing unproductive losses of water in both utility and customer applications.
- Advancing knowledge through investments that increase our understanding of new opportunities and the influence of existing programs.
- Valuing water appropriately by ensuring water rates and fees reflect the value of resources.

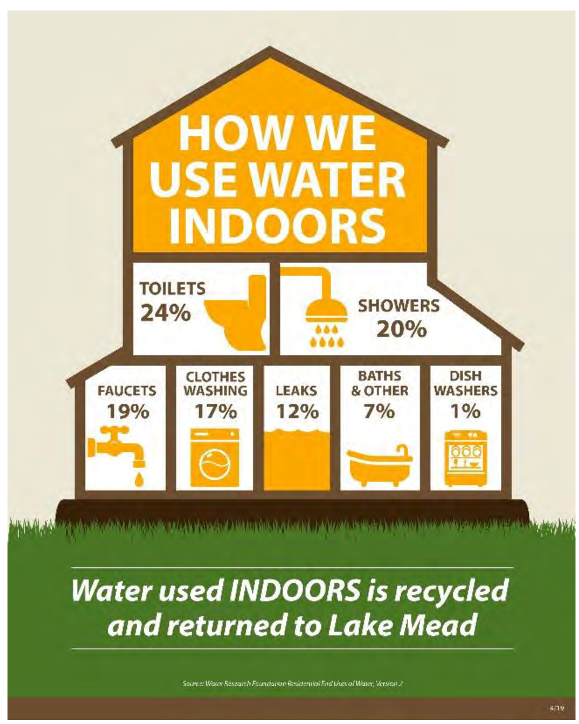
A CALL TO ACTION

Many of the conservation measures described in Chapter 5 are voluntary, which makes the public an essential partner as our community works to improve water efficiency and reduce water waste.

While this Plan describes many ways to improve water efficiency, the SNWA is specifically calling on residents and businesses to take three key actions that will together have a high impact on reducing water use:

- Remove ornamental turf – replace water thirsty grass with water efficient landscapes.
- Change your watering clock – follow mandatory time-of-day and day-of-week watering restrictions.
- Report water waste – help local water agencies to identify and address water waste in our community by reporting water waste.

Infographic: Most of our community's water is used outdoors.



Infographic: Water used indoors is recycled.

Water Service Overview

This chapter provides a general overview of the SNWA's water service area, including a description of major water facilities and supplies available to meet the community's short and long-term resource needs.

Southern Nevada Water Authority

The SNWA was formed in 1991 by a cooperative agreement among seven water and wastewater agencies (below). Collectively, the SNWA member agencies serve more than 2.2 million residents in the greater Las Vegas Valley.

- Las Vegas Valley Water District*
- City of Henderson*
- City of Las Vegas
- Big Bend Water District
- City of North Las Vegas*
- City of Boulder City*
- Clark County Water Reclamation District

As the region's wholesale water supplier, the SNWA is responsible for constructing and operating regional water facilities. This includes operations of the Southern Nevada Water System (SNWS), which has a total combined treatment capacity of 900 million gallons of water per day (MGD).

The SNWS is comprised of three raw water intakes and two raw water pumping stations that deliver SNWA's contracted Colorado River supplies from Lake Mead; two water treatment plants; approximately 30 pumping stations; more than 160 miles of large diameter pipeline; and more than 60 regulating tanks, reservoirs and surge towers. A new raw water pumping station is currently under construction to protect access to the community's water supply from effects of extended drought. This major addition is expected to be complete in 2020.

In turn, the SNWA's water purveyors (*), are responsible for municipal water service to residents and businesses in their respective service areas (Figure 2.1). As further described in Chapter 4, the SNWA member agencies meter all customer accounts and use increasing block tier conservation rates.

Las Vegas Valley Water District

The Las Vegas Valley Water District (LVVWD) is the region's largest municipal water purveyor, providing municipal water service to nearly 400,000 customer accounts in Las Vegas and portions of unincorporated Clark County. The system includes thousands of miles of pipelines, 53 pumping stations and 73 water storage reservoirs.

City of Henderson

The City of Henderson provides water, wastewater and reclaimed water services to approximately 98,000 customer accounts within the city's jurisdiction. The system includes more than 2,200 miles of pipelines, 43 pumping stations, and 55 water storage reservoirs.

City of North Las Vegas

The City of North Las Vegas provides municipal water service to more than 90,000 customer accounts in North Las Vegas and adjacent portions of Las Vegas and unincorporated Clark County. The system includes more than 1,100 miles of distribution pipelines, 10 pumping stations and nine water storage reservoirs. The City of North Las Vegas also operates facilities for direct and indirect reuse.

City of Boulder City

The City of Boulder City provides water service to more than 5,000 customer accounts in Boulder City. The system includes more than 145 miles of distribution pipelines and six water storage reservoirs.

Big Bend Water District

The Big Bend Water District provides municipal water service to approximately 2,000 customer accounts in Laughlin, Nevada. The water system is operated and maintained by the LVVWD under a cooperative agreement. The system includes more than 60 miles of distribution pipelines, six pumping stations and five water storage reservoirs.

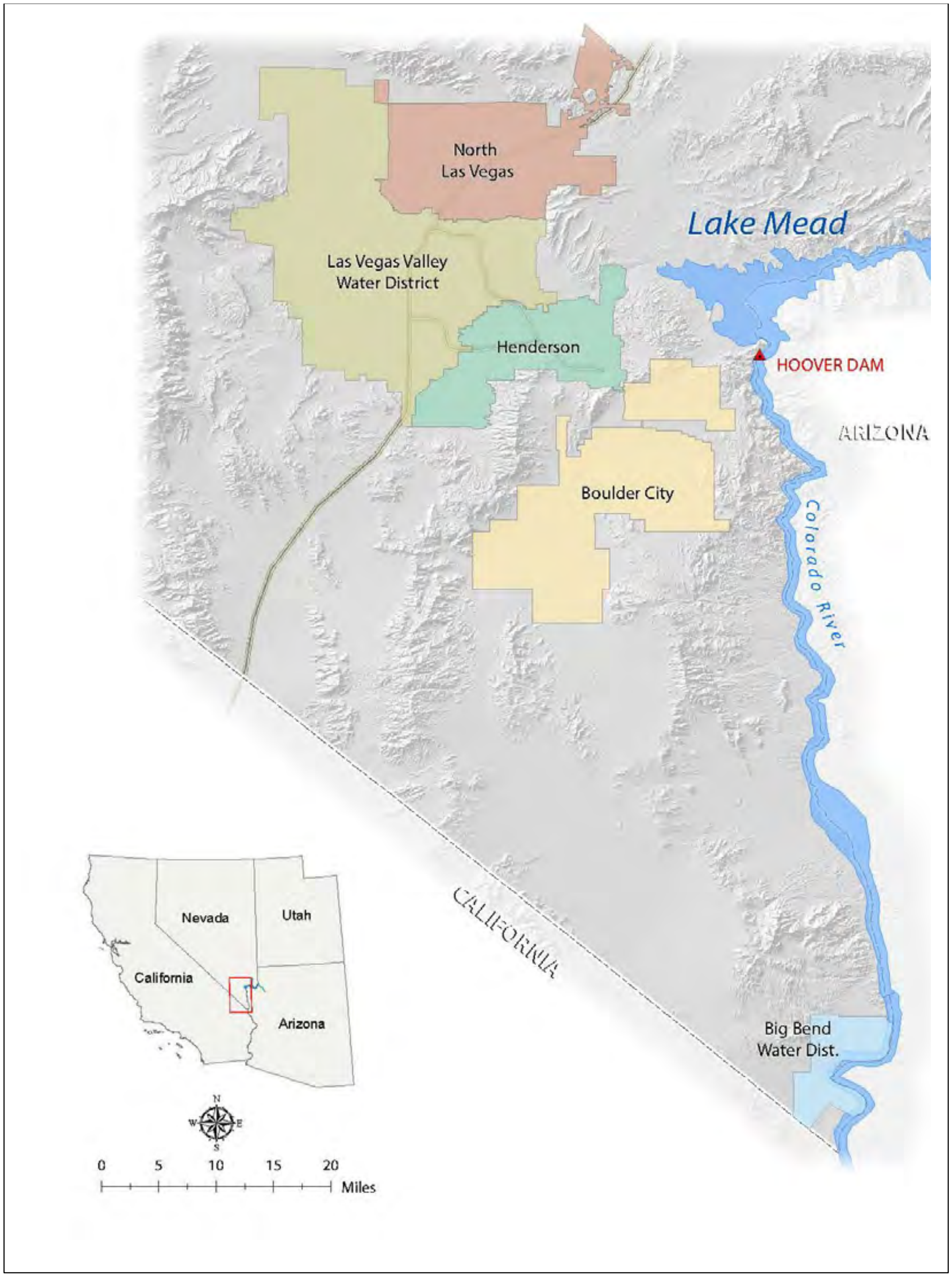
Clark County Water Reclamation District

The Clark County Water Reclamation District is the largest clean water agency in Nevada, collecting, treating and producing more than 105 million gallons of clean water each day. The majority of the clean water is returned to Lake Mead via the Las Vegas Wash and to the Colorado River at Laughlin for indirect reuse. It also provides a small portion of reclaimed water for irrigation and industrial coolant.

City of Las Vegas

The City of Las Vegas provides reuse water to customers within its service area. Municipal water supplies for the City of Las Vegas are provided by LVVWD.

Figure 2.1 SNWA and purveyor service areas



CUSTOMER CLASSES

As shown in Figure 2.2, residential customers make up the largest class of water users in Southern Nevada. Other customer categories include: commercial and industrial customers; resorts; golf courses; schools, government and parks; common areas; and other water users.

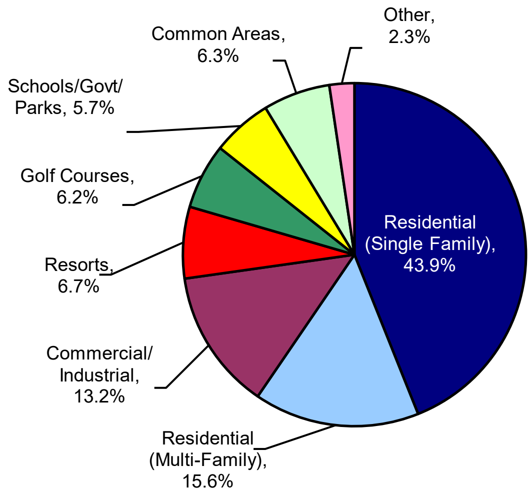


Figure 2.2 Municipal metered water use by customer class (2018)

MAJOR PLANNING EFFORTS

The SNWA conducts short- and long-range planning to ensure high-quality water supplies and reliable service to its customers. As noted in Chapter 1, the SNWA consistently relies on input from citizen committees to support planning efforts. Integrated resource planning initiatives have helped to inform and advance many of the planning processes described in the sections that follow.

Water Resource Plan and Water Budget

The SNWA conducts an annual review and update to its Water Resource Plan and Water Budget. These documents includes a summary of projected water demands in Southern Nevada over a 50-year planning horizon, as well as the resources available to meet those demands over time. Further, the plans demonstrates the SNWA's ability to meet future water demands under variable supply and demand conditions and presents a detailed forecast of water demands by SNWA purveyor member over a short-term (4-year) planning horizon.

Conservation Plan

The SNWA develops and implements a water conservation plan that provides a comprehensive overview of SNWA conservation goals and achievements, and discusses efforts planned or under way to reduce water waste and promote water efficiency. While the Plan is updated on a five-year schedule as required, the SNWA conducts regular reviews of its programs and strategies, adjusting as needed to help keep the community on track to meet its water conservation goals.

Drought Plan

The SNWA adopted a Drought Plan in 2002 that identified staged conservation measures that could be implemented based on the severity of drought conditions observed. Drought response actions identified in the plan and subsequent amendments have since become permanent conservation measures as discussed in Chapter 4. SNWA's current drought response actions are discussed in Chapter 3.

Major Construction and Capital Plan

The SNWA implements a Major Construction and Capital Plan that reports the costs of completed projects and defines authorized projects and initiatives for new regional facilities. This includes acquisition of assets and other capital-related activities. The plan further identifies estimated costs and schedules for approved projects and initiatives.

Water Quality Plan

The Regional Water Quality Plan for the Las Vegas Valley details implementation efforts for seven goals and strategies designed to protect, preserve and enhance the quality and quantity of water resources in the Las Vegas Valley Watershed, and to sustain economic well-being and protect the environment for present and future generations.

Financial Plan

The SNWA's Comprehensive Annual Financial Report is updated annually to provide a comprehensive overview of SNWA financial statements, accomplishments and financial forecasts.

WATER SUPPLY DESCRIPTION

The SNWA works to develop and manage a flexible portfolio of diverse water resource options; many of these resources have resulted from years of in-state, interstate and international collaborations. The portfolio includes permanent, temporary and future resources that are described in detail in the SNWA's 50-year Water Resource Plan. The following provides a general overview of water supplies that are available or are expected to be available through the SNWA's long-term (50-year) planning horizon. Visit snwa.com for plan updates and more detailed discussions.

Permanent Resources

Colorado River Water. Nevada's 300,000 acre-foot per year (AFY) Colorado River apportionment continues to be Southern Nevada's largest and most critical permanent resource. Nevada's right to this water was established under the 1922 Colorado River Compact and the 1928 Boulder Canyon Project Act (BCPA), which together set forth where and how Colorado River water is used.

The SNWA has contracts with the U.S. Secretary of the Interior for 272,205 AFY of Nevada's 300,000 AFY allocation. As detailed in the SNWA's Water Resource Plan, the SNWA may also utilize the unused apportionment of other Nevada Colorado River contract holders, as well as flood control and surplus Colorado River waters, as available.

