Moapa Valley Water District
2014 Integrated Water Resources Plan

June 4, 2015

Prepared by:

Glorieta Geoscience, Inc.
PO Box 5027
Santa Fe, NM 87502
505.983.5446

In cooperation with:

Moapa Valley Water District
601 N Moapa Valley Blvd
Overton, NV 89040
702.397.6893J

Table of Contents

Table of Tables

Table of Figures

APPENDICES

LIST OF ACRONYMS AND ABBREVIATIONS

afy – acre-feet per year

BLM – United States Bureau of Land Management

CSI – Coyote Springs Investments

DWR – Nevada Division of Water Resources

ET – evapotranspiration, water released to the atmosphere by vegetation and bare soils

FWS – United States Fish and Wildlife Service

gpcm – gallons per capita per minute

gpm – gallons per minute

LVVWD – Las Vegas Valley Water District

mgd – million gallons per day

MVWD – Moapa Valley Water District

NOAA – National Oceanic and Atmospheric Administration

NPS – United States National Park Service

ppb – parts per billion

RCA – Regional carbonate aquifer

SNWA – Southern Nevada Water Authority

USGS - United States Geological Survey

WCWCD – Washington County Water Conservancy District

WWTF – Wastewater Treatment Facility

1. EXECUTIVE SUMMARY

This *Integrated Water Resource Plan* (Plan) updates and replaces the 2002 Integrated Water Resource Plan and develops a long-term (year 2065) assessment of the Moapa Valley Water District's (District) current water resources relative to future demand and the constraints and options for expansion. The Plan presents dynamic strategies for meeting future water resource demands that will require updates as various factors change, e.g., population growth rate, groundwater resource availability, surface water availability, and cost of treatment, regulatory requirement modifications, etc.

The District was created by the Moapa Valley Water District Act approved May 24, 1983 (Chapter 477, Statutes of Nevada 1983). The creation of the District replaced the Overton Water District and Moapa Valley Water Company as the purveyors of municipal water in this general area. As of October, 2014, the District's service area encompasses 79 townships (Figure A.1).

As of May 2014, the District has permitted and certificated water rights and applications for water rights in Hydrologic Basins 205, 218, 219 and 220. Permits for water rights in Basin 205 total 4,344 acre-feet per year. The total permitted and certificated water rights in Basins 218 and 219 are 7,606 acre-feet per year (afy). The total permitted and certificated water rights in Basin 220 are 2,495 afy. In total, the District owns 10,877.5 afy and leases an additional 3,271 afy of water rights from the Muddy Valley Irrigation Company and the Church of Jesus Christ of Latter Day Saints.

Three growth scenarios were considered to facilitate planning for future water supplies: 1. Growth at the rate predicted for Clark County by the Nevada Demographer's Office for the next 20 years (0.75%); 2. Growth at a recent 10-year-sustained rate (2.2%); and 3. Growth between 1990 and 2010 (3.6%). Additional uncertainties regarding future demand are associated with the Coyote Springs master-planned community, which may have up to 50,000 residential units at full build-out, requiring 55,000 afy at 1.1 afy per unit. The future of Coyote Springs is uncertain, including the number of residential units at build-out and the water purveyor. In addition, at full build-out, the District's Service Area would require 48,000 afy at 1.1 afy per one-acre lot. Excluding Coyote Springs, the District's demand is projected to be between 3,700 and 15,350 afy depending on population growth.

Water demand based on the rapid growth rate exceeds the District's currently permitted and leased water rights and supply capacity. Peak day water demands will also surpass current water supply capacity between 2030 and 2060 under the lower growth projections. Adding a membrane filtration facility for the Logandale well would allow the well to be used as back-up to serve the domestic system, but would be insufficient in meeting projected peak demand.

To increase supply, ground and surface water sources are discussed. Due to recent (2014) rulings by the State Engineer in the basins the District occupies, appropriating additional water appears challenging barring significant new insights regarding the hydrology and perennial yield of affected basins. Utilization of reclaimed wastewater will be limited by the current lack of sufficient wastewater flows, agreements with the Clark County Reclamation District, and secondary system infrastructure. However, reclaimed wastewater utilization may be a feasible alternative in future.

Future power demands of the District's pumping equipment may require additional distribution facilities including substations, which will impose additional energy costs on the District. The District will continue to use Overton Power as its primary source for capacity and energy, since alternative sources appear not viable at this time.

2. OVERVIEW, PURPOSE, AND BACKGROUND

2.1 INTRODUCTION

The Moapa Valley Water District (MVWD, District) is located approximately 45 miles north and east of Las Vegas. The District's service area encompasses 79 townships serving the towns of Overton, Logandale, Glendale, and Moapa and rural lands surrounding these towns (Figure A.1). Moapa Valley currently has a population of about 8,500, which is projected to grow significantly due to urban development along the Interstate 15 corridor.

To manage this growth, the Integrated Water Resource Plan (Plan) sets forth the goals and guidelines for planning, defines the water resources and issues related to those resources, and provides specific alternatives and recommendations for the long-term (50-year) management of those resources. This Plan updates and replaces the District’s previous Integrated Water Resource Plan prepared by Waterresource Consulting Engineers, Inc. (2002).

2.2 PURPOSE AND SCOPE

The purpose of this study is to develop a long-term (50-year) water resource plan, which will help guide the future development, adaptive management, and use of the District’s water resources. The Plan describes the goals and guidelines for planning, defines the water resources and issues related to those resources, and provides specific alternatives and recommendations for the long-term management of those resources. Most importantly, the Plan will facilitate future planning and expansion of the District and provides a template for future updates.

This Plan is a living document and the findings by the Nevada State Engineer’s in Oder 1169 have added significant complexity to future development of the District’s water rights, water supplies and infrastructure. The State Engineer findings have resulted in the District needing to acquire additional well locations, right-of-ways and storage that will have to be identified and evaluated on an ongoing case by case basis over the 50-year planning period.

2.3 LOCATION AND HISTORY

The Moapa Valley Water District (District) is located in the northeast corner of Clark County, southern Nevada (Figure A.1). The District currently provides domestic and commercial water service to Moapa Valley, Moapa and Glendale. Moapa Valley includes the towns of Logandale and Overton. Moapa Valley is located on Interstate Highway 15, 45 miles northeast of Las Vegas, Nevada, and immediately northwest of Lake Mead. Moapa and Glendale are approximately 15 miles northwest of Logandale.

The Moapa Valley Water Company of Overton, Nevada was issued Articles of Incorporation on February 25, 1959, and adopted the by-laws on March 10, 1959 (Leavitt and Associates, 1970). In 1959, the Company’s first engineering project was initiated by the Soil Conservation Service, United States Department of Agriculture, and a contract was released to the engineering firm of Caldwell, Richards and Sorensen. Engineering design was completed and Stratton Brothers, Inc. was contracted to construct the first municipal water line between Warm Springs and Overton (Leavitt and Associates, 1970). Construction commenced in May 1960 and was completed October 1960. After a series of repairs and modifications, continuous water transmission commenced in December 1962 and has been maintained ever since. The Moapa Valley Water Company started to deliver and charge fees for water service on January 1, 1963 (Leavitt and Associates, 1970). The pipeline transmitted the Company's source of supply from Warm Springs (also known as the Muddy River Springs Area), approximately nine miles northwest of Glendale, to the Logandale municipal reservoir tank, approximately four miles north of Overton. From this reservoir, the distribution system served the Lower Moapa Valley and supplied a second storage reservoir at Overton. During the period of January 1963 to September 1966, the Company supplied water to 175 connections within the Upper and Lower Moapa Valleys and additional connections within the Muddy Valley Indian Reservation (presently known as the Moapa Indian Reservation) (Leavitt and Associates, 1970).

The Moapa Valley Water District was created by the Moapa Valley Water District Act approved May 24, 1983 by the legislature (Chapter 477, Statutes of Nevada 1983) to succeed the two previous purveyors, Overton Water District and Moapa Valley Water Company. The legislation gave the District powers to acquire water rights, sell and distribute water and to "construct, acquire, alter, improve, operate and maintain waterworks, conduits, pipelines, wells, reservoirs, structures, machinery and other property or equipment useful or necessary to store, convey, supply or otherwise deal with water." Furthermore, the legislation dissolved the Overton Water District and Moapa Valley Water Company and transferred all assets and liabilities to the Moapa Valley Water District.

2.4 CONSTRAINTS TO FUTURE EXPANSION

Constraints are imposed on the District by federal and state laws. On the federal level the Clean Water Act establishes standards for surface and groundwater protection, the Safe Drinking Water Act requires protection for sources of drinking water, and the Endangered Species Act constrains activities that may harm protected species. The Moapa Dace, which is endemic to the warms springs area, is a federally listed species and its habitat is restricted to the warm springs that represent the head waters of the Muddy River.

Nevada Water Law (NRS 533 and 534) establishes that all waters belong to the public and that associated rights are managed by the State Engineer and the Division of Water Resources (DWR). All four hydrographic basins the District lies in are designated, which means that the State Engineer can declare preferred uses and require metering on all diversions. Generally, designated basins have water rights exceeding the perennial yield.

Nevada Revised Statutes and Administration Codes (NAC 445A) regulates, among others, water pollution control, water quality standards, and water systems.

Specific to the District is the Muddy River Decree of 1920, which adjudicated surface water rights for the Muddy River and its tributaries. Since the Muddy River is a tributary to the Colorado, the Law of the River (Colorado River) also applies. The Colorado River is managed and operated under numerous compacts, federal laws, court decisions and decrees, contracts, and regulatory guidelines collectively known as the "Law of the River." This collection of documents apportions the water and regulates the use and management of the Colorado River among the seven basin states and Mexico.

Regional governmental or quasi-governmental entities that could potentially affect administration of the District's water supplies and water rights include the Southern Nevada Water Authority (SNWA), Lincoln County, the Virgin Valley Water District, the Moapa Indian Reservation, the US National Park Service (NPS), the US Fish and Wildlife Service (FWS), and the US Bureau of Land Management (BLM). Several of the governmental entities listed above have, at one time in the past, filed protests with the State Engineer with respect to the District's water rights filings. The Moapa Indian Reservation is adjacent to and served in part by the District.

The BLM administers a majority of the land in Moapa Valley, whereas private land ownership comprises only a small percentage of the total land area (Leslie and Associates, 1993a, Figure A.1). The NPS and FWS administer the Lake Mead National Recreation Area and the Moapa Valley National Wildlife Refuge (Moapa Dace), respectively.

2.5 PHYSIOGRAPHIC SETTING OF THE MOAPA VALLEY

2.5.1 Topography

The District is situated in the hydrographic region of Nevada referred to as the Colorado River Basin Province. The District is surrounded by the mountainous terrain of the Muddy Mountains to the south (maximum elevation of 3,281 ft), the Mormon Mountains to the north (7,414 ft elevation at Mormon Peak), the Arrow Canyon Range to the west (maximum elevation of 5,100 ft) and Mormon Mesa to the east (maximum elevation of 2,235 ft) (Figure 2.1). Within the District, elevation ranges from 1,830 feet in the upper portions of the valley to 1,250 feet in the lower portion (Leslie and Associates, 1993a).

Physiographic features of the Lower Meadow Valley Wash, Lower Moapa Valley and California Wash dominate the District's service area. The District's largest water feature, the Muddy River, originates in the Muddy River Springs Area in Upper Moapa Valley, and flows through the California Wash and Lower Moapa Valley before terminating in Lake Mead. Three major washes enter the District from the north and eventually converge with the Muddy River near Glendale. California Wash drains part of the Arrow Canyon Range from the west and the North Muddy Mountains from the east. Weiser Wash and Meadow Valley Wash drain the Mormon Mountains from the northeast and the Meadow Valley Mountains and parts of the Arrow Canyon Range from the west. However, surface water flow generally exists only during

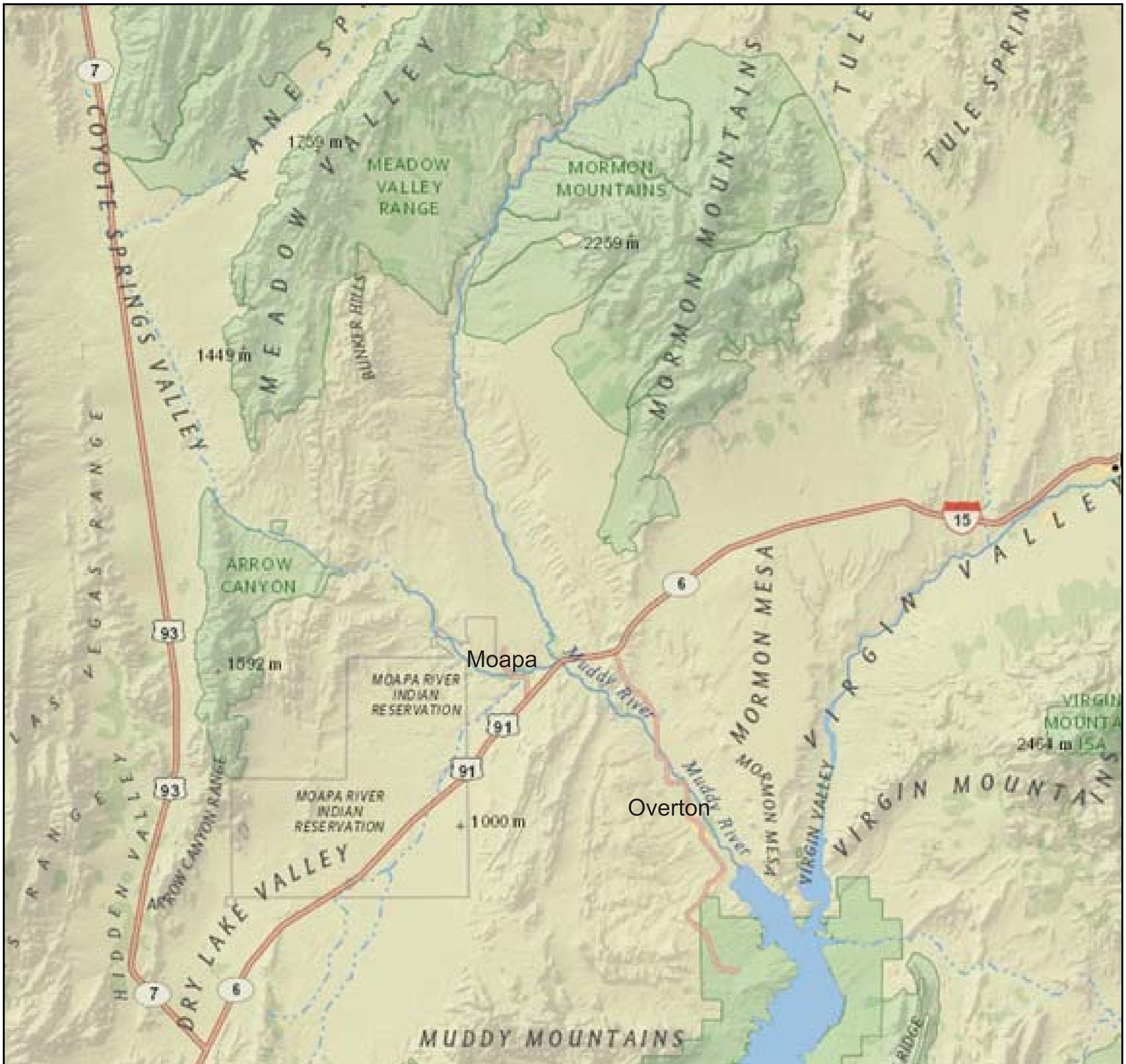

Figure 2.1: Physiographic Overview Map

0 2 4 Miles

N

GLORIETA GEOSCIENCE, INC.

major storm events. Other various small creeks and streams act as drainage systems for runoff originating in the Muddy Mountains, Arrow Canyon Range and Mormon Mountains.

2.5.2 Climate

The Moapa Valley is located in the Extreme Southern Climate Division (#4) of Nevada, which is characterized by an arid climate and a long-term annual precipitation average of seven inches (NOAA, 2014). Precipitation varies with elevation so that mountain ranges receive more precipitation than lower elevations. The Moapa Valley receives an average of five inches precipitation annually (Table 2.1).

Table 2.1 Overton, NV 1981-2010 Normals (National Climatic Data Center, NOAA 2014)

Season	Precipitation (in)	Minimum Temperature (°F)	Average Temperature (°F)	Maximum Temperature (°F)
Winter	2.08	36.1	49.8	63.4
Summer	0.80	73.1	89.8	106.6
Spring	1.00	52.7	68.4	84.1
Autumn	1.17	53.4	69.3	85.1
Annual	**5.05**	**53.9**	**69.4**	**84.9**

2.5.1 Regional Hydrology

The District is located at the southern, lower-elevation portion of the Colorado River hydrological region, which encompasses 34 hydrologic basins and over 16,000 square miles (Harrill, 1988) (Figure A.2). Groundwater recharge of the system occurs primarily at higher elevation mountain ranges. Individual basins are divided by bedrock mountain ranges that separate them yet allow groundwater flow between subsets of the individual basins. Based on these subsurface connections the hydrological region is subdivided into flow systems. Of these, two flow systems account for nearly all surface water and groundwater flow in the District area: the White River Flow System and the Meadow Valley Flow System.

The White River Flow System acts as one continuous carbonate-rock aquifer from Long Valley in the north to the Muddy River Springs Area in the south and includes 13 basins (Eakin, 1966). The White River Flow System was originally described by Eakin (1966) who concluded that spring and evapotranspiration (ET) discharge in individual basins does not equal basin recharge due to Paleozoic carbonate rocks that allow groundwater flow between individual basins. Eakin (1966) estimated an overall recharge from precipitation at ~100,000 afy for the entire flow system. Spring discharges occur in three basins: Muddy River Springs Area (36,000 afy, ~2,300 afy of which is consumed by ET, Pahranagat Valley (25,000 afy, completely consumed by ET within valley), and White River Valley (37,000 afy, completely consumed by ET within valley) (Eakin, 1966).

Thomas et al. (2001) used a deuterium mass-balance model to evaluate ground-water recharge and discharge rate estimates (including ET) developed by the Las Vegas Valley Water

District (LVVWD, 2001), which estimated recharge at 199,000 afy and ET plus spring discharges at 183,000 afy for the flow system. The results of the study were consistent with the estimates by LVVWD with the caveat that the mass-balance model provides non-unique solutions, which means that "proportionate changes in recharge and ET rates, or another combination of groundwater sources and mixing could produce the same results" (Thomas et al., 2001).

The Meadow Valley Flow System lies to the east of the White River Flow System and extends south from Lake Valley to Lower Meadow Valley Wash. The Meadow Valley Flow System includes nine basins and acts as a two-layer flow system with a carbonate-rock aquifer flow system in the north and west, and a volcanic-rock alluvial-fill aquifer system in the east and south that overlies the carbonate-rock aquifer flow system (Thomas et al., 2001). Similar to the White River Flow System, groundwater flows primarily in carbonate-rock aquifers from north to south.

Perennial yield for the Meadow Valley Flow System was first estimated at 37,000 afy (Rush 1964). In contrast, LVVWD (2001) estimated 122,000 afy due to significantly higher evapotranspiration estimates (91,000 afy versus 32,000 afy) and greater outflow estimates (32,000 afy vs. 7,000 afy).

The following subsections briefly describe hydrographic basins most suitable for water resource development by the District.

2.5.1.1 Lower Meadow Valley Wash (Basin 205)

The Lower Meadow Valley Wash (Figure A.2) receives groundwater flow from Panaca Valley to the north, including recharge from the Delamar Range, Clover Mountains, Meadow Valley Mountains, and Mormon Mountains. The groundwater flows to the south and is in hydraulic connection with groundwater from the White River Flow System in the volcanic rocks of the Caliente Caldera near Kane Springs Valley (LVVWD, 2001). Groundwater in Meadow Valley Wash in volcanic rock and alluvial aquifers is locally recharged (Thomas et al, 2001). Groundwater flow leaving Lower Meadow Valley Wash ultimately discharges from the volcanic rocks to the carbonate rocks. Near the southern boundary of the valley, the groundwater is constrained by the northeast end of the Glendale thrust. This thrust is, in part, responsible for the pooling effect seen in the carbonate rocks wells within a 15-20 mile radius centered on the Muddy Springs that have similar water-levels (LVVWD, 2001).

The Meadow Valley Wash is perennial to intermittent for most of its length starting in Spring Valley and flows generally to about 10 miles north of Moapa (LVVWD, 2001). The USGS gaging station near Caliente has recorded an annual average flow of 8,160 afy for water years 1951-1991 (LVVWD, 2001). Surface water flow in Lower Meadow Valley Wash is the result of groundwater discharge to the wash from the thin narrow strip of alluvium that occupies the canyon bottom. Except during flood flows, surface water from the upper portion of Lower Meadow Valley Wash generally does not extend into Clark County (LVVWD, 2001). Relatively small volumes of water are discharged at spring sources near Rox and Ferrier. These sources are entirely consumed through ET (LVVWD, 2001).

2.5.1.2 Coyote Spring Valley (Basin 210)

Groundwater flow through the carbonates in Coyote Spring Valley (Figure A.2) is not well defined. The valley receives recharge from the surrounding mountain blocks and valleys to the north. White River groundwater in the northern part of the Valley is hydraulically connected with Meadow Valley Wash groundwater, but no significant mixing occurs (LVVWD, 2001). The range front fault on the east side of the Sheep Range is highly permeable and is probably a major conduit for groundwater as it moves south. Some groundwater moves as fracture flow to the east-southeast along the course of Pahranagat Wash through Arrow Canyon to discharge at the Muddy Springs. The remaining groundwater continues south, leaving Coyote Spring Valley and flows into Hidden and Garnet Valleys and California Wash (LVVWD, 2001).

2.5.1.3 California Wash (Basin 218)

Groundwater in California Wash originates from the underlying carbonate rocks of the White River Flow System and from Coyote Spring Valley via Arrow Canyon (LVVWD, 2001). Groundwater leaves California Wash, moving south through the Dry Lake thrust to Black Mountain Basin, possibly discharging at Rogers and Blue Point Springs (see Figure A.2). A portion of groundwater in California Wash discharges to the Muddy River up-gradient from the Glendale thrust complex, with some water moving through the thrust to discharge from the carbonates beneath Lake Mead and the Colorado River.

2.5.1.4 Muddy River Springs Area, Upper Moapa Valley (Basin 219)

The Muddy Springs are the source of the Muddy River. There are approximately 20-30 separate springs, which are located over an area of about three square miles (LVVWD, 2001). Some groundwater moves as fracture flow to the east-southeast along the course of Pahranagat Wash through Arrow Canyon to discharge at the Muddy Springs. The Muddy Springs are the principal source of groundwater discharge in the White River Flow System (Eakin, 1964). Discharge at Muddy Springs becomes the Muddy River through Upper Moapa Valley, California Wash, and Lower Moapa Valley, finally terminating in Lake Mead.

USGS gaging station *09416000 Muddy River near Moapa* (Moapa gage, Figure A.1) is located downstream of the springs. The gaging station measures the baseflow of the springs (i.e., Muddy River) less surface water and groundwater diversions and ET between the gage and the springs. Eakin and Moore (1964) calculated the average flow at ~ 33,900 afy (46.8 cfs) based on the gage record of the Moapa station for 1945 to 1962. The difference between the January and annual average flow rates indicated that ~2,600 afy of spring flow was consumed by phreatophytes between the springs and the Moapa gage. Therefore, the springs collectively discharge approximately 36,000 afy or 50 cfs (Eakin and Moore 1964; LVVWD (2001).

The Muddy Springs provide habitat for the endemic and listed Moapa Dace, which is protected under the Endangered Species Act. The USFWS maintains the Moapa Valley National Wildlife Refuge, which encompasses the Apcar (or Pipeline Jones; main spring is owned by MVWD), Pedersen, and Plummer spring complexes. Potential Dace habitat extends outside of the refuge and includes private and SNWA land. Water discharging from Baldwin Springs historically had Moapa Dace, although none have been found in these reaches since 2010 (USFWS, 2014).

Data analysis by LVVWD (2001) suggests a correlation between valley-fill groundwater pumpage and surface-water diversions in the Muddy Springs Area and stream flow at the Moapa gage. Diversion of surface water upstream of the Moapa gage began in 1968 when the Nevada Power Company leased the 1920 decreed Muddy River water rights from the Muddy Valley Irrigation Company (LVVWD, 2001). This supports Eakin's (1964) conclusion that "groundwater in the valley fill…is recharged largely from the springs."

2.5.1.5 Lower Moapa Valley (Basin 220)

The Muddy River flows through Lower Moapa Valley before terminating in Lake Mead. The river represents the largest source of water in the basin with an estimated 33,000 afy before diversions (Rush, 1968). The Lower Moapa Valley receives groundwater flow from California Wash and Lower Meadow Valley Wash, which LVVWD (2001) estimated at 73,000 afy. In contrast, Rush (1968) estimated the total basin discharge at 37,000 afy. This would mean that only 4,000 afy flow into the basin from adjacent basins since Rush assumed that precipitation recharge was negligible.

2.5.2 Regional Water Quality

Source-water quality is a key consideration in any water resource development program. The most (recent) significant change in federal drinking water standards was lowering of the arsenic standard in 2002. The Safe Drinking Water Act required the United States Environmental Protection Agency (EPA) to revise the existing 50 parts per billion (ppb) standard down to 10 ppb for arsenic in drinking water. The previous MCL for drinking water was established in 1975 based on a standard set by the U.S. Public Health Service in 1943. The National Research Council of the National Academy of Sciences made a review of the current state of science for estimating risks associated with arsenic in drinking water resulting in a recommendation for a more stringent MCL of <10 ppb. This recommendation was based on the risks of skin, lung, and bladder cancers from inorganic arsenic in drinking water. Two inorganic species are the center of concern, Arsenic V (arsenate) and Arsenic III (arsenite).

Water in the regional carbonate aquifer (RCA) system of both the White River and Meadow Valley Wash systems is generally good with total dissolved solids (TDS) below 1000 mg/l (Thomas, 1996, Buqo 1993). Within the RCA, anion and cation concentrations are dependent on geochemical processes along the groundwater flow path (Thomas, 1996). For example, groundwater flowing down the White River Flow System is generally a calcium-magnesium-carbonate type water until the groundwater encounters evaporative salts, likely gypsum (calcium sulfate as $CaSO_4\ 2H_2O$) or anhydrite (calcium sulfate as $CaSO_4$) and halite (sodium chloride as NaCl) in the southern part of the flow system (Thomas et al., 2001). In contrast to the White River Flow System, groundwater in the Meadow Valley Flow System shows marked differences because of groundwater flow through extensive volcanic material. Groundwater in Lake Valley and the western mountains within the Meadow Valley Flow System, which are predominantly carbonate rock, is calcium-magnesium-carbonate type water. Groundwater in the volcanic rocks range from calcium-magnesium-carbonate water to more sodium and potassium-rich (Thomas et al., 2001).

Wells completed into the alluvium within the District's service area generally have significantly higher in TDS than the RCA-derived springs or wells completed into the RAC (Buqo, 1993).

As discussed above, of greatest concern to a public water supply are arsenic concentrations, which are not often analyzed in the regional groundwater studies (Thomas et al., 2001, Pohlman et al. 1998). Existing sources of water supply available to the District (Arrow Canyon Wells, Baldwin Spring, Jones Spring and MX-6 Well) as well as potential sources (wells in the Coyote Spring Valley) have documented arsenic concentrations ranging from 3 to 23 ppb (MVWD, 2011; SNWA, 2008; USGS, 2012).