Intentionally Created Surplus.
Under the 2007 Record of Decision for the Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead (Interim Guidelines), the SNWA can develop some of its surface and groundwater rights located in Nevada by allowing them to flow in Lake Mead in exchange Intentionally Created Surplus (ICS) credits. When needed, the credits can be withdrawn as Colorado River through SNWA facilities and returned to the system for return-flow credits.

Return-Flow Credits and Water Reuse. The BCPA defines all Colorado River apportionments in terms of "consumptive use." Consumptive use is defined as water diversions minus any water returned to the Colorado River. These returns are also referred to as "return-flow credits." With return-flow credits, Nevada can divert more than 300,000 AFY, so long as there are sufficient flows returned to the river to ensure the consumptive or 'net use' is no greater than 300,000 AFY.

In the Las Vegas Valley, nearly all water used indoors is recycled, either for direct or indirect reuse (Figure 2.3). Direct reuse involves collecting, treating and utilizing reclaimed water wastewater flows for non-potable uses such as golf course or park irrigation. Indirect reuse consists of recycling water by way of treatment and release to the Colorado River for return-flow credits. In 2018, Nevada's total consumptive Colorado River water use was 244,000 AFY.

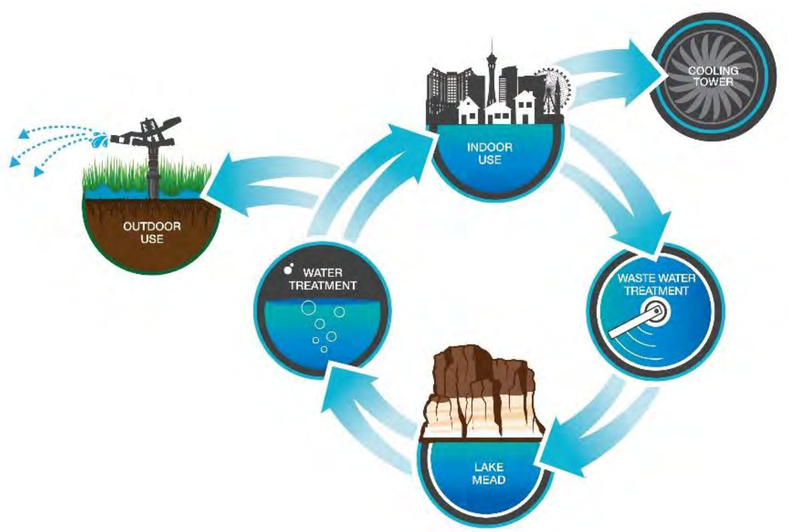


Figure 2.3: Uses of water

Las Vegas Valley Groundwater. The Las Vegas Valley Water District (LVVWD) and North Las Vegas have permanent groundwater rights totaling 40,760 and 6,201 AFY, respectively. These rights are among the most senior groundwater rights in the Las Vegas valley and remain a critical component of the SNWA's water resource portfolio.

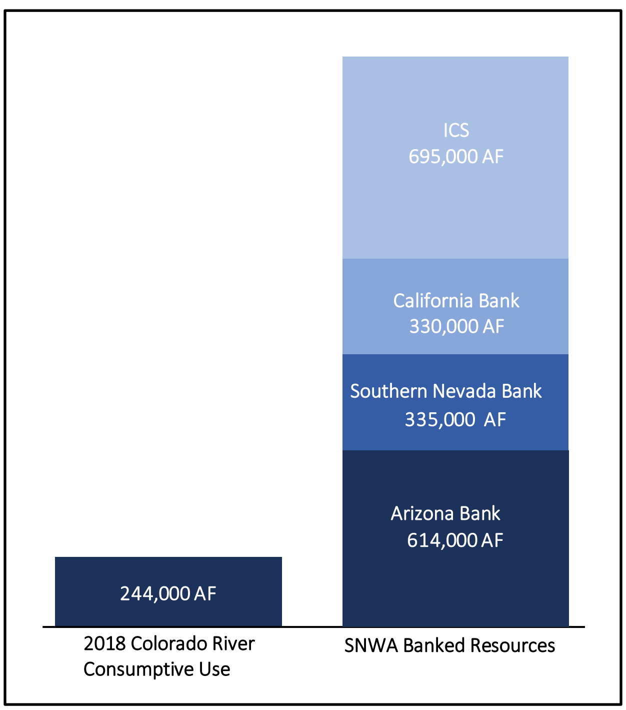
Temporary Resources

The SNWA reserves water in years when Nevada's Colorado River allocation exceeds community water demands. These resources are "banked" as temporary supplies for future use and serve as an important management tool – resources can be used to meet potential short-term gaps between supply and demand, and serve as a bridge to meet demands while other future resources are being developed. In some cases, banked resources may be used to help offset future reductions in permanent supplies due to federally imposed shortages (see Chapter 3).

Water Banking. SNWA water purveyors began storing or "banking" unused Colorado River resources in the Las Vegas Valley through direct injection beginning in the late 1980s. Banking programs have been expanded to include in lieu storage in the Las Vegas Valley and interstate banking agreements for storage in Arizona and California.

Another form of water banking was established under the 2007 Interim Guidelines, which allowed for water storage in Lake Mead in the form of ICS credits. As shown in Figure 2.4, the SNWA has banked approximately two million acre-feet of water through 2018. This is more than eight times Nevada's 2018 consumptive Colorado River water use.

Figure 2.4: Summary of banked supplies (in acre-feet) through 2018



The primary purpose of ICS is to encourage efficient Colorado River water use, increase storage in major system reservoirs, increase surface water elevations in Lake Mead, and minimize or avoid the potential for declared shortages. The SNWA accrues credits by conveying some of its surface and groundwater rights located in Nevada to Lake Mead in exchange for ICS credits. The SNWA also accrues credits by participating in Colorado River conservation and efficiency programs that save Colorado River water that would otherwise have been banked or lost from the system

The 2019 Lower Basin Drought Contingency Plan Agreement (DCP) expanded Lake Mead water banking opportunies for Southern Nevada with the authorization of a new ICS project. The project allows SNWA to leverage its past and future conservation savings and to obtain ICS credits. Ongoing accruals will be based on conservation achievements since 2002.

Future Resources

Water resource conditions have changed significantly for many Western states over the years, including Nevada. As a result, the SNWA has worked to implement strategies that conserve and maximize the use of Colorado River and groundwater supplies and help to establish temporary resources that can be used flexibly to meet evolving supply and demand conditions. These strategies increase overall efficiency, provide operational flexibility, buffer potential impacts of drought conditions, and help delay the development of costly facilities that may not be needed in the future.

To prepare for the future, the SNWA has identified a number of resources that are expected to be available at some point during the long-term planning horizon. These include desalination, in-state groundwater, Virgin River/Colorado River augmentation, and transfers and exchanges. In some instances, future resources are quantified, subject to water right permitting, while the availability and development of others require further research and analysis. The SNWA's future resource options are discussed in detail in the SNWA's Water Resource Plan.

Water Conservation

Water conservation is a resource but differs from other water supplies described in the preceding sections. Unlike other resources that are acquired and conveyed to meet demands, conservation reduces demands and extends the availability of existing, temporary and future water supplies.

WATER DEMAND PROJECTIONS

Forecasting water demands is a critical part of SNWA's resource planning process. The SNWA projects water demands over a 50-year planning horizon and reviews/revises its forecasts annually.

Precise accuracy rarely occurs in projecting water demands, particularly during periods of significant social and economic challenges. While making assumptions is a necessary part of the planning process, the SNWA recognizes that assumptions are unlikely to materialize exactly as projected. Likewise, climate variations, policy changes and/or implementation of new regulations can also influence water demands over time.

In response to this inherent uncertainty, the SNWA considers two water demand projections. An upper and a lower water demand projection are used to bracket the range of demand conditions expected to be experienced over SNWA's 50-year planning horizon. Detailed discussion about SNWA water demand projections are included in the SNWA's Water Resource Plan. The plan, including demand projections, is updated annually and include assumptions about conservation goals and achievements (see Water Resource Plan, Chapter 4).

Lower Demand Projection

The lower demand projection was derived from a population forecast and expected conservation achievements. The Clark County population forecast was obtained from the University of Nevada, Las Vegas Center for Business and Economic Research (CBER). The forecast is based on CBER's working knowledge of the economy and the nationally recognized Regional Economic Model Incorporated.

The lower water demand projection was derived using the latest CBER population forecast and trending through the balance of the planning horizon. The historical share of Clark County population attributable to the SNWA's service area was multiplied by current year water-use levels to represent expected achievements of the community's water conservation goal and further reductions in demand to reflect the potential for additional conservation once the current goal is met.

Upper Demand Projection

The upper demand projection was developed for planning purposes to reflect increased uncertainties related to possible changes in demand associated with climate variability, economic growth, increased population and water use patterns.

Drought Response

LOCAL CLIMATE

Nevada falls within two of North America's desert regions: The Great Basin Desert covers the northern, central and south-central portions of the state, while the Mojave Desert covers Nevada's southernmost tip where Southern Nevada is located. While topography and temperature vary greatly within these regions, Nevada is the driest state in the nation overall and is classified as semi-arid to arid.

Southern Nevada experiences temperature extremes that range from 8°F to 117°F[v]. High temperatures are moderated by dry air/low humidity conditions, typically below 40 percent year-round. Within this region, rainfall totals vary significantly, both seasonally and from year to year. The highest annual precipitation total on record occurred in 1941, measuring 10.72 inches. In contrast, the lowest occurred just twelve years later (1953), measuring 0.56 inches. On average, Southern Nevada receives 4.19 inches of precipitation annually. Nearly half of the last 15 years, however, have measured rainfall less than 2.65 inches.

Summer months (June – September) are extremely hot with normal average temperatures ranging between 82.6°F and 92.5°F – daytime temperatures often exceed 100.0 °F. Winter months (December – February) are chilly to mild with normal average temperatures ranging between 47.7°F and 52.9°F. Weather during spring and fall (March – May and October – November) is typically mild with normal average temperatures ranging between 56.4°F and 77.3°F.

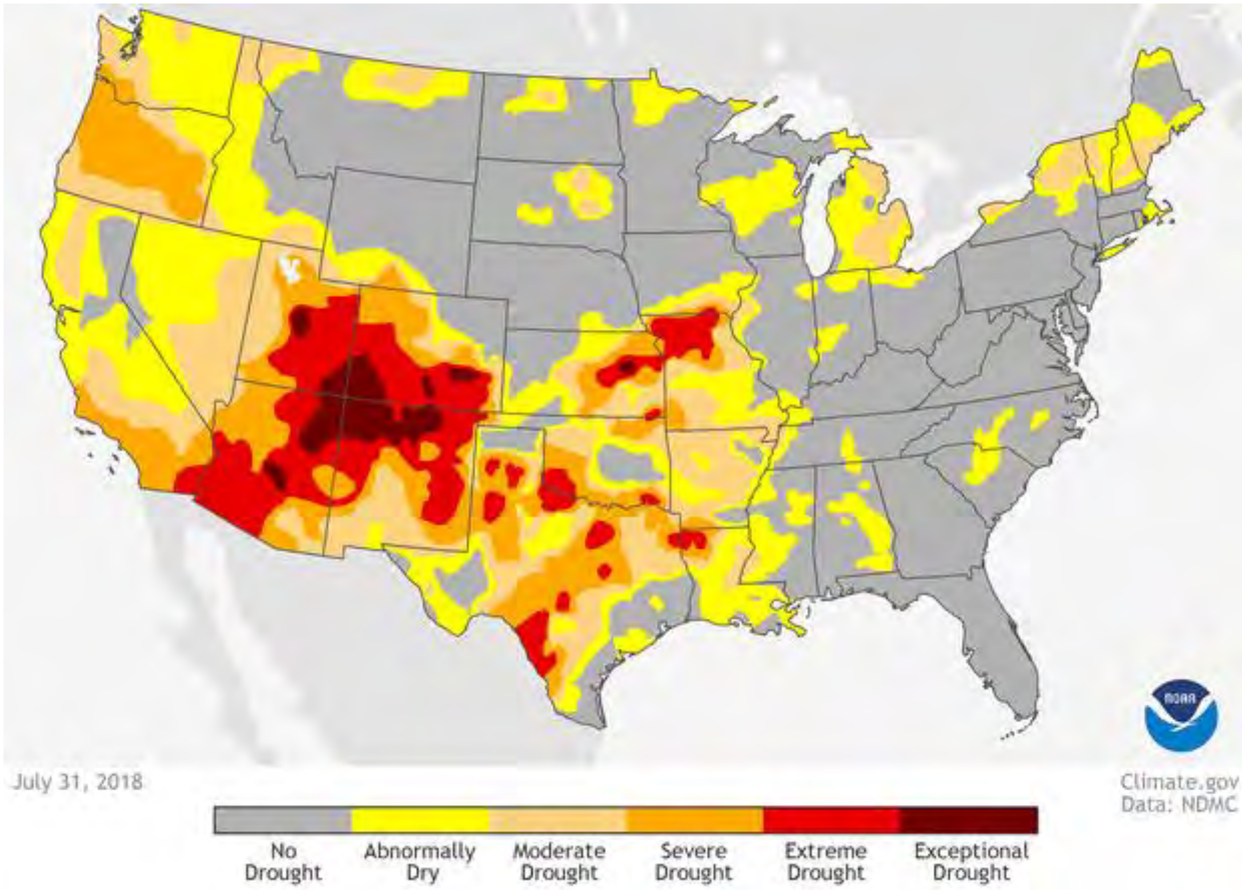
In 2017, the region broke several of its former weather records: 25 consecutive days with a high temperature of 105.0°F or higher (June 15 – July 9) and 116 consecutive dry days (September 14 – January 7). 2017 was the hottest year on record with 86 days that reached or exceeded 100°F.
Local climate conditions remained extremely hot and dry for 2018. September 2018 was the warmest month on record.[vi]

Temperature and precipitation data for the Las Vegas Valley is collected by the National Oceanic and Atmospheric Administration (NOAA) from the region's official climate station at McCarran International Airport. The station is located in the valley's urban core and frequently registers warmer low temperatures than outlying areas of the valley (+5° to 15°). This is due to increased urbanization of the Las Vegas Valley, which has resulted in a "heat island" effect.