2.6 CURRENT DISTRICT WATER RESOURCE OVERVIEW

The District currently supplies potable-quality water from four sources with a production capacity on the order of 5,000 gallons per minute (gpm) from three wells completed in the RCA (Table 2.2), although diversions are limited to 4,210 gpm. Two springs, also discharging from the RCA, provide an additional 1,769 gpm. The District's current potable water sources are all located in the Muddy River Springs Area (Basin #219, Upper Moapa Valley).

Table 2.2: Current Potable Water Source Capacities

Source	Capacity (gpm)	Capacity (afy)
Jones Spring	448	724
Baldwin Spring	1,321	2,132
MX-6 Well[a]	450	726
Arrow Canyon Well #1[a]	3,000	4,839
Arrow Canyon Well #2[a]	1,500	2,420
Logandale Well (inactive)	565	912
Total active	**7,284**	**11,753**

[a] Note that diversions from the three carbonate wells are limited to a combined total of 4210 gpm or 6792 afy.

The District's Logandale Well, which is completed in the alluvium, is only used in times of shortage and has the capacity to expand the District's potable water supply by adding 565 gpm to the system. Constituents reported in excess of federal/state drinking water standards include total dissolved solids (TDS), coliform, arsenic, radon, sulfate, manganese and fluoride. The District is currently evaluating the feasibility of constructing and operating a water treatment system for the Logandale well. Currently the well can provide potable water when blended at four parts of distribution water to one part of Logandale well water.

In 2009 the District installed two Severn Trent Services SORB 33 arsenic removal systems adjacent to the Arrow Canyon wells and Baldwin Springs. This system is a pump-and-treat system in which the water passes through a robust granular ferric oxide media (Bayoxide E33). As water passes through the media, arsenic is adsorbed and removed to a level below the 10 ppb standard. Water from MX-6 is mixed with Arrow Canyon water for treatment, while Pipeline Jones water is treated at the Baldwin Springs system.

2.6.1 Water Resource and Planning

Leavitt and Associates (1970) prepared a planning document to provide guidance for the future expansion and development of the Moapa Valley Water Company municipal water supply facilities. The document included a feasibility study to upgrading the Moapa Valley Water Company's water supply, storage, and distribution system. The following is a brief summary of these studies.

Leslie & Associates' (1993a) *Preliminary Engineering Report for Water System Improvements* reported the need for water system improvements (transmission lines, storage reservoirs, and distribution network) to replace aging facilities, satisfy fire flow requirements and accommodate growth. The report outlined essential improvements and construction cost estimates. Leslie & Associates (1993b) completed an addendum addressing comments by the Rural Development Administration on the preliminary report and provided a (static) network hydraulic analysis.

Leslie & Associates (1998a) analyzed the impact of anticipated rapid development on the District's water system and calculated development impact fees. System improvements to be funded by impact fees included water rights, water supply facilities, transmission, treatment, storage, pumping facilities and distribution piping.

Leslie & Associates (1998b) proposed system improvements to the Moapa River Indian Reservation (new storage reservoir and entirely new distribution system), the Warm Springs Area (storage reservoir and transmission/supply lines), and provided several network hydraulic analyses. Leslie & Associates (1999) proposed additional capital improvements that were not covered in the 1998 report. Additional capital improvements included two storage reservoirs (Moapa and Overton) and the associated transmission pipelines.

Montgomery Watson (2000) updated the *Northeast Clark County 208 Water Quality Management* Plan to address water quality management, wetlands systems, wastewater flow projections, wastewater treatment systems, non-point source management and water reclamation within the northeast Clark County area.

The Southern Nevada Water Authority (2000) prepared the *Draft Coyote Spring Valley Groundwater Development* Plan to outline the tasks, costs and schedule for development of water rights in Coyote Spring Valley.

Leslie & Associates (2002) proposed water resource developments to satisfy future water needs of the Moapa Valley Water District. Proposed projects included construction of three exploratory water wells in Meadow Valley Wash, two exploratory water wells west of Logandale, the construction of a membrane filtration system on the Logandale irrigation well and an interconnected pipeline to facilitate a long-term pump test within the Coyote Springs Valley. The project also included a feasibility study for construction of a secondary water system for irrigation purposes. The District's *Water Resource Development Strategy* includes groundwater exploration and development in the Lower Moapa Valley. In addition, the District, in cooperation with Southern Nevada Water Authority and Las Vegas Valley Water District, conducted a long-term pumping test on wells that produce from the carbonate aquifer in both the Coyote Spring Valley (MX-5 Well) and the Muddy River Springs Area (Arrow Canyon Well). This study provided information on the effect of carbonate aquifer pumping on existing water rights.

2.7 BIOTERRORISM ACT AND REQUIREMENTS

HR3448 requires all drinking water utilities serving a population of 3,300 or more to conduct and submit vulnerability assessments and develop emergency response plans. The District has performed the vulnerability assessment and has an approved Emergency Response Plan that is reviewed and updated regularly.

3. WATER RIGHTS

3.1 GENERAL

Nevada State water law is based on the prior appropriation doctrine. Prior to granting water rights, the State Engineer is required to make three determinations: (1) Is sufficient unappropriated water available? (2) What the impacts are on prior existing rights and the environment? (3) Is the appropriation in the public interest?

3.2 PERENNIAL YIELD OF HYDROGRAPHIC BASINS

The available water supply for hydrologic basins in Nevada is defined in terms of either *perennial yield,* if the basin's water supply is mainly groundwater, or *system yield* if the available water supply is a combination of ground and surface water. Perennial yield was defined by Rush (1964) as "the maximum amount water of useable chemical quality that can be withdrawn economically each year for an indefinite period of years." Eakin (1964) defined the perennial yield as the "upper limit of the amount of water that can be withdrawn economically from the system for an indefinite period of time without causing a permanent and continuing depletion of groundwater in storage without causing a deterioration of the quality of water." The concept of perennial yield can also extend to the capture of groundwater outflow from major flow systems such as the White River and Meadow Valley through deep-seated carbonate rocks underneath Lake Mead and the Colorado River (LVVWD, 2001). The system yield was defined by Worts and Malmberg (1966) as "the maximum amount of surface and groundwater of useable quality that can be obtained economically each year from sources within a system for an indefinite period of time."

This section summarizes the perennial yield for hydrologic basins that the District currently holds permits or applications for groundwater. The values presented herein were established by Nevada's Division of Water Resources (DWR) based upon United States Geologic Survey (USGS) reports. As mentioned above, because basins are interconnected and the basins of interest to the District are at the lower end of the flow systems, perennial yields of individual basins represent local recharge plus groundwater inflow from upgradient basins. Groundwater inflow would be affected by pumping in upgradient basins.

Basin 205, Lower Meadow Valley Wash. DWR has established a perennial yield of 25,000 acre-feet per year for the entire Meadow Valley Wash Flow System (Basins 198-205). The certificated and/or permitted groundwater rights total 21,146 acre-feet.

Basin 210, Coyote Spring Valley. DWR has established a perennial yield of 1,900 afy for Coyote Springs Valley based on precipitation recharge alone, and underflow in the RCA contributes another 18,000 afy (State Engineer Ruling 4542). SNWA Exhibit No. 452 suggests a perennial yield of 41,000 afy. The certificated and/or permitted groundwater rights in the basin total 16,200 afy. The State Engineer denied 136,097 afy of water rights applications with Ruling 6254 in January, 2014.

Basin 218, California Wash. USGS has established a perennial yield of 2,200 acre-feet per year, which DWR reports on their website. Katzer (1996) estimates a system yield in the order of 40,000 acre-feet per year for California Wash and Lower Moapa Valley combined. The certificated and/or permitted groundwater rights total 3,068 afy. 34,866 afy of water rights applications were denied by ruling 6258 in 2014.

Basin 219, Muddy River Springs Area (Upper Moapa Valley). DWR has established a perennial yield of 36,000 afy, which includes the spring discharges. The certificated and/or permitted groundwater rights total 14,528 afy. In addition, all Muddy River surface water was allocated in the Muddy River Decree.

Basin 220, Lower Moapa Valley. DWR has established a perennial yield of 50 afy from precipitation recharge, so this value does not include inflow from the Muddy River. Katzer (1996) estimates the system yield for both California Wash and Lower Moapa Valley is in the order of 40,000 afyr. The certificated and/or permitted groundwater rights total 5,776 afy. As mentioned above, all surface water was allocated by the Muddy River Decree.

3.2.1 Order 1169 Pumping Test

As part of the MX Missile investigations numerous wells were drilled in many of the valleys, and Ertec Western (1981) conducted an extensive aquifer test in Coyote Spring Valley in the MX No. 5 Well (Figure A.2). This well pumped at least 3,400 gallons per minute (gpm) for a 30-day test with virtually no drawdown at the wellhead. According to Buqo et al. (1992) the 3,400 gpm was the capacity of the pump used to test the well.

In 2002, the Nevada State Engineer issued Order 1169, which placed in abeyance all pending and new water right applications (>100,000 afy) in the carbonate-rock aquifer in Coyote Spring Valley (Basin 210), Black Mountains Area (Basin 215), Garnet Valley (Basin 216), Hidden Valley (Basin 217), the Muddy River Springs Area (Upper Moapa Valley, Basin 219), and Lower Moapa Valley (Basin 220) pending further study. California Wash (Basin 218) was later added to the list through Ruling 5115. Applications were held in abeyance in Order 1169 because the State Engineer required more information on the effects of groundwater pumping from the carbonate aquifer before making a determination on pending water right applications in the listed basins. Order 1169 called for a study covering a “5-year minimum period of time during which at least 50% of the water rights then currently permitted in the Coyote Spring Valley groundwater basin are pumped for at least two consecutive years.” The State Engineer required that approximately 8,050 afy be pumped during two consecutive years. Although the target test discharge was never fully pumped and after intermittent pump shut downs and restarts, the State Engineer subsequently amended Order 1169 stating that the test was completed on December 31, 2012, as he believed that sufficient information had been obtained from the test and related monitoring to make a determination on the pending water right applications. Approximately 21,600 afy of MVWD applications were held in abeyance during this period.

The pumping test on well MX-5 was conducted by the Southern Nevada Water Authority (SNWA). The test was delayed due to permitting issues and officially started on November 10, 2010. Carbonate pumping in Coyote Spring Valley, which began in 2006 and averaged about 2,000 afy from 2006 to 2009, more than doubled to 5,400 afy during the pumping test from November 15, 2010 to December 31, 2012. Groundwater pumping in adjacent basins remained relatively constant during the period of the pumping test. The volume of pumping in Coyote Spring Valley during the test was approximately one/third of the groundwater rights currently permitted in the basin.

During the Order 1169 test from November 15, 2010, through December 31, 2012, the pumping rate at well MX-5 ranged from 3,300 to 3,800 gpm and was the single largest stress on the RCA in the study area. A total of 4,131 afy and 3,961 afy were pumped from MX-5 during 2011 and 2012, respectively. Combined with Coyote Springs Investments (CSI) pumping from wells CSI-1 through CSI-4, a total of 5,331 afy and 5,102 afy were pumped in Coyote Spring Valley during 2011 and 2012, respectively.

MX-5 pumping was held fairly constant, with the exception of shutdowns due to facility maintenance and operational issues. CSI groundwater development was intermittent and fluctuated seasonally to meet water demands. During the Test, MVWD continued to produce groundwater from Arrow Canyon #1 and #2 wells located in the Muddy River Springs Area to meet water demands in its service area. Water pumped from MX-5 was piped to the MVWD system, routed through Bowman Reservoir, released in an open irrigation ditch from where a portion flowed to Lake Mead.

MVWD concluded that pumping of MX-5 beginning in September 2010 resulted in water level declines in monitoring wells completed in the RCA (Riesterer and Lazarus, 2013). Pumping of MX-5 also contributed to declining discharge from four of six springs monitored in the warms springs area, with effects being most pronounced on higher elevation springs. MVWD also concluded that groundwater development in Coyote Spring Valley did not result in any discernible effects on the flows of the Muddy River at the Muddy River gage near Moapa (see Figure A.1) as local alluvial pumping in the Muddy River Springs Area is the primary stress affecting Muddy River stream flows (Riesterer and Lazarus, 2013).

As a result of the MX-5 pumping test results, the State Engineer, without a hearing on the merits of each application, denied more than 100,000 afy of pending water right applications, including 21,600 afy of MVWD applications based on his conclusions that:

1. No unappropriated water is available in the subject basins without impacting existing water rights.
2. Approval of the applications would be detrimental to the public welfare and specifically to the habitat for the endangered Moapa Dace.

At the time of this report, MVWD has filed timely appeals of the State Engineer's denial of MVWD applications.

3.3 WATER RIGHTS INVENTORY

The information presented herein summarizes the information recorded in the Nevada Division of Water Resources regarding permitted water rights and applications submitted by the District in Hydrologic Basins 205, 218, 219 and 220; for location of basins and specific sources of supply, refer to Figure A.3.

3.3.1 Basin 205, Lower Meadow Valley Wash

Applications 63379-63381 (Denied, Ruling 6031). Each application was filed in August 1997 for the diversion of 6.0 cfs, or 4,344 acre-feet annually from an underground source to store for municipal purposes, though the District communicated to DWR that this was intended as the combined duty for the three applications. The proposed points of diversions were located in the SW¼ SW¼ of Section 7, T13S, R66E, SE¼ SE¼ of Section 26, T12S, R65E, and NE¼ NE¼ of Section 12, T13S, R65E. The applications were protested by the U.S. Fish and Wildlife

Service and the National Park Service. The District had submitted LVVWD's (2001) recharge estimate (23,000 afy) in support of its applications, which the State Engineer rejected. The State Engineer denied the applications in 2010, as he did 106 prior applications in the basin, because of a lack of unappropriated water in the basin and the Meadow Valley Wash Flow System.