Temperature and precipitation are variables that can significantly affect water use patterns in Southern Nevada, particularly for outdoor irrigation and large-scale air cooling facilities. Landscapes consume more water during high temperatures due to evaporation, evapotranspiration and overall plant water needs. Likewise, water used for air cooling increases when conditions are hot.

Photo: The Mojave Desert (below) is North America's driest desert.

Figure 3.1: U.S. Drought Monitor (NOAA) - July 2018



DROUGHT AND CLIMATE CHANGE

The Southwest region has experienced both rising temperatures and drought conditions for nearly two decades. As shown in Figure 3.1, drought conditions in 2018 ranged from abnormally dry to exceptional drought.[vii] Conditions have improved significantly with above-average snowfall in 2018/2019, however storage volumes in major system reservoirs remain below average.

In the Southwest, the persistence of drought and rising temperatures have resulted in changes to precipitation patterns; reduced snowpack and runoff to rivers, lakes and streams; drastic decreases to critical storage reserves; dry soil conditions and increased occurrence of wildfires; and the encroachment of non-native species. Average annual temperatures in the Southwest are projected to rise by an additional 3.5°F to 9.5°F by the end of the century, with the greatest temperature increases expected in the summer and fall. Likewise, drought conditions are expected to become more frequent, intense and longer.[viii]

As detailed in the water supply description, Southern Nevada's principal water supply is derived from precipitation and snowmelt that originates primarily in the Rocky Mountains of the Upper Colorado River Basin and flows into the Colorado River. Beginning in 2000 and continuing today, the Colorado River Basin has experienced drought conditions that quickly developed into the worst drought in the basin's recorded history.

According to the Fourth National Climate Assessment released in late 2018, changes in temperature have significantly altered the water cycle in the Southwest region. With continued greenhouse emissions, higher temperatures could cause more frequent and severe droughts in the Southwest, and lead to drier future conditions in the region.[ix]

Changes in air temperature and precipitation are likely to translate into diminished streamflow, drier soil conditions, increased water evaporation and evapotranspiration, and higher water demands for agricultural irrigation and landscaping uses.[x]

Water Supply Conditions

Drought and climate change have taken their toll on the Colorado River, which supplies approximately 90 percent of Southern Nevada's overall resource needs. Southern Nevada accesses a majority of its Colorado River supplies via Lake Mead, which was formed by the construction of Hoover Dam.

As shown in Figure 3.2, snowfall and runoff within the Colorado River Basin were well below normal between 2000 and 2019, representing one of the lowest 20-year averages on record. These conditions have resulted in significant water level declines at major system reservoirs. As of September 2019, the combined water storage in the Colorado River's two primary reservoirs (Lake Mead and Lake Powell) was less than 47 percent. [xi]

DROUGHT RESPONSE

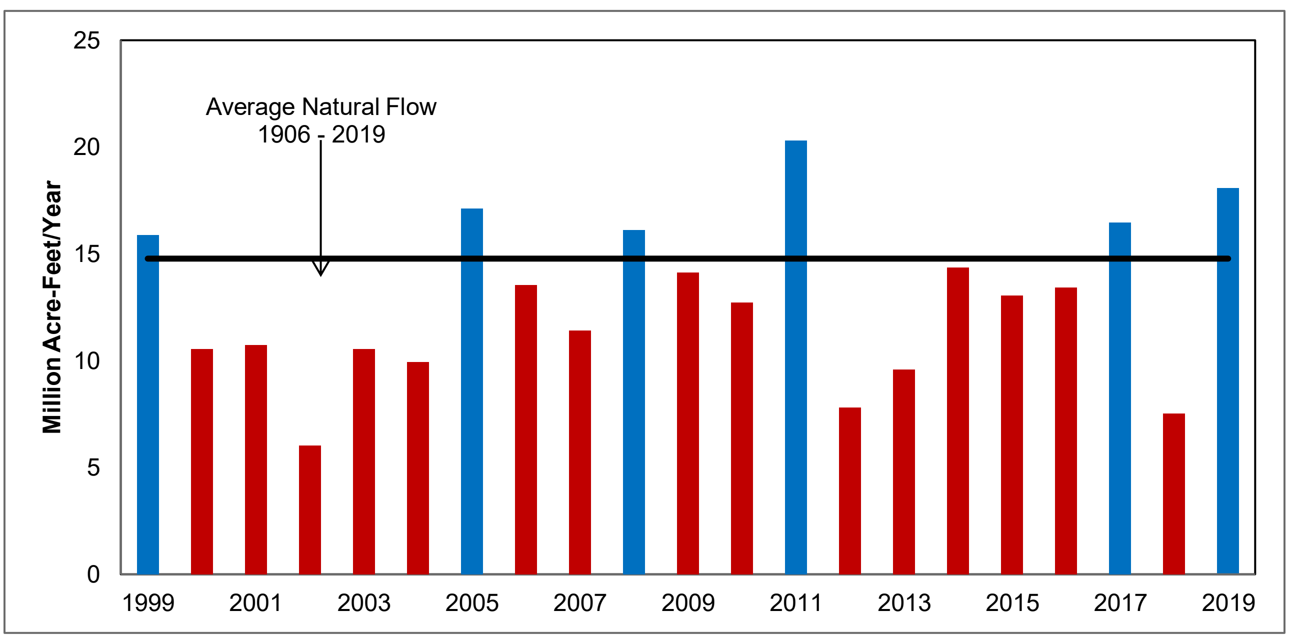
As described in Chapter 2, the SNWA and its member agencies worked to develop and implement a comprehensive Drought Plan in 2002 and 2003 as conditions in the Colorado River Basin worsened. Water management measures identified in the plan have since become permanent.

Since then, the SNWA has worked collaboratively with federal, state and municipal partners in the Colorado River Basin to implement new drought response measures designed to increase supplies, reduce demands and forestall the declaration of shortage. Likewise, the SNWA has worked to develop adaptive strategies and response efforts locally to mitigate continued impacts of drought. These initiatives are described briefly below.

Colorado River Interim Guidelines

The SNWA worked with federal, state and municipal water providers in the Colorado River Basin to develop and implement a shortage sharing agreement under the 2007 Interim Guidelines. Under current rules, the U.S. Secretary of the Interior will make a shortage declaration based on a projection of Lake Mead water levels as determined by the U.S. Bureau of Reclamation's modeling efforts.

Figure 3.2: Colorado River inflows into Lake Powell (1999 – 2018). Since 2000, only five years have exceeded average inflows.



The forecast is reviewed annually in August to determine water supply conditions in the coming year; a shortage will be declared for the following year if the lake is forecasted to be at or below 1,075 feet elevation on January 1. The amount of Colorado River water available to the states of Nevada and Arizona will be reduced during a federally declared shortage. Nevada's share of shortage is shown in Figure 3.3.

Modeling conducted by the U.S. Bureau of Reclamation in September 2019 indicate an approximate 4 to 43 percent probability of shortage in years 2021-2024.

Colorado River Drought Contingency Plan

In addition to the mandatory reductions defined by the Interim Guidelines, the SNWA and other Lower Colorado River Basin water users approved the Lower Basin Drought Contingency Plan Agreement (DCP) in 2019, which allows for additional voluntary contributions designed to reduce the magnitude and likelihood of continued Lake Mead water level declines and reduce risks of potential water supply interruptions for Lower Basin water users. Under the agreement, the states of Arizona, Nevada and California will make additional voluntary contributions. Like the Interim Guidelines, thresholds for voluntary contributions are based on Lake Mead water levels.

Implementation of the DCP will help to keep more water in the Colorado River for the benefit of all water users and the environment; help slow Lake Mead water level declines to preserve critical operations; and allow states to withdraw some of their contributions when Lake Mead water levels recover. Nevada's voluntary DCP contribution ranges from 8,000 AFY to 10,000 AFY and is based on Lake Mead water levels as shown in Figure 3.3. The SNWA intends to meet its commitments under the Interim Guidelines and DCP with conservation savings and banked supplies as described in Chapter 2.

The SNWA has banked approximately two million acre-feet of water as storage credits through 2018 as part of its water banking and collaborative initiatives. Banked resources can be used flexibly to meet demands and/or offset supply reductions when needed. Continued conservation will help to expand these stored water supplies and provide greater flexibility during times of drought

While federal, state and municipal partners are working to protect Lake Mead water levels, there is an ongoing risk that the lake could drop below 1,000 feet, a critical elevation for operations of Hoover Dam and Lower Basin water deliveries. With implementation of the DCP and other federal/international agreements, the risk of Lake Mead reaching this critical elevation has decreased substantially.

Figure 3.3: Nevada Shortage and DCP Contributions (in acre-feet)

Lake Mead Elevation (ft)	Shortage Amount (AFY)	DCP Contribution (AFY)	TOTAL (AFY)
Above 1,090	0	0	0
At or below 1,090	0	8,000	8,000
At or below 1,075	13,000	8,000	21,000
Below 1,050	17,000	8,000	25,000
At or below 1,045	17,000	10,000	27,000
Below 1,025	20,000	10,000	30,000

Adaptive Management

For nearly two decades, Southern Nevada has been preparing for and responding to drought and climate change impacts. From forging groundbreaking agreements for interstate banking and long-term resource planning to constructing massive-scale infrastructure projects and innovative conservation programming, the community has responded proactively, aggressively and in a sustained manner.

When the drought took hold in 2000, Southern Nevada was among the first Southwest communities to respond with advanced conservation measures, which have since become a permanent way of life for our desert community.

Through its adaptive management and response efforts, Southern Nevada has reduced its consumptive use of Colorado River water use by approximately 25 percent since 2002. As of 2018, Southern Nevada's consumptive use of Colorado River supplies is 244,000 AFY. This is well below the maximum reductions prescribed under existing rules described in the preceding sections.

Long Term Planning

The SNWA revised its water resource planning approach in 2015. Since then, the SNWA has developed a series of annual planning scenarios for inclusion in its 50-year Water Resource Plan. The scenarios represent a range of future water resource needs under variable Colorado River supply and demand conditions.

These supply conditions were developed to reflect current and likely conditions in the Colorado River Basin, as well as the potential for more significant water resource shortages than are currently prescribed under existing rules. Under a stress test scenario, the plan illustrates how significant reductions in available water supply might impact the region's long-term water resource picture, and what actions might be needed to balance supply and demand. These actions include:

- Potential changes to policy, pricing, education and incentive programs discussed in this plan to elicit an increased water conservation response.
- Accessing temporary water supplies to meet short-term gaps between supply and demand.
- Accelerating the development and/or use of future resources.

Southern Nevada's adaptive response measures and continued conservation response will allow the community to face federally-imposed reductions and voluntary contributions as described in the preceding section without customer impacts. A sustained conservation effort is required as we work to maximize the efficiency of our community's limited water supply and respond to ongoing drought.

Chapters 4-6 of this Plan detail the water management, conservation and education and outreach initiative managed by the SNWA to support Southern Nevada's achievement of the community's conservation goals. With a sustained conservation response and adaptive management efforts, Southern Nevada is well prepared to address the region's current and future water resource needs.

Photo: Lake Mead

Photo: Water efficient landscape

Water Management Measures

The SNWA and its member agencies implement water management measures designed to promote water conservation. The following sections describe these measures and detail new initiatives and strategies developed by the organization for implementation under the 2019-2024 Plan. New additions are designed to build upon the community's prior conservation success and/or address opportunities to improve water efficiency.

N *Look for this symbol (on left) to learn more about new strategies being implemented by SNWA under the 2019-2024 Conservation Plan.*

BEST MANAGEMENT PRACTICES

The SNWA Board of Directors and SNWA member agencies approved a Memorandum of Understanding (MOU) in 1994 regarding water conservation and efficiency programs. Amended in 1999, the MOU included 14 Best Management Practices (BMPs) for increased water efficiency in the SNWA service area.

As noted below, BMPs ranged from regulation and pricing to education and incentives:

- Water measurement/accounting system
- Incentive pricing and billing
- Water conservation/efficiency coordination
- Information/education program
- Distribution system audit program
- Customer audit/incentive program
- Commercial/industrial audit/incentive program
- Landscape audit program
- Landscape ordinances
- Landscape retrofit incentive program
- Wastewater management/recycling program
- Fixture replacement program
- Plumbing regulations
- Water shortage contingency plan

The MOU provided SNWA member agencies with the flexibility to prioritize and implement the BMPs on an individual basis, or to participate in joint programs that would cover some or all SNWA member agencies. The MOU served as a foundation for the agencies' subsequent water management, conservation and education/outreach initiatives as further described below and in Chapters 5 and 6.

MUNICIPAL WATER MANAGEMENT

Progress towards the SNWA's water conservation goal is dependent in part upon the water management and business practices of SNWA's member agencies. Consistent with the BMPs detailed on left, water management efforts include universal metering, managing non-revenue water, implementing tiered rates and water reuse. As described briefly below, the SNWA and its member agencies will continue to use these base water management practices.

Universal Metering

SNWA member agencies fully meter all customer connections for all classes of water in accordance with AWWA standards. Metering efforts include: source-water metering; service-connection metering and reading; fixed-interval meter reading; and meter-accuracy analysis.

Photo: WaterWorks, a new exhibit at the Springs Preserve

Meter Repair and Replacement. All water purveyors participate in ongoing meter repair and replacement efforts. Small meters are subject to a planned replacement program based upon life expectancy, while large meters are regularly maintained and calibrated. Inaccurate or non-functioning meters are subject to repair or replacement.