Applications 79632 through 79634. In February 2010, the District applied for the diversion of 6.0 cfs, or 4,344 acre-feet annually each from an underground source for municipal purposes in three applications. The proposed point of diversions are located in the SW¼ SW¼ of Section 7, T13S, R66E, NE¼ NE¼ of Section 12, T13S, R65E, and NE¼ SE¼ of Section 26, T12S, R65E. Each applications was protested by the U.S. Fish and Wildlife Service, the National Park Service, and the Bureau of Land Management, and Lincoln County Water District and Vidler Water Company, Inc. protested Application 79634. The State Engineer had not ruled on these applications at the date of this report.

Applications 66976 through 66999. In December 2002, the District filed applications to change the point of diversion, place and manner of use of water rights from rights transferred to the district by RC & V Lewis and Meadow Valley Farmlands Irrigation, with a combined maximum duty of 4,550 afy subsequently revised to 4,580 afy of non-supplemental groundwater rights. The State Engineer, in Ruling No. 5167 issued October 24, 2002, granted change applications in the amount of 3,802 afy based on 30% return flow of the 4,580 afy to the groundwater from irrigation, plus 596 afy from withdrawal of existing District water rights (both ground and surface). In October 2007 The Moapa Valley Water District, Glendale Water Holdings Company, LLC and Tracey Taylor, P.E., Nevada State Engineer entered into a Settlement Agreement and Mutual Release granting 4.5 out of 5.0 acre-feet or 90% of the original base rights of 4795.88 acre-feet; this equates to a net consumptive use of 4316.29 acre-feet.

In April of 2014 the MVWD deeded the applications to these water rights to Glendale Water Holdings Company, LLC to help satisfy the Nevada State Engineer ruling requiring clear title to the base permits and change applications in the same name. MVWD placed deed restrictions on the water rights, reserving the right to approve in writing applications concerning place of use and manner of use.

3.3.2 Basin 218, California Wash

Permit 26371, Certificate 9404. The point of diversion of this permit (NE¼ SW¼ of Section 25, T14S, R65E) is located within Hydrologic Basin 218, but is referenced in the limitations included under Permit 52520. Ownership of the permit was assigned to the District on May 11, 1983. This certificated permit allows the diversion of 0.37 cfs not to exceed 90.0 acre-feet annually from an underground source (Lyttle well, log 14772) for irrigation and domestic purposes. The place of use is 18.0 acres in the NE¼ SW¼ of Section 25, T14S, R65E.

The District filed Application 46168 requesting a change in the point of diversion (from Basin 218 to Basin 219), place of use and manner of use of Permit 26371. The District withdrew the application on October 14, 1993.

3.3.3 Basin 219, Muddy River Springs Area (Upper Moapa Valley)

Permit 22739, Certificate 10060. This certificated permit is jointly owned by the District (68 percent) and the Muddy Valley Irrigation Company (32 percent). The permit allows a diversion of 1.0 cfs, not to exceed 723.8 acre-feet annually for municipal and domestic purposes. The diversion is from Pipeline Jones Spring in the NW¼ SE¼ of Section 16, T14S, R65E. The permit changed to point of diversion, place of use and manner of use of Certificate 266 of the Muddy River Decree.

Permit 46932. This permit allows the diversion of 2.0 cfs not to exceed 325.9 million gallons annually (1,000 acre-feet) from an underground source for municipal purposes. The point of diversion is MX-6 in the NE¼ NE¼ of Section 35, T13S, R64E. The filing for Proof of beneficial use has been extended until February 9, 2019. A total combined duty of 6791.9 afy exists for permits 46932, 52520, 55450, 58269, 66043 (Ruling 4243).

Permit 52520. This permit allows the diversion of 2.0 cfs not to exceed 471.81 million gallons annually (1,447.94 afy) from an underground source for municipal purposes. The point of diversion is Arrow Canyon Well #1 located in the SE¼ NE¼ of Section 7, T14S, R65E. This permit limits the total annual duty under permits 26371, 28791, 46932 and 52520 to 1,062.7 million gallons annually (3,261.3 acre-feet). The filing for Proof of beneficial use has been extended to May 7, 2018.

Permit 55450. This permit allows the diversion of 3.0 cfs from an underground source for municipal purposes. The point of diversion is Arrow Canyon Well #1 located in the SE¼ NE¼ of Section 7, T14S, R65E. This permit limits the total diversion under Permits 52520, 55450 and 58269 to 3.2 cfs for 1996 and to 10.0 cfs thereafter. This permit also limits the total annual duty under Permits 22739, 28791, 46932, 52520, 55450 and 58269 to the "actual demand of the Moapa Valley Water District." The filing for Proof of beneficial use is due on or before January 19, 2019.

Permit 58269. This permit allows diversion of 1.5 cfs from an underground source for municipal purposes. The point of diversion is Arrow Canyon Well #1 located in the SE¼ NE¼ of Section 7, T14S, R65E. The permit limitations are the same as those described above under Permit 55450. The filing for Proof of beneficial use is due on or before January 19, 2019.

Permit 66043. This application requested a change in the point of diversion of the original 5.0 cfs held under Permit 58269. The application was approved for 3.5 cfs, and 1.5 cfs remain permitted under 58269. The point of diversion is Arrow Canyon Well #2 located in the SE¼ NE¼ of Section 7, T14S, R65E. The filing for Proof of beneficial use is due on or before January 19, 2019.

Application 58787 (Withdrawn). This application was filed jointly by the District and the Overton Power District. The application requested a diversion of 6.0 cfs or 2,000 afy from an underground source for power purposes. The proposed point of diversion is located in the NE¼

SE¼ of Section 7, T14S, R65E. The application was protested by the U.S. Fish and Wildlife Service, the National Park Service and the Las Vegas Valley Water District.

Application 59369 (Denied, Ruling 6259). This application requested a diversion of 10 cfs or 7,240 afy from an underground source for municipal purposes. The proposed point of diversion is located in the NE¼ NE¼ of Section 33, T13-1/2 South, R64E. The application was protested by the Fish and Wildlife Service, the National Park Service and the Bureau of Indian Affairs.

Permit 28791, Certificate 13445. This certificated permit was referenced in the limitations included under Permits 52520, 55450 and 58269. The records of the State Engineer show the owner of this permit to be the Muddy Valley Irrigation Company. The permit allows a diversion of 3.0 cfs not to exceed 694.733 million gallons annually (2,132.1 afy) for municipal and domestic purposes. The diversion is from the Muddy River via Baldwin Springs located in the SE¼ NW¼ of Section 16, T14S, R65E. This permit changed Permit 21876, which had changed Certificate 266 of the Muddy River Decree. The annual duty under Permits 26371, 28791, 46932 and 52520 is 1,062.7 million gallons annually (3261.3 afy). The District is leasing these water rights indefinitely.

3.3.4 Basin 220, Lower Moapa Valley

Permit 68524. This permit changed the place and manner of use under permit 23872, certificate 8600. This permit is limited to the amount which can be applied to beneficial use, and not to exceed 0.89 cfs or 209.96 million gallons annually (644 afy). The point of diversion is the Logandale well (well log 9719) located in the NW¼ NW¼ of Section 22, T15S, R67E. The filing for Proof of beneficial use is due on or before November 7, 2018.

Permit 24007, Certificate 8601. This certificated permit allows diversion of 2.3 cfs, or 1,582 acre-feet annually, from an underground source for irrigation purposes. The point of diversion is the Logandale well (well log 9719) located in the NW¼ NW¼ of Section 22, T15S, R67E.

Permit 72263. This permit changed the manner of use and place of use of a portion of water from appropriated under permit 24007, certificate 8601. The amount of water changed is 2.71 cfs not to exceed 87.34 million gallons annually (268.05 acre-feet). The point of diversion remained the same Logandale well (well log 9719) located in the NW¼ NW¼ of Section 22, T15S, R67E, although the second Logandale well (well log 61661) is also listed on the DWR website as a point of diversion.

Application 59368, 59370 and 59371 (Denied, Ruling 6261). Application 59368 was for the diversion of 10.0 cfs, or 7,240 acre-feet annually, from an underground source to store for municipal purposes. The proposed point of diversion is located in the NW¼ NW¼ of Section 10, T13S, R67E. Application 59370 was for the diversion of 5.0 cfs, or 3,620 acre-feet annually, from an underground source to store for municipal purposes. The proposed point of diversion is located in the SW¼ NW¼ of Section 32, T15S, R67E. Application 59371 was for the diversion of 5.0 or 3,620 acre-feet annually, from an underground source to store for municipal purposes. The proposed point of diversion is located in the SE¼ SE¼ of Section 19, T15S, R67E. The three applications were protested by the National Park Service and the Bureau of Indian Affairs. The State Engineer denied the applications in 2014 because the Lower Moapa Valley has an in-basin recharge of less than 50 afy with minimal subsurface groundwater inflow (based on Rush, 1968). Consequently, he ruled that no unappropriated water is available in the basin. The District has appealed this decision to the District Court.

3.3.5 Water Rights Summary

The District currently owns 10,877.5 afy of water rights in three basins (Table 3.1). In addition, the District leases 2,132.1 afy from the Muddy Valley Irrigation Company. These rights were tied to the Districts by the State Engineer in the approval of Permit 52520, which established a combined duty between Permits 26317, 28791, 46932, and 52520. In addition, the District is leasing water rights from the Church of Jesus Christ of Latter Day Saints. For many of these permits the actual diversion rate and duty have not been established since they are still permitted as irrigation rights with the Muddy River Decree seasonal diversions. Where the DWR website lists additional information, it is shown in Table 3.1.

The District owns additional surface water rights via ownership of stock in the Muddy Valley Irrigation Company. Each preferred share is equal to 8.36 acre-feet annually (AFA) and common shares equal 0.79 AFA. The District owns 71.879 preferred shares or 600.9 afy (71.879 x 8.36) and 222.666 common shares or 175.9 afy (222.666 x 0.79) for a total of 776.8 afy. Please note that an additional 70 preferred and 70 common shares are tied to Jones Spring and not counted in the total listed above or in Table 3.1. Currently, the District is leasing this water to its customers; however, the rights could supplement the current supply using water treatment.

In 1998, SNWA entered into a purchasing agreement with Coyote Springs Investment (CSI) to obtain 7,500 afy of groundwater rights in Coyote Spring Valley. Under the nine-year agreement, SNWA's purchase includes 7,500 afy of permitted water rights, the MX-5 Well, and five one-acre parcels of land for placement of future wells to develop the water rights. SNWA acquired the full 7,500 afy by 2002. SNWA may transfer these water rights to the District in exchange for Muddy Valley Irrigation Company water rights owned by the District.

Table 3.1: District Water Rights Summary (Rights leased by the District are italicized)

Application/Permit/Certificate	Diversion (CFS)	Duty (afy)	Point of Diversion
Basin 218, California Wash			
Permit 26371[a], Certificate 9404	0.37	90	Well log 14772 (Lyttle Well)
Basin 219, Muddy River Springs Area			
Permit 6419 [b], Certificate 6795	*0.2/0.14*	*70*	*Rock Cabin Springs*
Permit 25861 [b], Certificate 10944	*0.432*	*567.5*	*Baldwin, Pipeline Jones & Warm Springs*
Permit 26316 [b], Certificate 10951	*0.829*	*290*	*Baldwin, Caddy Lamb & unidentified Springs*
Permit 26317 [b], Certificate 10952	*0.057/0.040*	*18.02*	*Pipeline Jones & Warm Springs Creek*
Permit 26318 [b], Certificate 10953	*0.536/0.375*	*193.5*	*Baldwin Spring*
Permit 28791[c], Certificate 13445	*3.0*	*2,132.1*	*Baldwin Spring*
Permit 22739, Certificate 10060	1.0	723.8	Pipeline Jones Spring
Permit 46932	2.0	6,791.9[e]	MX-6
Permit 52520[d]	2.0		Arrow Canyon #1
Permit 55450	3.0		Arrow Canyon #1
Permit 58269	1.5		Arrow Canyon #1
Permit 66043[e]	3.5		Arrow Canyon #2
Muddy Valley Irrigation Co. Stock		776.8[f]	
Basin 220, Lower Moapa Valley			
Permit 24007, Certificate 8601	2.30	1,581.95	Well log 9719 (Logandale #1)
Permit 72263	2.71	268.05	Well logs 9719, 61661 (Logandale 1 & 2)
Permit 68524	0.89	644.97	Well log 9719 (Logandale #1)
Total Permitted **Owned by the District**		**14,148.6** **10,877.5**	

a. The point of diversion of this permit is located within Hydrographic Basin 218, but is referenced in the limitations included under Permit 52520.
b. The permits represent irrigation rights leased from LDS; per Muddy River Decree, water rights have two diversion rates: May 1 to Oct 1, and Oct 1 to May 1 and no annual duty. The acreage associated with these permits is as follows: 6419: 14.0 ac, 25861: 113.5 ac, 26316: 58.0 ac, 26317: 4.0 ac, 26318: 38.7 ac. For permits where DWR does not list an annual duty, 5 acre-feet per acre were assumed.
c. This certificated permit was referenced in the limitations under Permits 52520, 55450 and 58269. This permit changed Permit 21876 that changed Certificate 266 of the Muddy River Decree and is owned by the Muddy Valley Irrigation Company. The annual duty under Permits 26371, 28791, 46932 and 52520 is 3,222.13 afy.
d. Total combined duty under Permits 26371, 28791, 46932 and 52520 is 1,062.7 million gallons annually or 3,261.3 afy.
e. Total combined duty of 6791.9 afy is assigned to permits 46932, 52520, 55450, 58269, 66043, Ruling 4243 dated 1995.
f. An additional 70 common and 70 preferred shares are tied to Jones Spring and not included in this value

3.4 DEDICATION OF WATER RIGHTS AND FACILITIES

Presently, the District has an ordinance that requires land developers or contractors to dedicate water rights prior to water service. The dedication ordinance helps the District secure the necessary water rights to serve future growth and development. The ordinance requires that water rights and water supply, or substitute compensation, be dedicated to the District prior to provision of water service or a will-serve commitment. The ordinance also quantifies the required amount of dedicated water rights according to type of project or development (e.g., single/multi-family residential, commercial and industrial). The District's acceptance of water rights are based on factors including, but not limited to:

- The amount of water rights offered for dedication must be adequate to serve the proposed project. Consideration includes reliability of the source of water.
- The proximity of the source to the proposed place of use, including receiving approval from the State Engineer to change the place and/or manner of use of those water rights.
- Valid proof of ownership of the water rights, including a chain of title establishing ownership.
- The status of the water rights, including copies of permits or certificates underlying the water rights, the priority and yield of the water rights, the current place and manner of use of the water rights, the status of the permit or certificate or the status of water rights established by a court decree.
- Whether the water rights are subject to any action which would affect the amount of validity of the water rights.
- Water quality.

Land developers or contractors also must dedicate any facilities for the treatment, supply, storage or distribution of water and any appurtenances including wells, pipelines, pumps and storage tanks which are necessary to ensure an adequate supply of water.

3.5 WILDLIFE WATER RIGHTS APPLICATIONS

The District is committed to managing and protecting the water resources in and around its service territory boundaries for current and future residents and animals alike. The residents of Moapa Valley have regularly used the lands, waters, and associated natural resources that surround both the upper and lower Moapa Valley. It is the District's goal to help manage and protect resources for economic, educational, recreational and spiritual purposes with the intent of allowing current and future residents to continue using and enjoying these lands, waters and related natural resources for the foreseeable future.

In keeping with these goals, the District has submitted seven wildlife applications with the State of Nevada Division of Water Resources for the purpose of preserving local springs in the California Wash, Muddy River Springs Area and Lower Moapa Valley (Figure A.3). The applications apply to the following springs: Jackass, ERG 1 (upper and lower) and ERG 2, Magnesite, Lon’s, and Colored Magnesite. The amount of water applied for is based on the estimated ET downstream of and supplied by the springs as well as measured surface water flows. The duties requested range from 1.6 to 16.2 afy (Table 3.2).

Table 3.2: Pending Wildlife Water Rights Applications

Application/Permit/Certificate	Diversion (cfs)	Duty (afy)	Point of Diversion
Basin 218, California Wash			
Application 85037	0.003	2.2	Upper ERG-1 Spring
Application 85038	0.022	16.1	Lower ERG-1 Spring
Application	0.010	7.3	ERG-2 Spring
Basin 219, Muddy River Springs Area			
Application 85040	0.011	8.0	Jackass Spring
Basin 220, Lower Moapa Valley			
Application 85042	0.022	16.2	Magnesite Spring
Application 85041	0.002	1.6	Lon’s Spring
Application 85039	0.019	13.5	Colored Magnesite Spring (CMS)

4. GROWTH AND DEMAND PROJECTIONS

4.1 GENERAL

In the near future the District's expanding population will tax the existing developed water supply. The goal of growth and demand projections is to assist in developing the *Integrated Water Resource* Plan as well as the volume of wastewater flow to the Overton Wastewater Treatment Facility. The District's population projections can be estimated using historical data and statistical procedures.

4.2 POTENTIAL DEVELOPMENT AND ACREAGE

The District searched the Clark County, Nevada Government and Services website (http://www.co.clark.nm.us/) and contacted CCDCP's Advanced Planning Division. Proposed developments, as presently understood by the District, are discussed in the following sub-sections.

4.2.1 Coyote Springs Development – Coyote Springs

Coyote Springs Investment owns approximately 85 square miles (54,400 acres) in Coyote Springs Valley (Figure A.2). Published reports estimate the number of planned residential units at about 50,000 (Las Vegas Sun, November 3, 2000). The first phase of the master-planned community encompasses two golf courses and a village center. Coyote Springs Investment, L.L.C. is negotiating with Las Vegas Valley Water District and Moapa Valley Water District to provide service to the community.

The site is located on the north side of State Highway 168, approximately 1.5 miles east of U.S. Highway 93 within portions of Sections 22 through 26, T13S, R63 East. Clark County approved special use permit (UC-0436-00) on June 8, 2000 for a golf course with related facilities and a school on 525.9 acres in a rural open land (R-U) zone. A variance permit (VC-1165-00) was approved September 5, 2000 for an approved golf course and a proposed single-family residential subdivision on approximately 526.8 acres in Rural Open Land (R-U). Clark County approved special use permit (UC-1086-00) on October 5, 2000 for a golf course with related facilities on 172.5 acres in a Rural Open Land (R-U), located approximately 2,600 feet north of Highway 168 and 1.5 miles east of Highway 93 within portions of Sections 14, 15, 22 and 23, T13S, R63 East.

At full build-out of the community the 50,000 residences would require 55,000 afy assuming 1.1 afy per residence.

4.2.2 Riverview Master Planned Community – Moapa

Riverview, an 862-acre mixed-use master-planned community, is proposed to be developed within the existing town of Moapa, Nevada with in Sections 15, 16 and 22, Township 14 South, R66 East and Sections 1 and 2, Township 15 South, Range 66 East. Riverview consist of two villages (North Village and Town Center). The North Village is located on the north side of Learned Cactus Way on both sides of the Meadow Valley Wash. The Town Center Village is located on both sides of Interstate 15 roughly between the two Moapa/Glendale interchanges. The villages will be connected by a road network that is separated from nearby existing roads. Riverview consists of 2860 detached and 800 attached residential units on 533 acres, 240 acres of commercial and 69 acres of non-contributory development (open space/flood plain) equal to 3,300 dwelling units.

4.2.3 Village Courtyard Commercial Shopping Center – Logandale

According to the Board of County Commissioners Notice of Final Action, July 18, 2001, zone change (ZC-0349-01) permit was approved to reclassify 29.5 acres from rural open land (R-U) and residential agricultural (R-A) to general commercial (C-2) for a 217,000 square foot shopping center. The general location is on the east side of State Highway 12 (also known as Moapa Valley Boulevard) and the north side of Don Benjamin Circle in Moapa Valley (Logandale) within the NE¼ of Section 22, Township 15 South, Range 67 East.

The development plans propose a shopping center consisting of ten buildings including three fast food restaurants, a convenience store with gasoline fuel station and a 62,000 square foot super market. In between are retail buildings, restaurants, and a vehicle service facility.

4.2.4 Commercial Shopping Center (Wes and Elizabeth Adams) – Logandale

According to the Board of County Commissioners Notice of Final Action, August 8, 2001, ZC-0420-96 (ET-0191-0I) Holdover Zone Change first extension of time was approved for one additional year. The applicant is requesting the reclassification of 29.0 acres from rural open land (R-U) to general commercial (C-2). The development plans propose a 163,100 square foot shopping center and an 87,000 square foot office/medical complex consisting of four buildings with six pad sites for future commercial development. The property is generally located on the north and east sides of State Highway 12 and approximately 800 feet west of Lyman Avenue within the SE¼ of Section 27, Township 15 South, Range 67 East.

4.2.1 Potential Demand at Full Build Out

The MVWD service territory comprises of 51,172 acres of mostly rural land, with various classifications of zoning and development. Zoning data for lands within the District's service territory were downloaded from the Clark County online Geographic Information System (GIS) database (http://gisgate.co.clark.nv.us/gismo) on July 16, 2014 and are presented in Figure 4.1. Based on the zoning information from Clark County, a total of 7,256 acres within the District's service territory are zoned something other than 'RU – Rural Open Land,' representing a variety of residential, industrial, agricultural, and light manufacturing classes (Table 4.1) The remaining 43,916 acres of the District's service territory are zoned as RU – Rural Open Land.

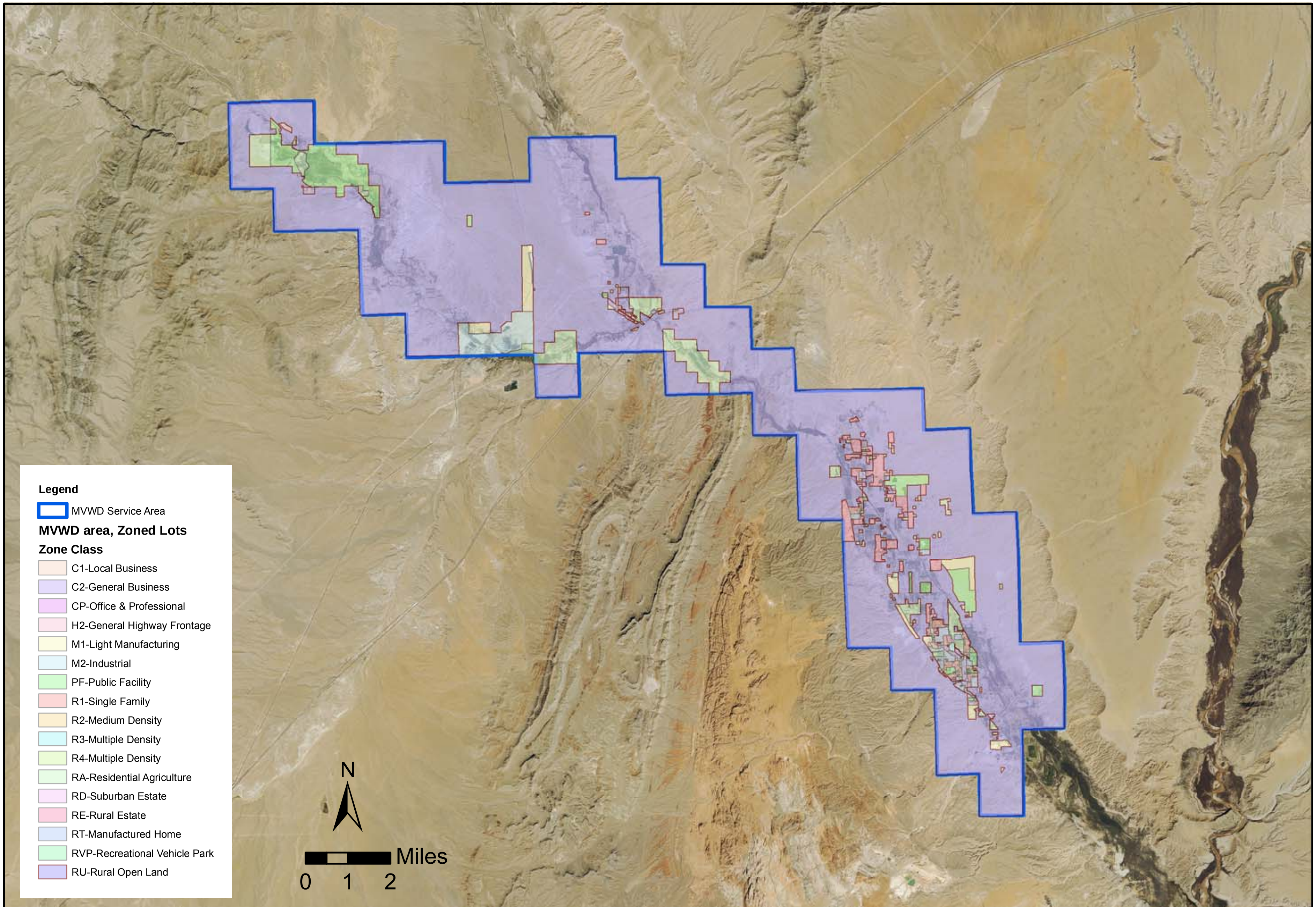

Figure 4.1: Land Use Distribution within the Moapa Valley Water District Service Area

Zoning information obtained from the Clark County online GIS database on 7/16/14.

MOAPA VALLEY WATER DISTRICT

GLORIETA GEOSCIENCE, INC.

These 43,916 acres represent land that could be developed in the future and connected to the MVWD distribution system. Potential subdivision of this land into one-acre tracts with a water demand of 1.1 afy per lot could create an additional demand of 48,307 afy.

Table 4.1: Summary of Zoned Lots within the MVWD Service Area

Zone Class	Total Acreage	Description
C-1	45	Local Business
C-2	244	General Business
C-P	8	Office and Professional
H-2	48	General Highway Frontage
M-1	732	Light Manufacturing
M-2	747	Industrial
P-F	1,903	Public Facility
R-1	201	Single Family
R-2	13	Medium Density
R-3	22	Multiple Density
R-4	5	Multiple Density
R-A	2,022	Residential Agriculture
R-D	21	Suburban Estate
R-E	955	Rural Estate
R-T	257	Manufactured Home
R-U	43,916	Rural Open Land
RVP	34	Recreational Vehicle Park
Grand Total	**51,172**	
Total Non R-U	**7,256**	
Total R-U	**43,916**	

Source: http://gisgate.co.clark.nv.us/gismo

4.3 POPULATION PROJECTIONS

Historical population data is based on information provided by the Nevada State Demographer (2014) and the US Census Bureau (2014). The Nevada State Demographer (2014) also has 20-yr population projections by county. Average annual growth rates for Clark County (dominated by Las Vegas) and the Moapa Valley were 3.6% and 1.8%, respectively between 2000 and 2010 based on Census Bureau data, and 5.0% and 3.6% between 1990 and 2010, respectively (Table 4.2). The Nevada State Demographer reports population data for Moapa Valley for the years 2001 to 2013. Based on these data, the Valley's population grew 2.2% annually between 2002 and 2011, a period of sustained and consistent growth (Figure 4.2). The Demographer's population projections to 2033 indicate an expected growth rate of 0.75% for Clark County (Hardcastle, 2014).

Table 4.2: Average annual population growth rates for Clark County and Moapa Valley

Source/Time Frame	Clark County	Moapa Valley
Census Bureau, 1990-2010	4.96%	3.55%
Census Bureau, 1990-2010	3.56%	1.82%
NV Demographer, 2002-2011	2.69%	2.22%
NV Demographer, 2013-2033 (predicted)	0.75%	N/A

Both historic and predicted growth rates in the Valley and Clark County provide data that can be used to develop a range of scenarios. For this Plan, three scenarios were adopted: 1. Conservative growth rates – 0.75% (NV Demographer's 20-year prediction for Clark County); 2. Growth at historic 10-year sustained levels in the Valley – 2.2% (based on population data reported by the NV Demographer); 3. Rapid growth rates – 3.6% based on US Census data for 1990 to 2010 for the Moapa Valley (Figure 4.2). Using these growth rates, population numbers for the Moapa Valley will reach between 10,000 and 42,200 in 2065.