Meter Reading and Monitoring. Meters are read monthly, and information is classified and retrievable based on customer class, meter size, land use and other relevant variables. Customer meters are monitored for consumption anomalies – such as spikes in consumption due to leaks – and this information is used to notify customers of unusual account activity.

Additionally, SNWA's largest water purveyors (LVVWD, Henderson and North Las Vegas) have implemented automated meter reading (AMR) and/or advanced metering infrastructure (AMI) systems. These technologies eliminate the need for individual manual reads, improve meter-reading efficiency, provide higher resolution data for research and analysis, and provide customers with improved billing processes.

Incentive Pricing and Billing

While the SNWA's member agencies set water rates independently, they use similar conservation rate principles to manage water demand. Over the years, SNWA water purveyors have compressed tier thresholds and significantly increased upper tier water rates. To maintain a strong pricing signal, the SNWA adopted the recommendation of a citizens' committee in 2015 to promote water rates that sustain and advance conservation achievements by ensuring rates keep pace with inflation.

Conservation Rates. The SNWA's purveyor members use incentive pricing to promote water conservation. Under an increasing block rate model, the unit price of water in each succeeding block or "tier" is charged at a higher price. In simple terms, as a customer's water use increases, so too does the price they pay for that water. This pricing provides a financial incentive for customers to improve efficiency and eliminate water waste. The SNWA's purveyors also implement a commodity charge, used to pay for SNWA water system enhancements. The fee is based on water usage; higher users pay a higher proportional share. Customers are billed monthly based on metered use, and bills include consumption information (gallons of water used/billed under each tier).

While rates are an effective conservation measure, public water agencies also have an obligation to the well-being and vitality of the communities they serve. As such, the SNWA's member agencies will consider further rate adjustments when warranted to achieve conservation goals or operational requirements, and work to ensure water pricing appropriately balances the need for conservation with economic factors.

Water Budget Surcharges. All golf courses in the SNWA service area are on an approved water budget. A surcharge is applied to golf courses that use more water than their budgeted amount. Surcharges are assessed on an annual basis in addition to the price paid for water.

Water Waste Fees. Customers are subject to fees if water waste issues are not resolved within a prescribed timeframe, or for recurring violations. The fees assessment doubles with subsequent violations.

Development Codes and Policies

The SNWA's member agencies adopted landscape and development codes that are among the most stringent in the U.S. These include:

Landscape Watering Restrictions. All jurisdictions implement assigned watering groups that limit watering to one day/week in winter, three days/week in spring and fall, and six days/week in summer. Spray irrigation is prohibited from 11 a.m. to 7 p.m. from May – August 31.

Vehicle Washing. A positive shutoff nozzle is required for residential vehicle washing. Commercial vehicle washing is prohibited unless water is captured to the sanitary sewer, where it can be treated and reused.

Turf Provisions. Turf installation is prohibited in new residential front yards and is limited to a maximum of 50 percent of the landscape area in backyards. Except for schools and parks, the use of turf is prohibited in new non-residential development.

Mist Systems. Commercial use of mist systems is limited from May – August from 12 p.m. to 12 a.m.

Golf Course Water Budgets. Golf Courses are subject to mandatory water budgets that allow 6.3 acre-feet of water annually per irrigated acre. New courses are limited to 45 acres per 18-hole course, plus five acres for a driving range.

Water Waste. The SNWA works with its member agencies to implement ordinances and/or service rules that prohibit water waste, which includes:

- Allowing water to spray or flow off a property.
- Watering outside of assigned day(s).
- Failure to comply with landscape codes and service restrictions.
- Using sprinklers from 11 a.m. to 7 p.m. between May 1 and August 31.
- Failure to repair a malfunctioning irrigation system or supply line within 48 hours.
- Failure to discharge swimming-pool/spa drainage water into a public sanitary sewer, if available.

Water Waste Enforcement

Compliance with water waste rules is implemented by individual SNWA member agencies. Upon observance of water waste, customers are provided with notice and allowed time to correct problems; citations and fees may be issued if water waste violations are not resolved within the prescribed timeframe, or for recurring violations.

N Reduce Outdoor Irrigation

Following a comprehensive ordinance review process between the SNWA and its member agencies, the SNWA Board approved and implemented a voluntary change to summer watering restrictions in 2016 that prohibits Sunday watering. That restriction was made mandatory and permanent in 2017, limiting irrigation to six days a week during summer months. It's estimated that eliminating landscape watering on Sundays will save the community up to 900 million gallons of water per year.

N Increase Water Waste Enforcement

The SNWA is working with its member agencies to investigate opportunities to increase water waste enforcement within their respective service areas – from deploying additional labor for compliance investigations to increased outreach and messaging for seasonal watering restrictions. Other purveyors are ramping up enforcement on an individual basis.

In late 2018, the SNWA's largest water purveyor (LVVWD) released a new mobile webpage using geo-location technology, which allows users to pinpoint the address of water waste with their phone – the application records the date, time and type of waste observed, and allows users to upload photos. The form sends users a confirmation email and prompts investigation by the water service provider. The City of Henderson has a similar application, and all SNWA municipal water providers have online systems to report water waste.

Water Efficiency Standards

Plumbing Fixtures. Plumbing fixtures in new residential or commercial buildings must incorporate state and federal standards for plumbing fixtures, including water-use standards for toilets, faucets, showerheads and urinals.

Increase Water Efficiency Standards

The Nevada State Legislature approved legislation in 2019 to increase water efficiency standards for new development. The new standards will become effective in 2020. Figure 4.1 includes a comparison of current and futue standards for residential toilets, showerheads and bathroom faucets, as well as commercial urinals. Efficiency standards are presented in terms of gallons per minute (gpm) and/or gallons per flush (gpf).

Figure 4.1: Proposed local water efficiency standards

Fixture/Appliance	Current Standards*	New Standards
Toilet	1.6 gpf	1.28 gpf
Urinal	1 gpf	0.5 gpf
Showerhead	2.5 gpm	2.0 gpm
Faucets	2.2 gpm	1.5 gpm

**gallons per flush (gpf) / gallons per minute (gpm)*

Water Loss Management and Prevention

All water delivery systems experience losses. In the water industry, these losses are known as non-revenue water or unaccounted-for-water. Non-revenue water losses are typically associated with leaks, variations in meter accuracy and theft.
The SNWA and/or its member agencies implement several strategies to minimize water loss within the regional and municipal water distribution systems. Described below, these efforts will continue to improve accounting accuracy for and minimize loss of non-revenue water.

- SNWA's member agencies have created and adopted Uniform Design and Construction Standards for Potable Water Distribution Systems. These detailed construction standards assure that water delivery systems meet or exceed industry standards. [xii]
- Efforts are ongoing in all service areas to identify and proactively replace older infrastructure deemed susceptible to leaks. For example, most cast-iron mains are being systematically replaced, as are polyethylene service connections that do not appear to be meeting longevity expectations.
- Soil testing is conducted before facility installation to identify potential distribution system threats. For example, plastic sleeves are used to prevent corrosion in areas where testing indicates soil chemistry will be destructive to copper pipes.
- Reservoirs are thoroughly inspected at regular intervals to assure integrity, and special monitoring devices detect and report leakage.
- A substantial portion of purveyor distribution lines have permanent listening devices installed that can signal patrolling employees of leaks that fail to surface and assist in accurately determining the leak location for excavation.
- Interagency collaboration speeds leak repairs through fast-tracking line location ("call-before-you dig") and prompt repair. The estimated system loss for each leak repaired is tracked.

N Expand Water Loss Programs

The SNWA conducted a survey among its purveyor member agencies and is developing strategies to help purveyors reduce water loss through collaboration and a new interagency water loss management group. The near-term goals of the group are to develop research projects that evaluate the savings potential of leak detection technologies, and to potentially deploy new technologies within member agency service areas to test their effectiveness and results. The SNWA's current water loss rate is approximately one percent; SNWA water purveyor's distribution system water loss rate is approximately five percent, both well below industry norms.

In 2019, the SNWA launched a new program to include customer incentives for leak detection devices. The organization also is looking into the feasibility of implementing a water line repair assistance program. Additionally, emerging technologies have been deployed on a trial basis through SNWA and member agency collaborations with WaterStart (see Chapter 7) to test the effectiveness of water loss management and prevention technology advancements, among other priorities; technology is implemented on a case-by-case bases based on a review of cost/benefit and overall performance.

Water Reuse

Nearly all water used indoors within the SNWA service area is recycled, either as direct or indirect reuse. Direct reuse involves capturing, treating and reusing wastewater flows for non-potable uses such as golf course and park irrigation. Indirect reuse consists of recycling water by way of treatment and release to the Colorado River for return-flow credits (see Chapter 2). Approximately 40 percent of water deliveries in the SNWA service area results in highly-treated wastewater. Of that, 99 percent is treated and recycled for water reuse.

As shown in Figure 4.2, nearly all the highly-treated wastewater from water used indoors is recycled for direct and/or indirect reuse. This reuse of water extends SNWA resources because it can be recovered and used again until that water is fully consumed. Consumptive uses – including water used for irrigation, evaporative cooling and other uses – comprise the largest consumptive use of water in Southern Nevada. The SNWA estimates that 60 percent of water delivered in its service area is not returned for wastewater treatment.

Although the SNWA supports and promotes water conservation, both indoors and outdoors, the organization specifically targets consumptive water use. By focusing on consumptive uses, SNWA can maximize conservation gains, as well as staffing and funding resources needed to support those gains.

N Maximize Reuse Outside the Valley

In 2017, the SNWA adopted a policy to address water use outside the Las Vegas Valley (Appendix 2). Among other things, the policy prioritizes the return of treated wastewater to Lake Mead for return-flow credits, and implementation of reuse to achieve full beneficial use of SNWA water resources where returning treated wastewater to Lake Mead is not feasible. There are few communities within the nation that implement water reuse as aggressively or effectively as the Southern Nevada community.

Water Pressure Management

Water pressure is related to the vertical distance between the property served and the reservoir providing service. Peak water use and routine water system operations can also cause water pressure to fluctuate. The vast majority of Southern Nevada water customers operate within a pressure range of 80-85 pounds per square inch (psi). In limited instances, pressure is higher or lower. Pressure reducing valves (PRVs) are located throughout the system to manage leaks and losses caused by high pressure. Most new buildings install PRVs as well.

The SNWA and its member agencies use Supervisory Control and Data Acquisition (SCADA) systems to monitor and adjust system pressure; conduct routine PRV calibration, and dispatch distribution crews to perform repairs.

Figure 4.2: Wastewater reuse

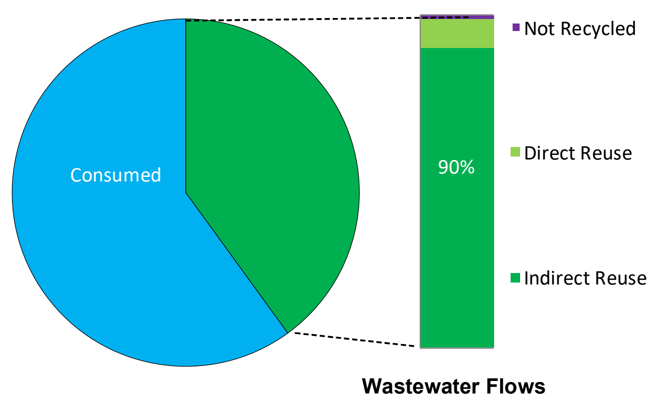


Photo: Landscape conversion

Specific Water Conservation Measure

This chapter describes specific water conservation measures that fall outside of the water management measures and education/outreach efforts described in Chapter 4 and Chapter 6, respectively. Many of the specific conservation measures detailed in this chapter rely on voluntary behaviors, product upgrades or mandatory behavior changes through enforcement of ordinances or conservation rules. These conservation measures address residential and commercial water use in Southern Nevada, as well as indoor and outdoor water uses. Estimated water savings by each specific conservation measure is provided in Appendix 3.

N *Reminder: Look for this symbol to learn more about new strategies being implemented by SNWA under the 2019-2024 Conservation Plan.*

INCENTIVE PROGRAMS

The SNWA has developed an extensive suite of tools to help customers in its service area improve water efficiency and reduce water waste. Below is a description of incentive programs the SNWA plans to offer over the five-year planning horizon.

WSL Landscape Rebate Program

The Water Smart Landscapes Rebate Program (WSL) offers financial incentives to residential and commercial customers in the SNWA service area that replace water-thirsty lawns with water-efficient landscaping. Since the majority of Southern Nevada's water is used outdoors on landscaping, the WSL program targets the largest consumptive use of water as a top priority.

Increased in 2018, the current rebate amount is $3.00 per square foot of grass removed and replaced with desert landscaping, up to 10,000 square feet, and $1.50 per square foot thereafter. The maximum annual award for any property is $500,000. To sustain results, participants must grant a conservation easement that promises the project will be sustained in perpetuity.

The WSL program is projected to remain a major demand-reduction tool as the community works to achieve its conservation goal. In addition to the financial incentives, the SNWA offers many free planning tools and resources to help residents and

Photo: Water Smart Landscape after conversion. More than 60,500 projects have been completed under SNWA's WSL program since 1999.

businesses prepare for their turf conversion.

- An online plant list that includes more than 500 trees, shrubs, groundcovers and other desert-adapted plants suitable for desert environments.
- An online plant search database that includes plant photos and characteristics (such as water and maintenance needs).
- Tools for landscape design, including a needs assessment, step-by-step design worksheet and design planning tips.
- Sample landscape designs with suggested plant selections, layouts and tips for success.
- Free landscaping and irrigation design classes offered by SNWA experts.
- Online and print resources for: qualified landscape contractors; installing/maintaining; managing pests; installing and maintaining drip irrigation; and setting irrigation controllers.