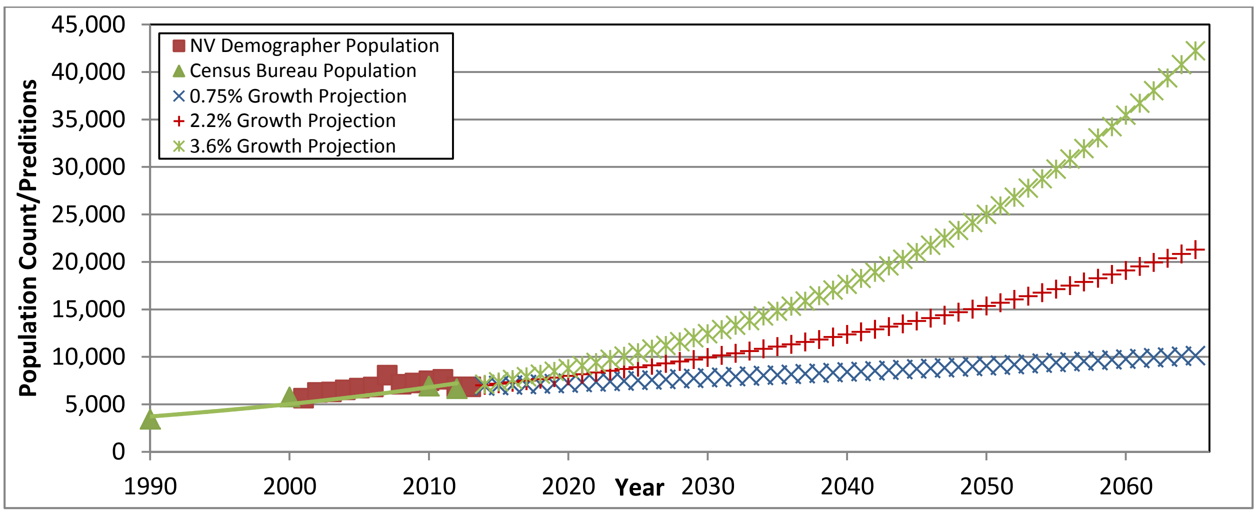

Figure 4.2: Historic and Predicted Population Data for Moapa Valley.

4.4 WATER DEMAND PROJECTIONS

4.4.1 *Historic Demand*

Water demand, as measured by the number of service connections and the total diversions from all sources, has fluctuated in response to changes in the number of residents and increased conservation. As a result, the number of connections (Table 4.3) and diversions have stayed relatively constant in the last 5-10 years (Figure 4.3). The 10-year average growth rate for service connections falls between the two more conservative growth projections assumed for this report at 1.4%.

Table 4.3: Historic Annual Change in District Service Connections

Year	Total Hookups	Net Change in Hookups	Percent Change
2004	2,756	132	5.03%
2005	2,904	148	5.37%
2006	2,980	76	2.62%
2007	3,005	25	0.84%
2008	3,026	21	0.70%
2009	3,014	-12	-0.40%
2010	3,010	-4	-0.13%
2011	3,011	1	0.03%
2012	3,014	3	0.10%
2013	3,016	2	0.07%
Average Annual Change			**1.40%**

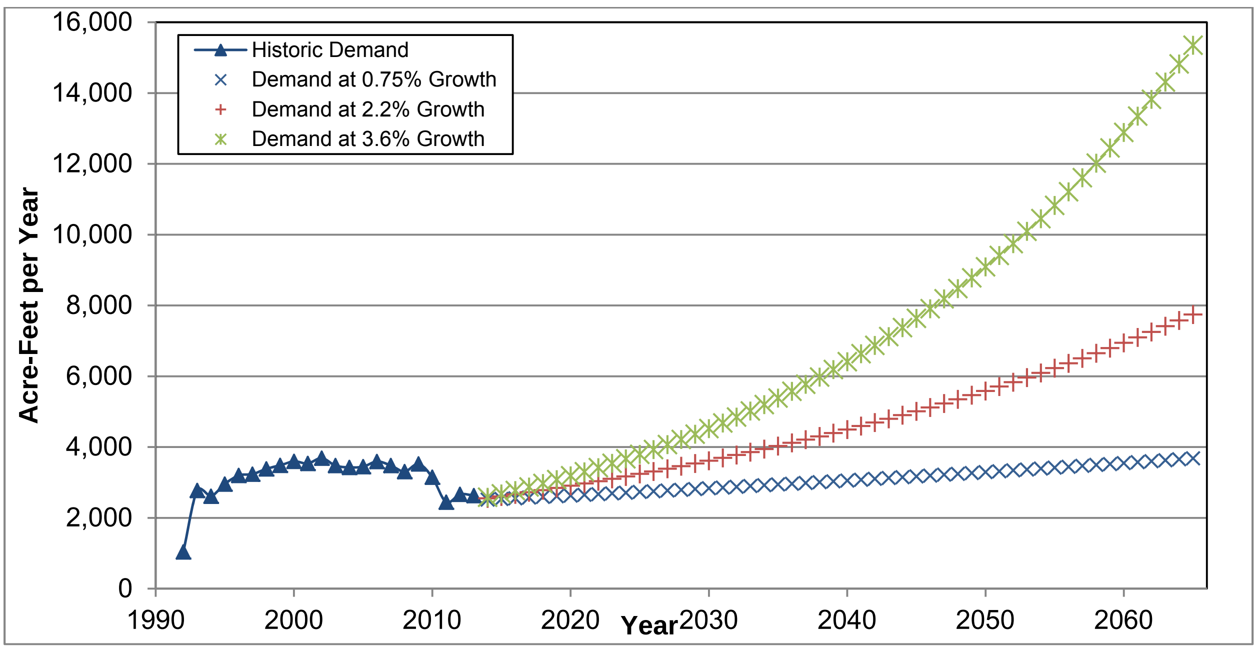

Figure 4.3: Historic and Predicted Water Demand.

Utilizing the total diversions for 2011, 2012 and 2013 (796,586,921 gallons, 869,187,144 gallons; and 856,326,347 gallons, respectively) and three persons per meter, the average capita use estimate is 252 gallons per person per day (gpcd, Table 4.4). Using the Demographer's Office population data for the Moapa Valley (7,647, 6,868, and 6,871, respectively) and the diversion data from above, a per capita water use of 325 gpcd results, which is similar to the value for the maximum water use month (Table 4.4). Since population projection data are based on the value reported by the Demographer's office for 2013, for consistency 325 gpcd was used to predict future demand. The reported demands are based on water diverted (i.e., pumped from the District's various sources) rather than water sold (service meters and hydrants).

Table 4.4: Average per Capita Water Demand 2011-2013

Demand Condition	Gallons per Capita per Day	Demand Factor [a]
Average Day	252	
Minimum Use Month	125	0.50
Maximum Use Month	323	1.28
Peak Day	580	2.30
Peak Hour [b]	882	3.50

[a] Demand Factor represents the ratio of per capita use relative to the average day.
[b] Peak hour demand will occur only once during a day (24 hours).

The average unaccounted water, the difference between diversion metering and consumer metering is approximately 8 percent for the years 2011-2013. The unaccounted water is attributed to tank overflow, system losses, meter calibration errors and unmetered water use, fire hydrants, etc. Therefore, the system is presently selling and accounting for 92 percent of the total production from all water sources.

As is common for the arid southwest, outdoor/irrigation uses accounted for 75 percent of the District water demand while indoor/culinary uses accounted for the remaining 25 percent (Leslie, 1993). The District is presently evaluating the metered use in the portion of the system that is sewered to the Overton Wastewater Treatment Plant to better estimate indoor consumption.

4.4.2 Demand Projections

The District's future water consumption was estimated using the projected population presented in Figure 4.2 and multiplying by a demand of 325 gpcd (see above). The peak day demand was calculated using the peak day demand factor 2.3 (Table 4.4). The water demand projection for the planning period is presented in 10-year increments in Table 4.5 and graphically in Figure 4.3. The water demand in 2065 is estimated between 3,700 and 15,350 acre-feet. The latter exceeds the currently permitted water rights the District owns.

Peak day demand will exceed the capacity of the currently active wells (Arrow Canyon 1 & 2, MX-6) of 4,900 gpm between 2030 and 2060 even under the slower growth projections (Table 4.5). Thus the most urgent challenge for the District will be the ability to meet peak rather than annual demand. The District's network hydraulic analysis plan is currently being updated and will aid in planning.

As mentioned above, several developments are planned in the Valley. The rate at which these developments occur, especially Coyote Springs, will greatly affect future water demand. The full build-out of the District Service area could add a demand of 48,000 afy, and Coyote Springs at full build-out could add another 55,000 afy. To account for unforeseeable, larger-than-expected growth associated with these developments, the District intends to aggressively pursue increases in its water rights portfolio.

Table 4.5: District Water Demand Projections

0.75% Annual Population Growth Demand Projection						
		Avg. Day Demand		Peak Day Demand		Annual Demand
Date	Population	GPM	MGD	GPM	MGD	acre-feet
2015	6,974	1,572	2.26	3,615	5.21	2,535
2025	7,516	1,694	2.44	3,896	5.61	2,732
2035	8,099	1,825	2.63	4,198	6.04	2,944
2045	8,727	1,967	2.83	4,524	6.51	3,172
2055	9,404	2,119	3.05	4,874	7.02	3,418
2065	10,134	2,284	3.29	5,253	7.56	3,684
2.2% Annual Population Growth Demand Projection						
		Avg. Day Demand		Peak Day Demand		Annual Demand
Date	Population	GPM	MGD	GPM	MGD	acre-feet
2015	7,177	1,617	2.33	3,720	5.36	2,609
2025	8,921	2,011	2.90	4,624	6.66	3,243
2035	11,090	2,499	3.60	5,748	8.28	4,031
2045	13,786	3,107	4.47	7,146	10.29	5,012
2055	17,138	3,862	5.56	8,883	12.79	6,230
2065	21,304	4,801	6.91	11,043	15.90	7,744
3.6% Annual Population Growth Demand Projection						
		Avg. Day Demand		Peak Day Demand		Annual Demand
Date	Population	GPM	MGD	GPM	MGD	acre-feet
2015	7,368	1,660	2.39	3,819	5.50	2,678
2025	10,447	2,354	3.39	5,415	7.80	3,798
2035	14,813	3,338	4.81	7,678	11.06	5,385
2045	21,003	4,733	6.82	10,887	15.68	7,635
2055	29,781	6,712	9.66	15,437	22.23	10,826
2065	42,226	9,516	13.70	21,888	31.52	15,350

5. WATER RESOURCE CONCEPT

5.1 GENERAL

The District currently supplies domestic water to its service area (Figure A.1) through two carbonate aquifer wells and two spring sources within the Muddy River Springs Area groundwater basin of Upper Moapa Valley. The District has actively pursued additional water resources by conducting a number of hydrogeological studies and entering into cooperative agreements with other major water purveyors. In addition, the District developed a *Water Resource Development Strategy* (Appendix C). The *Development Strategy* was part of the March 2000 application for funding pursuant to Section 595 of the Water Resources Development Act of 1999, The Rural Nevada Water Infrastructure Initiative. While the funding was granted, the District could not secure permitting from the BLM to drill monitoring and exploratory wells. As a consequence, funding was returned.

This section presents water resource alternatives to assist in developing the District's *Integrated Water Resource Plan* and optimize the potential water resources for future utilization. Optimizing the District's future water resources involves determining the water quantity and quality of potential resources as well as the quantity required to meet projected demands, and promoting conservation practices. The desirable water use plan for the District would incorporate a goal for all major non-potable water users to be converted over to a secondary (non-potable) system, therefore alleviating the demand on the limited potable water resources. The fact that groundwater may be considered the most readily available and feasible resource warrants a brief discussion on the regional hydrology.

5.2 EXISTING GROUNDWATER RESOURCES

The District's existing groundwater sources are located in Upper Moapa Valley and Muddy River Springs Area (Upper Moapa Valley) groundwater basins. The District currently supplies potable-quality water from four sources: MX-6 Well, Jones Spring, Baldwin Springs Channel and Arrow Canyon Wells draw water from the carbonate aquifer portion of the White River Flow System. Groundwater transmitted through the carbonate aquifer recharges the alluvial aquifer and springs in the Muddy River Springs Area, e.g. Jones Spring and Baldwin Spring (Dettinger, 1995).

The District is looking at two possibilities for utilization of the Logandale Well. If funding is available through the District's *Water Resource Development Strategy*, the water source will be treated and used as back-up to serve the domestic system. The capital cost for the membrane facility is estimated to be $500,000 (year 2000 dollars). The 1,850 acre-feet constitute a significant portion of the District's total water rights. Therefore, optimizing the potential use of this resource is essential.

5.3 GROUNDWATER ALTERNATIVES

5.3.1 New Appropriations

The Order 1169 MX-5 pumping test has made it difficult to appropriate more water in the basins the District encompasses. The pumping test's goal was to assess if additional water could be appropriated from the RCA without causing significant declines in the spring discharge or water table. The test affected the warm springs that provide critical habitat for the listed Moapa Dace and adjacent wells, which led the State Engineer to conclude that previously adopted perennial yield estimates for the hydrographic flow systems/basins are valid and that no unappropriated water is available. Consequently, he denied all pending water rights applications (See Rulings 6259 and 6261).

Similar reasoning was adopted by the State Engineer for Lower Meadow Valley Wash, where the District had filed three applications (63379, 63380, 63381), which were denied in Ruling 6031 due to no unappropriated water being available. This ruling was issued in spite of the District's suggestion to include incorporating all monitoring and water supply wells into the existing Muddy Springs area monitoring network, which was accepted by FWS and NPS. The District had estimated a capital cost of $525,000 for three exploratory wells (see *Water Resource Development Strategy* in Appendix C). It is assumed that these wells/permits will not be available for the 2065 planning period.

Based on the State Engineer rulings, the purchase of existing rights and their transfers appear a better alternative to increasing the District's water rights portfolio.

The District's *Water Resource Development Strategy* includes further resource development in the Lower Moapa Valley. This strategy includes exploratory well drilling at two well sites, with a capital cost of up to $1,000,000 for two completed wells. The Logandale Well is a non-potable source currently used for irrigation and other non-potable uses.

5.3.2 Pending Applications

Currently the District has three applications for the appropriation of new water rights pending (Applications 79632, 79633, 79634, Figure A.3) in the Lower Meadow Valley Wash basin. The applications are for the diversion of 6.0 cfs, or 4,344 acre-feet annually each from an underground source for municipal purposes.

Applications 59368, 59370 and 59371 in the Lower Muddy Valley were denied by the State Engineer in Ruling 6261. The District appealed the ruling in District Court. The applications were for 14,480 afy to be diverted from three wells for municipal purposes (Figure A.3).

5.3.3 Arizona Groundwater Bank (Colorado River Water)

The Arizona Groundwater Bank is an idea originally conceived by Arizona, California, Nevada, the Lower Colorado River Indian Tribes, and Bureau of Reclamation in 1994. Arizona proceeded with the concept and created the Arizona Water Banking Authority (AWBA) in 1996. The groundwater-banking program allows interstate water marketing and storage, where Colorado River water could be "banked" or stored in off-stream facilities or groundwater aquifers. Participation in the Bank would allow storage of water in wet years for use in dry years. When future demand dictates the need, the user would be able to withdraw Lake Mead (Colorado River) water. In exchange,Arizona withdraws stored groundwater instead of diverting Colorado River water.

The AWBA has been recharging water in its water bank since 1996 and intends to continue through the year 2017 – the end of the Banking Authority determined by the legislature. Until then, the AWBA plans to recharge up to 400,000 afy (Southern Nevada Water Authority, 1999). The Bureau of Reclamation issued the final regulations for *Offstream Storage of Colorado River Water and Interstate Redemption of Storage Credits in the Lower Division States* a 43 CFR Part 414 (November 1, 1999).

The Arizona Water Banking Agreement was approved July 2001. The agreement allows Nevada to store 1.2 million acre-feet of water in Arizona. However, only 100,000 acre-feet may be recovered in any single year. The agreement will terminate June 2050 or when all SNWA storage credits are recovered, whichever occurs first.

This concept is one of several future water resource options that the Authority outlined in its *1999 Water Resource Plan* to meet water demands beyond the 2020/2030 time period. To utilize this alternative, the District must be a member of the SNWA, thereby benefiting from the negotiating powers of the Authority. Also, the cost of this alternative needs to be carefully evaluated, particularly the cost of bringing treated Lake Mead water to the District.

5.3.4 Southern Nevada Groundwater Bank

This resource alternative utilizes the Las Vegas Valley groundwater basin to store water for future uses. Two SNWA agencies, Las Vegas Valley Water District and City of North Las Vegas, inject more than 18,000 acre-feet of treated Colorado River water annually. Based on the program's success, SNWA is expanding its well recharge capability and exploring other suitable recharge aquifers in Southern Nevada.

Utilization of this alternative may involve the exchange of water rights (surface or groundwater). The District may bank water rights in exchange for treated water through a pipeline from SNWA's Lake Mead water treatment facility to the District. Alternatively, the District would need to have an exchange program with the SNWA, whereby the District would exchange the surface water rights for SNWA groundwater rights in a local hydrographic basin. This alternative would be enhanced by District membership in the SNWA.

5.3.5 Cooperative Water Project

The Cooperative Water Project involves the collection and transmission of up to 84,000 afy of groundwater to Las Vegas from sixteen hydrologic basins in four Nevada counties: Clark, Lincoln, Nye, and White Pine. The estimated cost of construction in 2014 dollars is $7.4 billion. According to SNWA's *1999 Water Resource Plan,* neither LVVWD nor SNWA are pursuing construction of the Cooperative Water Project due to potential environmental issues, lack of public support, and low benefit/cost ratio. The District understands that SNWA has initiated efforts to assemble a tri-county conservancy to further evaluate the Cooperative Water Project and possibly pursue this alternative.

5.4 SURFACE WATER ALTERNATIVES

5.4.1 Muddy River

The Muddy River water originates in the Muddy River Springs Area and flows into Lake Mead. A 1920 State Decree allocated the entire flow of the River (approximately 25,000 to 30,000 afy) and declared the Muddy River as a Nevada resource separate from the waters of the Colorado River. A majority of the water is used for agriculture and power generation. SNWA estimated a maximum of 5,000 acre-feet of water rights could become available through fallowing farm land. In 1997, SNWA began purchasing Moapa Valley Irrigation Company stock to acquire water from the river.

An agreement between the District and SNWA limits the amount of water that could be transferred by SNWA out of the Moapa Valley. Part of the *Coyote Spring Valley Groundwater Development Plan* involves a water rights exchange between the District and SNWA.

5.4.2 Blending Muddy River Water with Reclaimed Wastewater

The concept of blending Muddy River water with reclaimed wastewater (treated effluent) for irrigation purposes requires a secondary-use-system. A secondary system would be equipped with a river induction well, pumping facility (pump to reservoir or tanks), delivery system, and storage tanks. Reclaimed wastewater would originate from the Overton Wastewater Treatment Facility (WWTF).

The District currently owns secondary water rights to treated effluent. At the present time, Overton benefits from a wastewater collection system and treatment facility. Clark County (2000) reported a wastewater production rate of 60 gallons per capita per day (gpcd) using 1998 Overton WWTF wastewater flows. Expanding the collection system will increase Overton WWTF influent flows and accordingly, effluent discharge and reuse potential. For purposes of projecting future wastewater flows, the Plan assumes 110 gpcd for Moapa, Glendale and Logandale, based on historic average production rates in Mesquite and Las Vegas Valley. Clark County (2000) recommended to the Clark County Board of County Commissioners that the District and Clark County Sanitation District develop an Effluent Management Plan addressing water reclamation and reuse. The District's *Water Resource Development Strategy* includes a proposed study to determine the feasibility of constructing a pressurized irrigation water distribution system (secondary water system). The District currently owns 777 afy (excluding irrigation shares tied to Jones Spring) of Muddy River water rights for irrigation use.

5.4.3 Lake Mead Storage and SNWA Treated Water Exchange

Lake Mead (see Figure 2.1) could potentially be used for storing the District's acquired Muddy River water rights (the Law of the River notwithstanding). The District could allow their Muddy River water to flow into Lake Mead and exchange it for treated water through a pipeline from SNWA's Lake Mead water treatment facility.

The capital cost of extending a pipeline from the treatment facility to the District's distribution system will need to be evaluated with other water supply options; however this option offers a source of water from SNWA that is independent of water quality issues and drought concerns. Muddy River water stored in Lake Mead may also provide short and long term drought protection. A stored-water-accounting system may need to be approved by the Nevada State Engineer and the Colorado River Commission. Law of the River legal issues (i.e., wheeling) will require negotiation.

5.4.4 Lake Powell Pipeline (Water via Virgin River)

This alternative would involve the lease/purchase of Colorado River water from Lake Powell. The District, through agreement with the SNWA, could utilize the Virgin River (see Figure 2.1) to convey its Lake Powell water to Lake Mead (the Law of the River not withstanding). This requires an agreement with SNWA for treated water purchase from the Lake Mead water treatment facility and transmission to the District. Alternatively, the acquired water rights could be traded to SNWA in return for regional groundwater rights.

Utah's Washington County Water Conservancy District (WCWCD) commissioned the *Lake Powell Pipeline Feasibility Study* to investigate the feasibility of delivering Utah's upper basin Colorado River water from Lake Powell to Washington County. Conceptually, Lake Powell water could be diverted (via pipeline) and discharged into the Virgin River at St. George, Utah. The studies concluded that a pipeline from Lake Powell could deliver water at a reasonable unit cost, however the high initial cost may be prohibitive. The pipeline would be 120 miles long with a design capacity of 70,000 acre-feet. The estimated unit cost of water was $256/acre-foot, including annualized capital costs, O&M, and power (Boyle Engineering Corp., 1998).

A transmission main from Lake Powell to the Virgin River appears to be infeasible due to the excessive length; however, a joint effort by the Distrtict/SNWA/WCWCD may make this option feasible. Additionally, Law of the River legal issues (i.e., wheeling) will require negotiation.

5.4.5 Surface Water Treatment

To meet future growth and development need, the District had Black & Veatch (2005) evaluate the use of Bowman Reservoir as a viable source of potable water supply. The existing groundwater supply serving the District is limited due to environmental issues and endangered species protection.

The *Bowman Reservoir Surface Water Treatment Evaluation* identified two alternative treatment technologies, and developed capital and operation and maintenance cost for surface water treatment. A water quality monitoring program is also described for Bowman Reservoir to further define water quality characteristics and provide a basis for detailed process design.

The two technologies investigated were a conventional treatment plant and a low-pressure membrane filtration plant. The conventional water treatment plant includes an influent pumping station and reservoir intake, rapid mix, coagulation, flocculation, sedimentation, filtration, disinfection, clear well, treated water pumping station and sludge lagoons for the waste. The microfiltration plant includes an influent pumping station and reservoir intake, pretreatment, membrane filtration, clear well, treated water pumping station and sludge lagoons for the waste. The degree of pretreatment upstream of filtration is highly dependent on water quality, and could range from inline coagulation to conventional pretreatment involving coagulation, flocculation and sedimentation.

2005 cost estimates indicate a cost of $9.5 million for the conventional water treatment plant and $11.1 million for the microfiltration plant.

It is envisioned for this Plan that surface water rights could be utilized through exchange for groundwater rights, or as discussed in some of the resource alternative (Section 6.0), treated water from the SNWA. Another potential use of surface water is to supply re-use irrigation through a dual water system. Surface water with minimal treatment such as disinfection could supply irrigation water for large green belt areas and playing fields such as Moapa Valley High School and the Clark County Fair Grounds.

5.5 WASTEWTER TREATMENT AND REUSE POTENTIAL

Overton is the only community currently sewered in the Moapa Valley and producing approximately 0.22 MGD of wastewater. By 2020 an estimated 0.36 MGD of reclaimed wastewater would be available based on projected wastewater flows at Overton (Montgomery Watson, 2000). This estimate is based on an average annual growth rate of 2.4%.

The small, distant communities in the study area make it currently uneconomic to integrate sanitary sewer collection and treatment infrastructure with Overton needed as the precursor to reclaiming wastewater. And with potential and projected population and wastewater production limitations, there is too little water of poor quality at too high a cost to implement purposeful effluent reuse. It will be a very long time before projected populations in the District could possibly generate sufficient wastewater flows to warrant the cost of developing, permitting, construction and operating a complete system to treat and reuse wastewater. The conjunctive use of Muddy River water for secondary uses could make the re-use of non-potable source feasibility.

5.6 WATER RESOUCE ALTERNATIVES RATING CRITERIA

1. Capital Cost – The greater the initial capital expenditure, the less attractive the alternative. Capital costs are ranked as follows: 1 = greater than $40 million, 2 = $30-$40 million, 3= $15-$30 million, 4= $5-$15 million, and 5=less than $5 million.

2. Operation and Maintenance Cost – The higher the operation and maintenance costs, the less attractive the alternative.

3. Treatment Requirements – Alternatives are rated according to the required level of treatment as required by water quality.

4. Reliability – Alternatives are rated according to how reliable they are for providing water and if subject to interruptions created by power failures and mechanical breakdowns or drought/flood.

5. Water Rights – Alternatives are rated according to water rights availability or acquisition feasibility.

6. Political Feasibility – Alternatives are rated according to political ease-of-approval, which includes Health Department approval, any permitting, or potential protest from others (i.e., Law of the River litigation, approval by the Colorado Basin States or protest from any entities, etc.).

7. Overall Feasibility – The feasibility of each alternative is rated from a preliminary overview.

5.7 CONSERVATION PLAN

In 2014 the District adopted a conservation plan (Appendix B) to encourage water conservation among the primarily residential customers. Implementation of a conservation plan has the potential to reduce water use, thereby producing additional water to meet a portion of the future demands presented in Section 5.0.

6. ELECTRICAL RESOURCE PLAN

(Frank Loudon, P.E.)

6.1 INTRODUCTION

The new pumping loads contemplated by the Moapa Valley Water District (District) will generally be located within the Overton Power District No. 5 (OPD) service area. This section summarizes the OPD requirements for line extensions and provides a synopsis of sources of capacity and associated energy from alternative resources.

6.2 OPD POWER SUPPLY RATES

Table 6.1 presents the OPD rate schedule as of October 1, 2012. The District pumping loads fall under the Municipal and Water District. (Tariff #5) OPD absorbs short-term fluctuations in fuel and purchased power costs and adjusts its rates based on long-term changes in operating costs and additions to its transmission and distribution systems. These long-term adjustments to rates are mitigated somewhat by OPD's allocation of Federal Hydroelectric Power, but the volatility of the deregulated market combined with the need to purchase more resources above the hydropower allocation may result in more frequent rate adjustments to OPD than has historically been the case.

OPD has a policy of collecting in advance, from customers with new or additional electrical load, the cost of building the additional distribution facilities required to serve that load. The advance is collected in accordance with the utility's line extension policy, OPD-S-2.200 dated 09/21/04, which provides for a refund of a portion of the advance if additional customers connect to the line for which the funds were advanced within five years of the construction of the distribution facilities.