N Boost Participation in WSL

The SNWA's Water Smart Landscapes Program has been highly-effective in reducing outdoor consumptive water use. Since program inception in 1999, residents and businesses have completed more than 60,500 conversions, resulting in the removal of nearly 190 million square feet of turf.

Increased Incentive Amount. The SNWA monitors participation in its incentive programs and has made adjustments to maintain public interest and participation over time. The SNWA increased the WSL program incentive amount in 2018 due to plateauing annual enrollment and has experienced a significant rise in interest and applications since. SNWA will continue to monitor program results and support applicants through the conversion process.

Targeted Outreach. Since 2015, more than 4,400 customers began the application process but did not complete a conversion through the SNWA's WSL program. The SNWA began targeted outreach to these customers in 2018 to promote completion of the application and conversion process. The SNWA will monitor the effectiveness of its targeted outreach efforts and continue to employ these or similar outreach strategies if efforts are effective in drawing WSL program enrollment and project completion.

N Target Median/Streetscape Turf Removal

Turf has long been a popular landscaping choice for medians, traffic circles and streetscapes. These applications of turf, however, drain our community's water resources and provide no functional value for our residents. Grass requires more than four times more water than desert-adapted landscapes. SNWA estimates there is approximately 5,000 acres of non-functional turf left within the service area. The replacement of non-functional turf, particularly in streetscapes and medians, is a high priority for the SNWA and the community, since these applications provide no practical benefit.

The SNWA does not anticipate removing all turf within the region, but rather seeks to encourage the use of turf in only those applications where it is functional, or regularly utilized.

Image: WSL program facts. The program has saved more than 119 billion gallons.

The SNWA is developing tactics to reduce non-functional median and streetscape turf, and to limit new turf installations to functional applications such as sporting and recreational fields at schools and parks. While current building codes restrict turf installation for new development, many projects were authorized under prior rules and additional outreach is required.

The SNWA continues to develop its tactics for this program goal but has begun targeted outreach to homeowner associations and other commercial customers that have entry, sidewalk or median turf. Targeted outreach is a high priority and the SNWA is investing significant time and effort to set up and conduct tailored meetings and/or formal presentations that include individualized information about potential water and cost savings to these customers. Additional strategies to reduce and replace median and streetscape turf are currently being evaluated and/or are under development.

Photo: Streetscape turf. Replacing turf along streets and in medians will improve water efficiency and reduce water waste.

N Replace Cool Season Grasses

The SNWA expanded WSL provisions in 2018 to allow for schools and parks to replace cool- season grass with warm-season varieties. Replacing cool-season grasses (such as bluegrass, fescue and ryegrass) with warm season varieties (such as Bermudagrass or seashore Paspalum) in functional play areas can significantly reduce irrigation water use. Warm season grasses are known to thrive in warmer climates and are durable for high-traffic play.

To support this effort, the SNWA conducted a basic assessment to determine the number of eligible parcels and program potential. The SNWA will monitor water savings to determine if ongoing implementation or program expansion is warranted.

Water Efficient Technologies Rebate Program

The SNWA's Water Efficient Technologies (WET) program offers financial incentives to commercial and multi-family property owners that install water-efficient devices. Consumptive-use technologies earn a one-time payment of $45 per 1,000 gallons conserved annually or up to 50 percent of the product purchase price, whichever is less. Non-consumptive use technologies earn a one-time payment of $15 per 1,000 gallons conserved annually or up to 50 percent of the product purchase price, whichever is less. The rebate amount excludes labor and installation costs.

Businesses can work directly with the SNWA to implement custom technology that meets their needs or select pre-approved water saving technologies with predictable savings and a defined monetary incentive for technology improvements.

Some of the pre-approved technologies include:

- High-efficiency toilet retrofits
- Efficient showerhead retrofits
- Waterless and high-efficiency urinal retrofits
- Conversion of sports fields to artificial surfaces
- Retrofits of standard cooling towers with qualifying, high-efficiency drift elimination technologies

N Boost Participation in WET Program

Like the SNWA's WSL program, WET works to reduce consumptive and non-consumptive water use. More than 300 WET projects have been completed at commercial properties since program inception. The following new strategies are being employed under the 2019-2024 Plan to achieve continued conservation gains, increase program participation and/or expand offerings.

Increase Incentive Amount. In 2018, the SNWA increased the WET incentive amount to achieve continued conservation gains and increase program participation. Likewise, the SNWA removed the maximum annual rebate amount for schools and parks to further incentivize their participation in the program, and to obtain data that can help to inform potential program changes in the future.

Support Athletic Field Conversions/Park Conversions
As noted above, the SNWA removed the maximum annual rebate amount under WET for schools and parks in 2018. Schools and parks represent a significant opportunity for turf conversions since athletic fields are only in use seasonally and/or large portions of turf in many parks is not utilized for recreation and play.

The SNWA began investigating the feasibility of offering an increased incentive to schools within the Clark County School District (CCSD) for the conversion of high school football fields from grass to artificial turf. A typical field includes 94,000 square feet of play area and a single field conversion could yield a seven-million-gallon annual water savings. Benefits include water savings, operational cost savings for schools from reduced water/maintenance fees, and year-round aesthetic appeal. The SNWA will work with CCSD to identify candidate schools, implement conversions and monitor results to gauge effectiveness of this conservation measure.

Likewise, the SNWA began investigating opportunities for the conversion of underutilized park turf to more water-efficient surfaces such as sport court hardscapes and skate parks; splash pads with recovery and reuse systems; playground and picnic areas; and more efficient turf grasses or ground covers at recreational facilities. Anticipated benefits include improved quality of life, higher utilization of play areas, and cost and water savings. The SNWA will work with park managers to identify candidate parks, implement conversions and gauge the effectiveness of this conservation measure.

Partner to Test New Technologies. Through collaborations with WaterStart (see Chapter 7), the SNWA is testing the effectiveness of new water saving technologies. Based on the results of pilot programs, the SNWA may add technology options to its list of pre-approved technologies or share program results with the businesses community as an opportunity under the WET program.

Conduct Targeted Outreach. Outreach efforts to businesses include letters and/or formal presentations that present individualized information about potential water and cost savings under the new WET incentive amounts. The SNWA will monitor the effectiveness of its targeted outreach efforts and continue to employ these or similar outreach strategies if efforts are effective in drawing WET program participation.

Coupons and Rebates

The SNWA offers a variety of instant coupons and rebates for single-family, residential property owners. The programs contribute to water use reductions within the community and offer customers easy access to water efficiency tools while minimizing the SNWA's program time and management costs.

Water Smart Car Wash Coupons. As of 2018, coupons are available from 17 partners for use at 39 valley-wide locations. The SNWA's Water Smart Car Wash partners recycle water used on-site or send it to a water treatment facility, where water is treated and returned to Lake Mead for reuse.

Smart Irrigation Controller Rebates.
As of 2018, rebates are available for the purchase of 25 qualifying products. Smart controllers can improve water efficiency by helping homeowners

automatically adjust their watering schedule according to weather and plant demands. Customers can save up to $100 or 50 percent off the price of a smart controller, whichever is less. For commercial properties and HOAs, the SNWA's rebate pays up to $40 per valve or 50 percent off the product costs for smart controllers.

Pool Cover Rebates. An exposed pool can lose approximately 50 gallons of water per square foot to evaporation annually. Pool cover rebates are available for use at eight valley-wide retailers. The SNWA's rebate pays up to $50 for the purchase of a temporary pool cover or 50 percent off the purchase price, whichever is less. For permanent, mechanical pool covers, the SNWA pays up to $200 or 50 percent off the purchase price, whichever is less.

N Offer Rebates for Leak Detection

Water Leak Detection Rebates. New to the program as of 2019, the rebate pays up to $200 for the purchase of a leak detection unit or 50 percent, whichever is less. The unit monitors water flow and pressure going into the home and can provide early warning of potential problems.

Other Resources

The SNWA offers several resources to help residential water users become more efficient, both inside and outside the home. From how-to leak detection videos to indoor water saving tips, online resources provide customers with information on new high-efficiency products as ways to maximize the water savings. Other offerings include:

Indoor Water Audit Kits. The SNWA provides free indoor kits for residential customers located within the SNWA's member agency service area. Kits include a kitchen faucet fixture, bathroom sink aerators, a water flow testing bag, leak detection tablets, thread-sealing Teflon tape and a water-efficient shower head.

Water Use Estimator. This free online tool helps customers calculate their water footprint based on the size of their home, number of occupants, existing appliances and outdoor landscaping. The water use estimator projects water usage by month and provides customized tips for reducing indoor and outdoor water use.

Photo: Pool cover. An exposed pool can lose more than 50 inches of water per year to evaporation.

Demonstration Gardens. The SNWA and its member agencies operate, support and/or promote several desert demonstration gardens throughout the Las Vegas Valley, and support the development of smaller demonstration projects.

Likewise, the SNWA promotes the Springs Preserve's demonstrative gardens, its water-efficient landscaping, and its classes by master gardeners and horticulturists. Regular programing (that is free to the public) includes irrigation system maintenance and drip irrigation basics.

N Offer Site Appraisals to High Water Users

The SNWA has designed a new program for single-family residential properties. Select high water-use customers will be invited to participate in an on-site appraisal, based on their water use history. The review will include an audit of indoor plumbing and appliances, and outdoor water uses. The goal of the program is to help single-family residential customers with unusually high water use to identify conservation opportunities and implement solutions.

SNWA staff will provide information on irrigation controller management, as well as information on SNWA rebates, incentives and other programs designed to help customers save water and money. The program launched in 2019 and will be evaluated for continued implementation based on program results.

As part of the appraisal, multi-family and commercial properties receive a water use analysis based on their landscape area and five years of water use history. The results help property owners/managers identify opportunities to reduce landscape overwatering.

Photo: Photo: Outreach. SNWA's Conservation Team launched a new program in 2019 to offer site appraisals to select customers.

Public Education and Outreach

In addition to its water management and incentive programs, the SNWA continues to maintain education and public outreach programs designed to keep residents and businesses informed of current conditions and encourage ongoing conservation. Education and outreach efforts are extensive and are described briefly below.

ADVERTISING, PUBLICATIONS & MEDIA

The SNWA executes a comprehensive campaign of television, print and radio ads designed to educate the community on the value of water, need for conservation, and specific programs.

The SNWA's current ethics campaign focuses on the value of water. Key messages for the campaign are 'every drop makes a difference in our community' and 'every drop counts.' The agency's compliance campaign focuses on compliance with seasonal watering restrictions, including no watering on Sunday. A new compliance campaign launched in early 2019. The campaign emphasizes that irrigation restrictions are mandatory. Campaign materials can be found in paid advertising (television, print and radio), as well as online at SNWA.com and on social media outlets.

Direct Mail. In coordination with its member agencies, the SNWA distributes bill inserts that contain useful information and conservation tips. Bills provide easy-to-read information about assigned watering days and comparative water use information/graphics that help customers identify possible problems.

Additionally, the SNWA distributes a Landscape Watering Schedule and Water-Smart Living to residential water customers throughout the Las Vegas Valley. The latter is a tri-annual publication mailed to more than 700,000 single and multi-family homes in Southern Nevada. It includes drought updates, information on conservation programs and incentives, and tips for landscape care and water efficiency.

Interactive Website. The award-winning snwa.com features videos, infographics, multimedia demonstrations and other features to help residents and businesses save water. Customers can find their watering group, submit a water waste report, sign up for rebate programs, print coupons, and calculate potential water savings of converting grass to water-smart landscaping. A plant list, sample landscape designs and other landscape resources discussed in this plan also are available.

Water Ways. This monthly television program airs daily on local government cable channels and includes information on current water supply conditions and water conservation topics.

Videos and Multimedia. Instructional videos are available free of charge at snwa.com and youtube.com. They feature how-to multimedia demonstrations that aid customers with finding and fixing leaks, converting grass to water-efficient landscape, setting irrigation clocks, and other topics.

Photo: SNWA advertising campaign. Recent campaigns have focused on humor to attract and hold audience attention.

Social Media. The SNWA has an active online presence, engaging customers through Facebook, Twitter and other social media platforms daily. Followers receive conservation tips, weather-related landscaping information and how-to photos and videos.

Education, Engagement and Support

WaterSmart Innovations. The SNWA hosts an international peer-to-peer conference annually that allows attendees to obtain the most current information about water efficiency concepts in urban environments, as well as water conservation education. Since its inception in 2008, the program has featured more than 1,000 professional sessions, panel discussions, and pre-conference workshops. More than 8,300 attendees and 550 exhibitors have attended.

Youth Education. The SNWA's youth education program provides training and materials to teachers so they can help students learn about our region's unique water resource issues.

- Desert Discovery is published twice annually and features articles and activities about desert conservation and water resources. Newsletters are available for grades K-2 and 3-5. It is distributed free of charge to about 250 local public and private elementary schools. The newsletters are accompanied by a teacher's edition.

- The SNWA established a Youth Advisory Council comprised of local high school students who have been appointed by their principals based on academic and leadership skills, as well as an interest in environmental issues. The council provides a forum for local youth to research water-related issues and suggest fresh ideas to the SNWA Board of Directors.

- The SNWA mascot, Deputy Drip, makes free presentations to schools upon request. Designed for students in kindergarten through second grade, the interactive presentation teaches students about the value of water conservation.

School Grants. The Water Conservation Education Grant Program is a partnership with educational organizations in the SNWA service area that encourages resource stewardship. Eligible projects may receive grants up to 50 percent of project costs, up to a maximum of $5,000.

Other. Public educational and outreach activities focus on the SNWA's incentive programs and may include technical classes, speaking engagements, and community events.

Conservation Helpline. The Conservation Helpline (702-258-SAVE) serves as a point of contact for residents interested in available incentive programs and to request various education and literature resources.

Photo: 2018 Water Smart Innovations Conference

PARTNERSHIPS & COLLABORATIONS

Community Partnerships

Water Smart Home. Developed by the SNWA and the Southern Nevada Home Builders Association, the Water Smart Home (WSH) program promotes water efficiency, requiring homes built through the program to include water-smart landscaping and water-efficient appliances.

Homes built in the WSH program adhere to stringent water use efficiency requirements. WSH builders must utilize high-efficiency toilets, dishwashers and washing machines, efficient faucets and showerheads, and install water-efficient landscaping, low volume irrigation and efficient hot water delivery systems. Water Smart Homes use approximately 49 percent less water than homes built between 1990 and 2003.

Water Smart Contractor. The SNWA offers a Water Smart Contractor program. Companies participating in the program ensure their staff members are trained in water-efficiency practices through free, SNWA-sponsored workshops. In turn, SNWA features these companies in its Find a Landscaper application.

Contractors must complete at least eight hours of SNWA water-efficiency training, comply with business standards, maintain good standing with the Nevada State Contractors Board, and be licensed and insured. Training provided includes a detailed overview of the SNWA's programs, xeric principles, efficient irrigation design and scheduling. Annual refresher training is required.

Water Conservation Coalition. This public-private partnership was formed by community leaders to help increase water-efficient practices within the Southern Nevada business community and to promote community-wide water conservation. Through initiatives such as its speakers bureau, Business-to-Business Challenge and various public projects, the Coalition works closely with the SNWA to identify areas of conservation that are most beneficial to local businesses and the community's overall water conservation goal.

Water Upon Request. The SNWA, Water Conservation Coalition and Nevada Restaurant Association partnered to create the Water Upon Request program for restaurants. Partners agree to serve water only when patrons request it. Every glass not served saves up to 1.5 to 3 gallons of water.

WaterStart. The SNWA is a WaterStart partner. Formerly known as the Nevada Center for Excellence, WaterStart formed in 2013 as a partnership between public and private sectors to foster economic growth in the water industry (see also Chapter 7).

The SNWA has participated in several pilot projects designed to improve leak monitoring and notification, pressure surge monitoring and flow meter/pump flow efficiency. After successful testing, new technologies have been adopted/deployed within SNWA service area and/or within member agency distribution systems.

N Conduct Targeted Outreach

As noted in Chapter 5 and detailed in Figure 6.1, The SNWA began to ramp up its targeted outreach efforts in late 2018 to promote conservation programs with the largest water-saving potential for various customers/customer classes. The table below summarizes past and planned efforts.

Figure 6.1: Outreach initiatives

Targeted Outreach Initiative	2018 (Complete)	2019 (Planned)
Reengage customers that enrolled in WSL but did not complete conversion.	2,600	1,800
Promote WSL to customers with landscapes suitable for conversion.	20,000	36,000
Meet with HOAs to promote WSL and benefits.	18	36
Watering schedule reminders to customers based on meter usage data (LVVWD).	16,000	Based on meter data.
Watering schedule reminders (general).	332,000	All service areas.
Promote Pool Cover rebate to pool owners.	N/A	100,000
Offer site appraisal to high water users to promote efficiency and program enrollments.	N/A	1,000 per month.

Water Smart Innovations Conference

Research Initiatives

The SNWA has a long history of conducting conservation research and collaborating with other organizations to advance knowledge and water efficiency. The SNWA's Conservation Division provides full-time support for research and analytical services. In addition to supporting and tracking Conservation Plan implementation and conducting customer use analyses, the team helps evaluate new techniques/technologies that hold promise for water savings and efficiency, particularly related to consumptive water uses

Past research efforts were largely focused on irrigation efficiency. For example, the SNWA's best-known research initiative was the Xeriscape Conversion Study. To date, the study represents the largest and most comprehensive study on the water demand influence of landscape style on water demand. As detailed below, the Division's research focus has expanded over time as various SNWA conservation programs and initiatives have matured.

TECHNOLOGY RESEARCH

New and expanding technologies represent a growing tool for conservation and efficiency enhancements. The following describes the SNWA's current areas of exploration.

Cooling Technology

While landscaping remains the principal consumptive use of water in the Las Vegas Valley, commercial cooling represents another major consumptive demand. Although the SNWA has long supported cooling efficiency programs, the organization recognized a need for more comprehensive technical information.

The Alliance for Water Efficiency (AWE) works to explore the potential for water conservation in urban areas. As a member of the organization, SNWA is leading a bi-national study to gain foundational knowledge needed to support greater efficiency in cooling systems. The results of the study are expected to expand existing knowledge for AWE members and the SNWA hopes to use information gained to support development of effective, targeted and appealing incentive and outreach programs related to cooling. The initial research phase aims to:

- Develop best practices for identifying water-cooled facilities in urban areas.
- Develop best practices for estimating consumptive and non-consumptive water demands for cooling.
- Determine the conservation potential for various improvements to traditional cooling technologies such as cooling towers.
- Determine the conservation potential of alternative cooling technologies.
- Develop practical guides, incorporating study results, to increase the effectiveness of cooling incentive and outreach programs.

Image: Commercial cooling tower

Nine AWE members from the U.S. and Canada have made monetary, data and informational commitments to support this effort. Current study participants include:

- Southern Nevada Water Authority (Lead Agency)
- City of Guelph (Canada)
- Metropolitan Water District of Southern California
- San Antonio Water System
- City of Tucson
- City of Santa Fe
- Santa Clara Valley Water District
- California Water Service
- Denver Water

Smart Leak Detection

Smart leak detectors are a new class of smart consumer devices that have recently emerged in the marketplace. The technology is designed to monitor water use 24/7 and provide real-time information to their owners via smartphones. The SNWA is evaluating the technology under a new program to determine the potential smart leak detectors have to reduce water demand in residential households, as well as to reduce or avert major leak events and modify consumer water use behavior through engagement.

Remote Sensing

The SNWA has developed methodologies to identify irrigated turf using remote sensing technology. The data derived from this process allows the SNWA to monitor annual progress in the reduction of high-water demand landscaping. The data has also been used to improve the effectiveness of program marketing by allowing the SNWA to specifically target property owners who have a significant amount of ornamental turf on their properties.

Automatic/Advanced Meter Reading

Understanding the dynamics of customer water demand through higher frequency data is a growing opportunity as the SNWA's member agencies increase the use of Automatic Meter Reading and Advanced Metering Infrastructure. The SNWA is developing methods to utilize data to provide more insight into how and why residents use water, and subsequently develop customer engagement strategies.

EMERGING TECHNOLOGIES RESEARCH

The SNWA collaborates with the business sector to evaluate and boost adoption of new water efficiency technologies. These efforts include:

<u>WaterStart.</u> The SNWA is a member agency of WaterStart, formed as a Governor's Office of Economic Development initiative. WaterStart works to identify technology needs of its partners, recruit companies with novel solutions, and provide expertise and funding to test and demonstrate the variability of emerging technology products. The organization aims to help scale effective solutions, faster.

The SNWA supports WaterStart by evaluating proposals and conducting evaluations of promising new technologies. The SNWA and LVVWD have both participated in several innovation projects to pilot new technology. The following technology innovations have been deployed by the SNWA and/or the LVVWD permanently based on the value and success of pilot studies:

- Leak monitoring and real-time notification (Echologics and APANA)
- Pressure surge monitor and analyzer/leak detection (Syrinix)
- Flow meter/pump flow efficiency (Riventa)

<u>Innovative Conservation Program.</u> The SNWA previously partnered with the Metropolitan Water District of Southern California's Innovative Conservation Program. The program objective is to evaluate the water savings potential and reliability of innovative water savings devices, technologies and strategies. More than a dozen projects have been completed under the program since inception. SNWA continues to look for cost-effective opportunities to evaluate new technology.

WaterSmart Innovations. Since 2008, the SNWA has hosted the world's largest water efficiency conference and trade show. The event structure facilitates collaboration and exchange between the private and public sector. In 2018, more than 50 trade show vendors participated to showcase water-efficiency products, programs or other conservation and outreach initiatives.

OTHER RESEARCH INITIATIVES

Below is a brief summary of other related initiatives SNWA is involved in as of 2019.

National and International Code, Standards and Rating Systems Development

As a world leader in water efficiency, the SNWA has consistently engaged in the development of codes, policies and standards for water efficient devices, programs and rating systems. The SNWA will continue this work throughout the 5-year planning period.

Collaborative Research Subscriptions

The SNWA frequently provides technical and financial support to national and international initiatives relating to water efficiency. As of the release of this Plan, the SNWA is a partner to multi-agency projects studying the savings of landscape transformation, case studies in drought response measures, and technologies and practices for evaporative cooling system management.

Ongoing Program Evaluation

The SNWA's Conservation Division conducts frequent evaluations of existing programs. For example, SNWA monitors the cost of clients' landscape projects to ensure rebate incentives remain meaningful, and conducts analyses of customer response to program outreach efforts. These types of program support research and will continue throughout the duration of this Plan.

Photo: Landscape conversion at Griffith Elementary School

Plan Implementation & Schedule

PROGRAM STAFFING

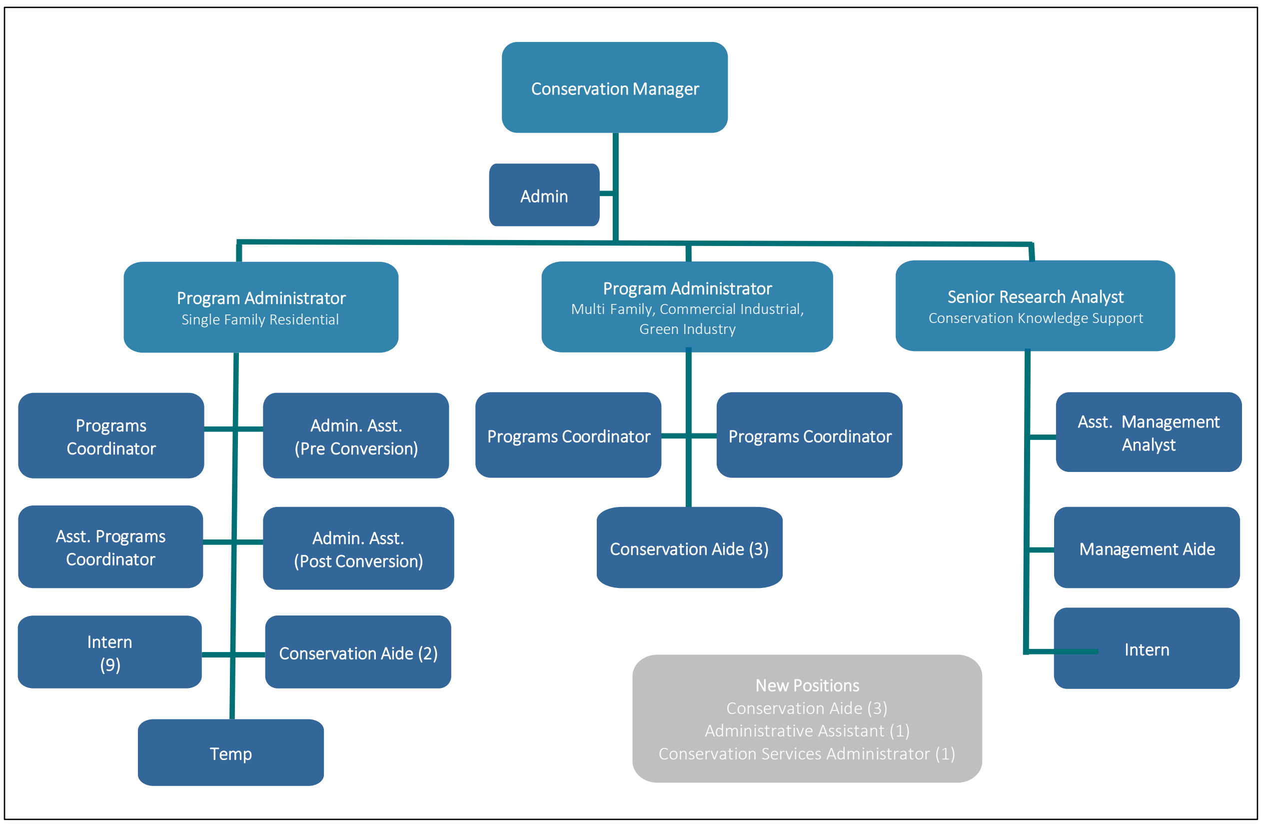
The SNWA's Conservation Division falls under SNWA's Water Resources Department. The division is led by a Conservation Manager and is supported by a team of knowledgeable conservation and program experts. As of late 2018, the division consisted of 18 full-time employees (Figure 8.1). Core staffing is augmented by interns and/or limited-term employees to support outreach, water waste enforcement and other conservation program initiatives. Likewise, the SNWA Board approved several new positions for Fiscal Year 2019/2020.

The Conservation Division is responsible for formulating and implementing the SNWA's Water Conservation Plan; developing new programs and administering existing programs as described; tracking and evaluating program progress; and making recommendations for program changes based on ongoing reviews of program performance.

Likewise, the team provides regional coordination on conservation issues and programs, with dedicated technical assistance to its member agencies. Each SNWA member agency has an appointed conservation coordinator. The SNWA also has established management and technical workgroups comprised of member agency participants that meet monthly to discuss and coordinate efforts. Discussions include ongoing implementation and maintenance of water efficiency programs and standards across jurisdictions.

Other SNWA workgroups within the organization provide support to: development and implementation of advertising, publications and media; education, engagement and support activities; partnerships and collaboration; and water waste enforcement efforts.

Figure 8.1: Conservation Division organizational chart



IMPLEMENTATION SCHEDULE

The SNWA offers conservation programs to residential and non-residential customers, targeting both consumptive and non-consumptive water uses. Consumptive water uses typically related to outdoor landscaping and non-consumptive uses are typically related to indoor uses.

As shown in Figure 8.2, existing programs are planned for continued implementation over the 5-year planning horizon. New strategies are anticipated for launch in the 2018/2019 timeframe. These will be monitored for overall performance and results. Based on ongoing assessment of conservation gains, implementation cost and other factors, the SNWA will make decisions about continued implementation, modifications or discontinuation.

Testing new strategies and tactics helps the SNWA to determine which efforts are most effective at reducing water demands.

Figure 8.2: Plan implementation schedule

PROGRAM	CUSTOMER TYPE		WATER USE TYPE		MEASURE		5 YEAR SCHEDULE (2019 2023)				
	Residential	Non Residential	Indoor	Outdoor	Existing	New*	1	2	3	4	5
INCENTIVES											
Water Smart Landscapes	x	x		x	x						
Increase incentive amount (2018)						x					
Targeted outreach to program dropouts						x	..				
Targeted streetscape turf removal						x	..				
Cool Season-Turf Incentive		x				x					
Water Efficient Technologies		x	x	x	x						
Increased incentive amount (2018)						x					
Removed annual cap for parks/schools						x	..				
Partner to test new technologies						x	..				
REBATES											
Car Wash Coupons	x	x		x	x						
Smart Irrigation Controller	x	x		x	x						
Pool Cover	x			x	x						
Water Leak Detection	x	x	x	x		x	..				
RETROFITS AND AUDITS											
Indoor Retrofit	x		x		x						
Targeted Audits for SFR Turf Customers	x		x	x		x	..				
WATER MANAGEMENT MEASURES											
Universal Metering	x	x	x	x	x						
Incentive Pricing and Billing	x	x	x	x	x						
Development Codes and Policies	x	x	x	x		x					
Landscape Watering Restrictions											
Lawn installation											
Mist systems											
Golf Course Water Budgets											
Fountains/Ornamental Water Features											
Water waste											
Water Waste Enforcement	x	x		x	x						
Water Efficiency Standards	x	x	x	x	x	x					
Water audit/loss prevention committee						x					
Water Loss and Prevention	x	x	x	x	x						
Enhanced new development codes						x					
Water Reuse and Recycling	x	x	x	x	x	x					
Out-of-Valley Reuse Policy						x					

Figure 8.2 (Cont.): Plan implementation schedule

PROGRAM	CUSTOMER TYPE		WATER USE TYPE		MEASURE		5 YEAR SCHEDULE (2019 2023)				
	Residential	Non Residential	Indoor	Outdoor	Existing	New*	1	2	3	4	5
EDUCATION AND OUTREACH											
Classes, Speaking Engagements & Events	x	x	x	x	x						
Demonstration Gardens/School Grants	x	x		x	x						
Publications and Media	x	x	x	x	x						
Conservation Helpline	x	x	x	x	x						
Youth Education			x	x	x						
PARTNERSHIPS AND COLLABORATION											
Water Smart Home	x		x	x	x						
Water Smart Contractor	x	x	x	x	x						
Water Conservation Coalition	x	x	x	x	x						
Water Upon Request	x	x	x		x						
Water Start Partner	x	x	x	x	x	x					
WaterSmart Innovation	x	x	x	x	x						

(*) New to the 2019-2024 Plan.
(..) Based on performance monitoring.

PLAN FORMULATION

The SNWA conducted a conservation strategic planning exercise in mid-2018 to identify opportunities to generate additional conservation and water efficiency savings. More than 70 measures and/or tactics were discussed and organized into six key strategic arenas:

- Engaging our Community
- Transforming Demand
- Building a Smarter Community
- Curtailing Waste and Losses
- Advancing Knowledge
- Valuing Water Appropriately

Conservation measures/tactics were evaluated on a weighted scale based on a number of factors including: overall conservation potential, public acceptance, regulatory difficulty, cost and other factors. The team considered both new initiatives and existing program enhancements. The team used this exercise as a basis for selecting new programs and/or program enhancements discussed in this Plan.

PLAN MAINTENANCE AND EVALUATION

The SNWA updates its conservation plan every 5-years as required and conducts assessment and maintenance of its program offerings on an ongoing basis.

Evaluation is an important tool that helps to inform the organization's staff and financial investments. The SNWA tracks incentive/rebate program enrollment and participation on a weekly, monthly and annual basis. Metrics evaluated by program type include: number of inquiries, projects completed, gallons of water saved, and expenditures by program type.

Program performance trends are used to identify which programs have the largest impact on reducing water demands, and which programs are drawing the highest levels of public interest/participation. Likewise, evaluation helps guide and inform public education and outreach efforts, as well as potential changes to program incentive amounts, staffing needs, and program funding.

In recent years, these metrics have identified areas of diminishing returns. As a result, the SNWA has made several changes to programs (most notably to WSL and WET) to help maintain and boost participation levels, and associated water conservation gains.

As noted in this Plan, the SNWA also monitors and tests new water-saving technology within its distribution system, monitors advancements in plumbing fixtures and appliances, and actively seeks out opportunities to advance and employ new strategies. The programs, strategies and results discussed in this Plan are evidence of the SNWA's ongoing commitment to helping the Southern Nevada community improve water efficiency and achieve its conservation goals. The next Plan update is scheduled for August of 2024.

Reporting

The SNWA reports information on conservation achievements to its Board of Directors and proposes program funding as part of its annual budget process. Likewise, information on drought, water resources and/or water conservation are typically standing items on the Board's regular meeting agenda. A summary of past performance and program benchmarks for 2019-2023 is provided in Appendix 3.

Appendix 1

MUNICIPAL WATER WASTE ORDINANCES

Water waste ordinance, building codes and other water management measures described in this plan are implemented by the SNWA's member agencies.

Boulder City

- Section 9-8-17

Clark County

- Chapter 24. 30
- Chapter 24.34
- Title 30
- Las Vegas Valley Water District Service Rules

City of Henderson

- Section 14.14.020
- Chapter 14.14

City of Las Vegas

- Section 14.08
- Section 14.08.040
- Section 14.11
- Las Vegas Valley Water District Service Rules

City of North Las Vegas

- Section 13.08.040
- Section 13.08.030
- Section 13.08

Appendix 2

POLICY REGARDING OUT-OF-VALLEY WATER USE

Managing Southern Nevada's water resources responsibly is critical to the continued vitality of the region. The ongoing risk of supply reductions underscores the need for responsible and sustainable management of Southern Nevada Water Authority (SNWA) water resources. This policy is designed to maximize the productivity of all SNWA water resources. To provide for the long-term sustainable development of resources and reduce demand impacts to Colorado River resources, the SNWA Board of Directors agrees to support the following principles for the use of Colorado River water and other SNWA water resources outside areas that are currently served by SNWA members' wastewater systems.

- Adoption of service rules and development codes by SNWS Purveyor Members that rely on industry best practices to minimize consumptive use of water resources.

- Returning treated wastewater to Lake Mead to receive return-flow credits should be accomplished whenever feasible.

- If returning treated wastewater to Lake Mead is not feasible, Colorado River water and other SNWA water resources should be reused either through direct or indirect reuse to achieve full beneficial use of recycled water similar to existing practices within the Las Vegas Valley.

- Wastewater will be treated to levels sufficient to allow the water to be reused.

- Implementation of localized, beneficial direct reuse within the development area for industrial and commercial uses, and school and community parks where feasible should displace the need for SNWA water resources.

- Implementation of aquifer storage and recovery programs, where possible.

- Limitation on the use of evaporative coolers.

Introduced and passed by SNWA Board of Directors on May 18, 2017.

Appendix 3

SUMMARY OF PAST PERFORMANCE AND ESTIMATED WATER SAVINGS/PROGRAM BENCHMARKS FOR 2019-2023 PLAN BY SPECIFIC CONSERVATION MEASURE.

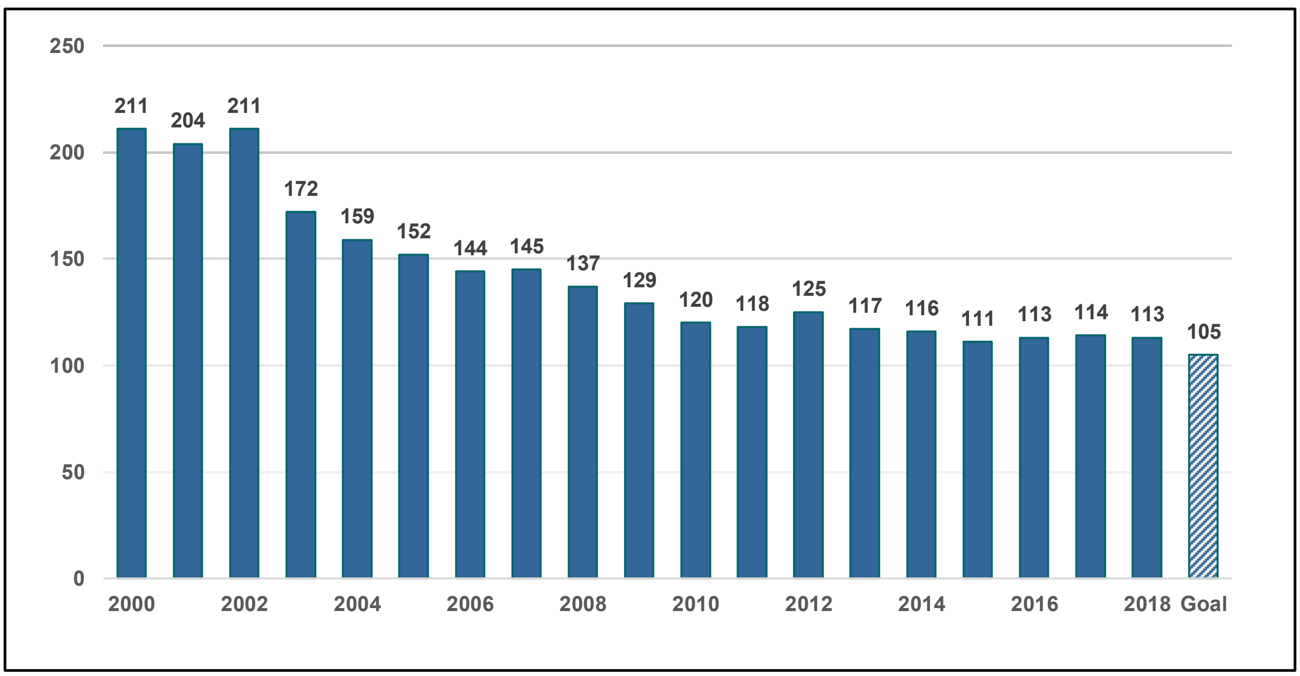
Figure A-1 includes a summary of historical SNWA water use and progress towards the SNWA's conservation goal. The pages that follow include a series of tables that provide a summary of past performance by Specific Conservation Measures as detailed in Chapter 5.

The tables include participation figures (projects completed, coupons received, etc.), associated water savings data and SNWA investment amounts by program type since individual program inception. Program statistics for the years covered under the prior water conservation plan (2014-2018) are shaded in light blue. The tables are followed by a brief narrative on estimated water savings under the current plan, as well as an explanation of how benchmarks for the 2019-2024 Plan were determined.

While benchmarks play an important role for tracking progress and setting performance targets, it is important to note that there are significant outside factors that can influence participation and results. Economic conditions are one such factor. Given that many of the SNWA's conservation incentive programs pay only a portion of the costs to purchase or upgrade landscapes, tools or technologies, economic factors can significantly influence participation levels. During the most recent economic downturn, participation levels in the SNWA's incentive offerings were significantly lower than in years prior.

It also is important to note that the SNWA has reached many of the community's most willing participants through its incentive programs and other offerings over the years. It also follows, that the well of opportunity has diminished through the success of prior efforts (i.e. there is less available turf to convert/pools to cover, etc. due to prior program enrollment). While future gains are anticipated, the SNWA recognizes they are likely to come slower than in prior years, and potential participants may be harder to compel towards change.

Figure A-1: SNWA water use and conservation goal in GPCD



PAST PERFORMANCE SUMMARY

Figures A-2 through A-4 include a summary of performance for specific water conservation measures since individual program inception. The shaded blue areas in each table correlate to the SNWA's 2014-2018 water conservation plan and provides a basis for water savings estimates/benchmarks as further described in this section.

Figure A-2: Water Smart Landscapes program performance summary 1999-2018

Year	Projects Completed	Annual Savings (Gallons)	Cumulative Savings (Gallons)	Annual Savings (AFY)	Cumulative Savings (AFY)	Dollars Rebated	Turf Converted (SF)
1999*	298	N/A	N/A	N/A	N/A	$ 77,817	N/A
2000	262	37,214,091	37,214,091	114	114	$ 368,830	666,919
2001	490	128,389,495	165,603,586	394	508	$ 894,314	2,300,887
2002	602	195,104,477	360,708,063	599	1,107	$ 1,358,253	3,496,496
2003	2379	662,176,384	1,022,884,447	2,032	3,139	$ 10,284,527	11,866,960
2004	8618	1,900,975,958	2,923,860,405	5,834	8,973	$ 28,669,569	34,067,670
2005	5735	858,585,460	3,782,445,865	2,635	11,608	$ 14,236,924	15,386,836
2006	3466	597,643,640	4,380,089,505	1,834	13,442	$ 10,964,885	10,710,460
2007	5862	1,031,129,662	5,411,219,167	3,164	16,606	$ 23,961,354	18,479,026
2008	7528	1,572,958,621	6,984,177,788	4,827	21,434	$ 43,429,187	28,189,223
2009	4938	954,473,508	7,938,651,296	2,929	24,363	$ 22,879,317	17,105,260
2010	3187	483,549,743	8,422,201,039	1,484	25,847	$ 10,753,972	8,665,766
2011	2729	364,543,353	8,786,744,392	1,119	26,966	$ 8,321,126	6,533,035
2012	2445	309,113,028	9,095,857,420	949	27,914	$ 7,084,378	5,539,660
2013	2283	270,262,334	9,366,119,754	829	28,744	$ 6,226,191	4,843,411
2014	2192	245,692,143	9,611,811,897	754	29,498	$ 5,732,305	4,403,085
2015	2113	248,696,471	9,860,508,368	763	30,261	$ 6,123,405	4,456,926
2016	2277	245,197,588	10,105,705,955	752	31,013	$ 7,094,233	4,394,222
2017	2016	196,069,426	10,301,775,381	602	31,615	$ 5,927,138	3,513,789
2018	1223	102,067,909	10,403,843,291	313	31,928	$ 3,943,377	1,829,174
Totals	**60,643**	**10,403,843,291**	**118,961,421,709**	**31,928**	**365,079**	**$ 218,331,099**	**186,448,805**

**The SNWA began tracking turf removed/gallons saved under the WSL program in 2000.*

Figure A-2: Water Efficient Technologies program performance summary 2001- 2018

Year	Projects Completed	Annual Savings (Gallons)	Cumulative Savings (Gallons)	Annual Savings (AFY)	Cumulative Savings (AFY)	Dollars Rebated
2001	2	8,293,107	8,293,107	25.45	25	$ 24,277
2002	1	19,600,000	27,893,107	60.15	86	$ 20,783
2003	2	41,968,592	69,861,699	128.80	214	$ 161,796
2004	11	98,152,157	168,013,856	301.22	516	$ 251,676
2005	6	69,901,506	237,915,362	214.52	730	$ 113,283
2006	9	79,193,774	317,109,136	243.04	973	$ 32,671
2007	17	107,441,724	424,550,860	329.73	1,303	$ 490,833
2008	4	114,851,967	539,402,827	352.47	1,655	$ 243,836
2009	9	14,604,974	554,007,801	44.82	1,700	$ 159,520
2010	33	261,594,823	815,602,624	802.81	2,503	$ 459,998
2011	22	257,135,835	1,072,738,459	789.12	3,292	$ 212,264
2012	25	116,552,466	1,189,290,925	357.69	3,650	$ 290,547
2013	23	44,133,533	1,233,424,458	135.44	3,785	$ 186,665
2014	27	108,763,954	1,342,188,412	333.78	4,119	$ 237,966
2015	33	102,154,169	1,444,342,581	313.50	4,433	$ 295,167
2016	31	58,508,976	1,502,851,557	179.56	4,612	$ 435,987
2017	46	36,198,761	1,539,050,318	111.09	4,723	$ 283,762
2018	6	7,575,453	1,546,625,771	23.25	4,746	$ 180,953
Totals	307	1,546,625,771	14,033,162,855	4,746.42	43,066.20	$ 4,181,981.87

Figure A-3: Pool Cover program performance summary 2005 – 2018

Year	Clocks Rebated	Annual Water Savings (Gallons)	Cumulative Water Savings (Gallons)	Annual Water Savings (AFY)	Cumulative Water Savings (AFY)	Dollars Rebated
2005	3,910	49,852,500	49,852,500	153	153	$ 183,357
2006	3,942	50,260,500	100,113,000	154	307	$ 297,183
2007	3,388	43,197,000	143,310,000	133	440	$ 164,191
2008	3,452	44,013,000	187,323,000	135	575	$ 173,451
2009	3,985	50,808,750	238,131,750	156	731	$ 204,957
2010	4,158	53,014,500	291,146,250	163	893	$ 215,087
2011	3,743	47,723,250	338,869,500	146	1,040	$ 193,588
2012	3,290	41,947,500	380,817,000	129	1,169	$ 175,113
2013	2,953	37,650,750	418,467,750	116	1,284	$ 154,907
2014	2,904	27,588,000	446,055,750	85	1,369	$ 153,353
2015	3,006	28,557,000	474,612,750	88	1,457	$ 160,141
2016	1,877	17,831,500	492,444,250	55	1,511	$ 104,001
2017	2,060	19,570,000	512,014,250	60	1,571	$ 116,078
2018	1,222	11,609,000	523,623,250	36	1,607	$ 70,073
Totals	43,890	523,623,250	4,596,781,000	1,607	14,107	$ 2,365,481

Figure A-4: Smart Controller program performance summary 2006-2018

Year	Clocks Rebated	Annual Water Savings (Gallons)	Cumulative Water Savings (Gallons)	Annual Water Savings (AFY)	Cumulative Water Savings (AFY)	Dollars Rebated
2006	10	97,100	97,100	0.30	0.30	$ 26,228
2007	41	359,270	456,370	1.10	1.40	$ 25,119
2008	14	106,810	563,180	0.33	1.73	$ 27,925
2009	10	48,550	611,730	0.15	1.88	$ 18,974
2010	21	116,520	728,250	0.36	2.23	$ 75,628
2011	30	213,620	941,870	0.66	2.89	$ 9,168
2012	42	339,850	1,281,720	1.04	3.93	$ 22,097
2013	23	155,360	1,437,080	0.48	4.41	$ 21,622
2014	75	495,210	1,932,290	1.52	5.93	$ 57,398
2015	228	1,767,220	3,699,510	5.42	11.35	$ 120,991
2016	836	7,855,390	11,554,900	24.11	35.46	$ 152,008
2017	941	8,952,620	20,507,520	27.47	62.94	$ 168,278
2018	599	5,728,900	26,236,420	17.58	80.52	$ 359,455
Totals	2,870	26,236,420	70,047,940	80.52	214.97	$ 1,084,889

ESTIMATED WATER SAVINGS/PROGRAM BENCHMARKS

Figure A-5 provides a summary of estimated water savings by specific conservation measure for the five-year planning horizon and Figure A-6 provides a cumulative water savings for the five-year period. These tables are followed by a short explanation on how estimated water savings/ program benchmarks were derived, by program initiative. Figure A-7 includes a summary of other program benchmarks, including current and future (target) service levels.

Figure A-5: Annual water savings estimate/program benchmarks by specific conservation measure 2019-2023 (in gallons)

Program / Initiative	2019 Benchmark	2020 Benchmark	2021 Benchmark	2022 Benchmark	2023 Benchmark
Water Smart Landscapes	195,300,000	175,770,000	158,193,000	142,373,700	128,136,330
Water Efficient Technologies (WET)	40,000,000	40,000,000	40,000,000	40,000,000	40,000,000
Smart Controller	8,156,400	8,156,400	8,156,400	8,156,400	8,156,400
Pool Cover and Developing Coupons	14,250,000	14,250,000	14,250,000	14,250,000	14,250,000
Site Evaluation	1,400,000	2,100,000	2,800,000	3,500,000	4,200,000
Indoor Retrofit	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000
Water Efficiency Code Enhancements	-	40,906,700	61,814,600	52,724,200	52,724,200
Total	**262,387,600**	**284,464,300**	**288,495,200**	**264,285,500**	**250,748,130**

Figure A-6: Cumulative water savings estimate by specific conservation measure 2019-2023 (in gallons)

Program / Initiative	2019 Savings	2020 Savings	2021 Savings	2022 Savings	2023 Savings
Water Smart Landscapes	195,300,000	371,070,000	529,263,000	671,636,700	799,773,030
Water Efficient Technologies (WET)	40,000,000	80,000,000	120,000,000	160,000,000	200,000,000
Smart Controller	8,156,400	16,312,800	24,469,200	32,625,600	40,782,000
Pool Cover and Developing Coupons	14,250,000	28,500,000	42,750,000	57,000,000	71,250,000
Site Evaluation	1,400,000	3,500,000	6,300,000	9,800,000	14,000,000
Indoor Retrofit	6,000,000	12,000,000	18,000,000	24,000,000	30,000,000
Water Efficiency Code Enhancements	-	40,906,700	102,721,300	155,445,500	208,169,700
Total	**262,387,600**	**546,851,900**	**835,347,100**	**1,099,632,600**	**1,350,380,730**

Water Smart Landscapes: Continued implementation of the SNWA's Water Smart Landscapes program is estimated to generate between 128,136,330 and 195,300,000 gallons of water annually over the five-year planning horizon for a cumulative water savings of 799,773,030 during the same period. The projection includes an assumed ten percent year over year reduction in water savings as the program moves closer to maturity.

Water Efficient Technologies: The SNWA estimates an annual water savings of 40,000,000 gallons for the Water Efficient Technology program between 2019-2023, which would result in a cumulative water savings of 200,000,000 gallons during the same year period. The projection includes a slight increase to 2017/2018 program results, sustained for the five-year planning horizon.

Smart Controllers: The SNWA estimates an annual water savings of 8,146,400 gallons for the Smart Controller Rebate program between 2019-2023, which would result in a cumulative water savings of 40,782,000 gallons for the same five-year period. The projection is based on the five-year program average.

Pool Cover and Developing Coupons: Continued implementation of the SNWA's Pool Cover Rebate program and the introduction of new coupons (Leak Detection Rebate) are estimated to save 14,250,000 annually between 2019 and 2023 for a cumulative water savings of 71,250,000 during the same five-year period.

Site Evaluations: The SNWA launched a new site-evaluation program in 2019. This invitation-only initiative targets the community's highest water users. The program is estimated to save between 1,400,000 – 4,200,000 annually, increasing year over year as program startup, launch and maintenance activities are underway. Over the five-year planning horizon, cumulative water savings are estimated at 14,000,000 gallons.

Indoor Retrofit: Continued distribution of indoor retrofits kits is estimated to generate 6,000,000 gallons of water annually over the five-year planning horizon for a cumulative savings of 30,000,000 during the same period.

Water Efficiency Code Enhancements: Proposed water efficiency code enhancements are expected to become effective December 31, 2019 with dwellings impacted in by change occupied in mid-to-late 2020. Water savings/benchmark calculations assume 114,500 residents in more than 44,000 dwellings will be affected by code changes. Estimated annual water savings range from approximately 41,000,000 - 53,000,000 gallons per year for a cumulative water savings of 208,169,700 gallons over the five-year period.

Figure A-7: Other program benchmarks

Program/Initiative	Current Levels (2018/2019)	5 Year Benchmark (target)
Continue to meter new service connections.	All accounts metered	Maintain current service level
Continue to conduct incentive pricing and billing and evaluate pricing structures to ensure a strong pricing signal is maintained to promote conservation.	All customers on conservation pricing structure	Maintain current service level
Continue to implement development codes and policies that restrict landscape watering, lawn installation, use of mist systems, fountains/ornamental water features, and water waste.	Codes/ordinances in place	Maintain current service level
Continue to require water budgets for golf course customers.	All golf courses on water budgets	Maintain current service level
Continue to conduct water waste enforcement and collaborate to identify possible opportunities to for increased compliance through regional coordination.	Active enforcement	Increase compliance
Support increased water efficiency standards through changes to state law and/or local ordinances.	EPA WaterStart standards in effect	Iimplement higher standards (see pg. 20)
Continue to implement aggressive water reuse, including implementation of SNWA's 2017 Out-of-Valley Reuse Policy.	99% of reuse treated of wastewater flows through direct and indirect reuse.	Maintain current service level
Conduct ongoing meter repair and replacement.	Ongoing	Maintain current service level
Notify customers of high-water use/possible leaks based on meter data.	Ongoing	Maintain current service level
Inspect and assess water delivery infrastructure and develop plans to proactively replace assets deemed susceptible to leaks, as practical.	Ongoing	Maintain current service level
Continue to implement leak detection programs as described and seek opportunities to further reduce water loss within the SNWA service area. Establish a water audit/loss prevention committee to increase coordination of efforts.	Ongoing	Maintain current service level
Monitor and adjust system pressure, conduct routine PRV calibration.	Ongoing	Maintain current service level
Prioritize and expedite leak repairs to reduce magnitude of water loss.	Ongoing	Maintain current service level
Continue to implement existing incentive and rebate programs; expand program offerings where feasible.	See Figure 1.17-1.20	Maintain current incentive amount and/or evaluate for continued effectiveness
Continue to promote conservation through advertising, publications and media (including direct mail, website, videos/multimedia/social media).	Ongoing	Maintain current service level and conduct targeted outreach
Continue to track GPCD progress annually and make program adjustments as needed.	Ongoing	Maintain current service level
Continue to maintain education, engagement and support programs.	Ongoing	Maintain current service level

PLAN REFERENCES

[i] "Water Conservation Plan Guidelines. Part 5 Advanced Guidelines - designed for use by water systems serving over 100,000 people." Retrieved 8/8/18. https://www.epa.gov/sites/production/files/2017-03/documents/part-5-advanced-guidelines.pdf.

[ii] "AWWA G480-13 Water Conservation Program Operation and Management." American Water Works Association, 2013.

[iii] The 2014-2018 Water Conservation Plan presented SNWA's conservation goal and progress in "Total System" (or gross) GPCD terms. The SNWA has changed its approach for its 2019-2024 Conservation Plan. The SNWA's formerly noted conservation goal of 199 Total System GPCD has been translated to 105 Consumptive Use GPCD. This methodology reflects actual per capita SNWA consumptive use of Colorado River water excluding off-stream storage and well production including recovered storage (SNWA per capita "water resource footprint" vs. SNWA total per capita water deliveries including direct reuse). Historical GPCD goal progress also has been restated using the same methodology. This approach reduces the number of sources and inputs required to calculate SNWA GPCD, improving transparency and explanation. For consistency, this change is being made to other planning documents, including the SNWA's Water Resource Plan.

[iv] Ibid.

[v] "Climate of Las Vegas, Nevada," Updated January 8, 2018, National Oceanic and Atmospheric Administration (NOAA), National Weather Service.

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