In addition to the non-refundable advance of funds for construction, OPD collects an impact fee from new customers. Impact fees are non-refundable and are collected on the basis of $50 per installed kVA of transformer capacity required to serve the new load.

Table 6.1: Overton Power #5 Rate Schedule

	Number 100	Number 110
Tariff #1 – Residential		
Customer Charge	$25.00 per month	$25.00 per month
First 500 kWh	$ .0747 per kWh	$ .07812 per kWh
Next 1,500 kWh	$ .0852 per kWh	$ .08900 per kWh
Over 2,000 kWh	$ .1000 per kWh	$ .10000 per kWh
Tariff #2 – Irrigation Rate		
Customer Charge	$21.50 per month	$21.50 per month
Demand Charge	$ 7.47 per kW	$ 7.47 per kW
Energy Charge	$ .0690 per kWh	$ .0690 per kWh
Tariff #3 – General Service Non-Demand		
Customer Charge	$21.50 per month	$21.50 per month
First 1,000 kWh	$ .0870 per kWh	$ .0870 per kWh
Next 1,000 kWh	$ .0940 per kWh	$ .0940 per kWh
Over 2,000 kWh	$ .1010 per kWh	$ .1010 per kWh
Tariff #4 – General Service Demand		
Customer Charge	$35.00 per month	$35.00 per month
Demand Charge	$ 8.62 per kW	$ 9.01 per kW
Energy Charge	$ .0655 per kWh	$ .06845 per kWh
Tariff #5 – Municipal and Water District		
Customer Charge		$35.00 per month
Demand Charge		$ 8.62 per kW
Energy Charge		$ .06550 per kWh

These fees are intended to defray the cost to OPD of enhancing or rebuilding existing distribution facilities in order to reliably serve the load of the new customer. For those service points within OPD's service area that require additional substation construction or a new feeder from an existing substation, no impact fees are imposed. However, the advance of funds in aid of construction will still be collected.

OPD's line extension policy permits loads greater than 500 kW to be served under a special contract that sets forth the terms and conditions of service. Such contacts may provide a vehicle for the District to obtain a cleaner and firmer understanding of required construction advances and their timing as well as the rights and obligations of both OPD and the District.

The facilities to which the non-refundable advance applies are those new distribution facilities required between the point of interconnection with Overton Power's existing distribution facilities and the point of connection to the new load. The District has the option of hiring its own contractor to install new distribution facilities on behalf of OPD. Those facilities must be constructed in accordance with OPD' standards and after completion of construction, OPD must assume ownership of the facilities.

6.3 ALTERNATIVE RESOURCES

OPD is exempted from the deregulation statutes that permit certain retail customers to seek alternative suppliers of power. However, it may be possible for the District, the Southern Nevada Water Authority, and OPD to come to a mutually beneficial agreement for power supply to pumping loads particularly in a shared pumping arrangement between the District and Southern Nevada Water Authority.

Self-generation owned and operated by the District is a reasonable option when line extension costs or utility rates and prohibitive. Self-generation can also be used as a resource by the serving utility or independent supplier. This arrangement can be accomplished in at least two ways. Under the first, the OPD would have the option of calling upon the District to run its generation in order to reduce its load during hours of peak requirements. Payment to the District would be, at a minimum, enough to cover the difference between the fixed and variable costs of the District generation and the OPD tariff. Actual reimbursement to the District would be based on a cost sharing agreement with OPD that considers both the cost of generation to the Distract and the cost savings of OPD. There will very likely be periods during the hours of summer peak electric loads when the short-term cost of power will be very high, thus providing incentive to both OPD and the District to share generation.

The second way for the District to utilize its self-generation as a way to reduce its costs is to operate in parallel with OPD's system. Under that arrangement, OPD would install "net metering" which would measure the bi-directional flow of power at the customer meter. The District's bill would reflect the difference between power used and power generated.

Self-generation technologies such as conventional diesel or gas fueled systems; simply cycle combustion turbines, with or without heat recovery steam generation; and micro-turbines can provide a reliable and cost-effective means of providing capacity and energy for the District pumping loads. A long-term self-generation strategy for the District to consider is the application of fuel cells as a power source for its more remote wells. Fuel cell technology is not new and is being improved at a rapid rate, primarily as a source of distributed generation. Within the next ten to fifteen years it is very likely that fuel cell technology will prove both cost effective and reliable as a primary source of power in remote locations where the cost of transmission and distribution facilities is prohibitive. Table 6.2, below, summarizes the costs of the alternative resources discussed.

Table 6.2: Generation Technology Summary

	Diesel	Microturbine	Combustion Turbine	Fuel Cell
Size (kW)	10-4000	25-1000	1000-50,000	3-3000
Installed Cost $/kW	300-800	700-1100	300-1000	3,500-10,000
Efficiency	12%-20%	22%-30%	21%-42%	40%-65%
Maintenance Cost ($/kWh)	0.015-0.025	0.003-0.01	0.003-0.008	0.005-0.01

6.4 CONCLUSIONS

The OPD tariffs are competitively priced and relatively stable as compared to the pricing of the alternative resources listed in Table 6.2; however, the District should carefully compare the costs and reliability of alternative resources as compared to the cost of a line extension from the serving utility.

Diesel/gas generation is still a cost effective and reliable source of back-up power and probably will remain so for some time. It is also a technology that lends itself to a peak shaving agreement with the electric utility which can benefit both parties to such an agreement.

Combustion turbines running in either simply cycle or combined cycle configurations are cost effective, efficient, and environmentally acceptable sources of primary power for water pumping but generally must be installed in sizes greater than the needs of the District. Microturbines in sizes of 1000 kW or less present a very acceptable alternative to large combustion turbines for self-generation to supply water pumping loads. Their ability to burn natural gas, propane, or #2 oil make them an attractive alternative in areas where expensive line extensions are required from traditional utilities. In the longer term, fuel cells are a very promising resource for remote pumping loads. Fuel Cell efficiency and lack of negative environmental impact make it the likely choice for the future to supply supplemental generation.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

In accord with the District's active pursuit of groundwater resources, and the costs of treatment and quality concerns with available surface water resources, particularly the Muddy River, this *Integrated Water Resource Plan* presents groundwater as the District's primary resource through the planning period 2065. Foreseeable significant costs likely include groundwater exploration/monitoring projects, arsenic removal, water rights acquisition, surface water treatment along with additional operation and maintenance costs.

The District's projected water demand for the year 2065 is estimated between just under 4,000 and 15,350 acre-feet per year. This means that if rapid growth rates prevail over the planning period, water demand will exceed currently permitted and leased water rights.

As mentioned above, several developments are planned in the Valley. The rate at which these developments occur, especially Coyote Springs, will greatly affect future water demand. Full build-out of the District Service area could add a demand of 48,000 afy and Coyote Springs at full build-out another 55,000 afy. To account for unforeseeable, larger-than-expected growth associated with these developments, the District intends to aggressively pursue increases in its water rights portfolio.

In the year 2065, the peak (maximum) day demand will require an average source production capacity between 5,200 and 22,000 gallons per minute. Active pumping capacity from the three groundwater wells is currently 4,900 gpm, thus depending on the rate of population growth, demand will exceed groundwater production capacity between 2030 and 2060 pursuant to NAC 445A requirements. Therefore, the District needs to plan for a potential short-fall to meeting peak day water demands in the future. The District's network hydraulic analysis plan is currently being updated and will aid in future planning.

Due to recent (2014) rulings by the State Engineer in the basins the District lies in, appropriating additional water appears challenging barring significant new insights regarding the hydrology and perennial yield of affected basins. Surface water utilization and treatment may provide an additional source of water for the District. Utilization of reclaimed wastewater will be limited by the current lack of sufficient wastewater flows, agreements with the Clark County Reclamation District, and secondary system infrastructure. However, reclaimed wastewater utilization may be a feasible alternative in future.

7.2 RECOMMENDATIONS

1. Use of groundwater with arsenic treatment is the recommended water supply source for the planning period.
2. The District should continue the groundwater exploration program to develop the most effective sources of supply from a water quality and cost perspective.

3. The District should continue to explore surface water treatment in conjunction with Bowman Reservoir.
4. The District should increase its peak production capacity by adding points of diversion.
5. The District should continue to participate with the Southern Nevada Water Authority regarding water resource development alternatives, e.g., groundwater exploration and exchange of surface water rights for groundwater rights.
6. The District should maintain a pro-active water conservation effort to alleviate resource and supply impacts.
7. The District should investigate cost savings through self-generation as a reasonable option for alternative electrical power by either reducing Overton Power's load or reducing cost to the District by running in parallel with Overton Power.

8. REFERENCES

Black & Veatch, 2005, Bowman Reservoir Surface Water Treatment Evaluation, Report for the Moapa Valley Water District.

Boyle Engineering Corp., 1998, Water Supply Needs for Washington and Kane Counties & Lake Powell Pipeline Study: Washington County Water Conservancy District & Utah State Division of Water Resources, Utah.

Buqo, T. S., Drici, Q. and Goings, D.B., 1992, Hydrology and Steady-State Ground-Water Model of Coyote Spring Valley, Clark and Lincoln Counties, Nevada: Las Vegas Valley Water District, Cooperative Water Project, Report No. 3, 84 p.

Buqo, T. S., 1993, Hydrology and Water Resources of the Moapa Valley Water District Service Area. Report for the Moapa Valley Water District. 54 p.

Clark County, Nevada Government and Services website (http://www.co.clark.nv.us/)

Clark County Department of Air Quality and Environmental Management, 2000, Northeast Clark County 208 Water Quality Management Plan.

Dettinger, M.D., Harrill, J.R., Schmidt, D.L., and Hess J.W., 1995, Distribution of Carbonate-Rock Aquifers and the Potential for Their Development, Southern Nevada and Adjacent Parts of California, Arizona, and Utah: U.S. Geological Survey Water-Resources Investigations Report 91-4146, 100 p.

DWR, 1999. Nevada State Water Plan. Nevada Division of Water Resources. 959 p.

Eakin, T. E. and Moore, D.O., 1964, Uniformity of Discharge of Muddy River Springs, Southeastern Nevada, and Relation to Interbasin Movement of Ground Water: United States Geological Survey Professional Paper 500-D, pp. D171-176.

Eakin, T.E., 1964, Ground-Water Appraisal of Coyote Spring and Kane Spring Valleys and Muddy River Springs Area, Lincoln and Clark Counties, Nevada: Nevada Department of Conservation and Natural Resources, Division of Water Resources, Ground-Water Resources – Reconnaissance Series Report 25, 40p.

Emme, D.H., 1986, Delineation of Subsurface Flow in the Upper meadow Valley Wash Area, Southeastern Nevada: University of Nevada-Reno, unpublished Master's Thesis, 90 p.

Ertec Western Inc., 1981, Water Resources Program, Results of Regional Carbonate Aquifer Testing, Coyote Spring Valley: Department of the Air Force, MX Siting Investigation, Water Resources Report E-TR-57, Long Beach, CA, 190 p.

Riesterer, J.R. Lazarus, J., 2013, Memorandum to Joe Davis – Evaluation of MX-5 Pumping Test on Springs and Wells in the Muddy Springs Area

Hardcastle, J. 2014. Nevada County Population Projections 2014 to 2033. Nevada State Demographer's Office. 119 p.

Harrill, J.R., Gates, J.S., and Thomas, J.M., 1988, Major Ground-Water Flow Systems in the Great Basin Region of Nevada, Utah, and Adjacent States, USGS Hydrologic Investigations Atlas HA-694-C.

Katzer, T., 1996, Conceptual Model of the Hydrogeology of Coyote Spring Valley, Clark and Lincoln Counties, Nevada and the Feasibility of Developing Ground-Water Resources: Cordilleran Hydrology, Inc., 16 p.

LVVWD, 2001, Water Resources and Ground-Water Modeling in the White River and Meadow Valley Flow Systems: Las Vegas Valley Water District, Las Vegas, Nevada.

Leavitt and Associates, 1970, A Preliminary Feasibility Report on the Moapa Valley Municipal Water System for the Moapa Valley Water Company: Moapa Valley Water Company, Overton, Nevada.

Leslie & Associates, Inc., 1993a, Preliminary Engineering Report Water System Improvements, Moapa Valley: Moapa Valley Water District, Logandale, Nevada, 17 p.

Leslie & Associates, Inc., 1993b, Addendum to Preliminary Engineering Report: Water System Improvements, Moapa Valley: Moapa Valley Water District, Logandale, Nevada, 3 0.

Leslie & Associates, Inc., 1998a, Draft Moapa Valley Water District Impact Fee Study: Moapa Valley Water District, Logandale, Nevada.

Leslie & Associates, Inc., 1998b, Preliminary Engineering Report for Water System Improvements at the Moapa River Indian Reservation and the Warm Springs Area: Moapa Valley Water District, Logandale, Nevada, 14p.

Leslie & Associates, Inc., 1999, Preliminary Engineering Report for Water System Capital Improvements within the Moapa Valley Water District Service Area: Moapa Valley Water District, Logandale, Nevada, 15 p.

Leslie & Associates, Inc., 2000, Formal Comment on the Proposed Rule for MCL Adjustment of Arsenic: Moapa Valley Water District, Logandale, Nevada.

Leslie & Associates, Inc., 2002, Preliminary Engineering Report for Proposed Water Resource Developments to Supply Domestic Drinking Water to the Moapa Valley Water District Service Area: Moapa Valley Water District, Logandale, Nevada, 14 p.

MVWD. 2011. 2011 Consumer Confidence Report, http://www.moapawater.com/water-quality.cfm.

Montgomery Watson, 2000, Northeast Clark County 208 Water Quality Management Plan: Clark County Board of County Commissioners, Nevada.

Nevada State Demographer. 2014. http://nvdemography.org/data-and-publications/ accessed on 11/25/2014.

NOAA, 2014, http://www.ncdc.noaa.gov/cdo-web/, accessed 11/3/2014.

Pohlman, K.F., Campana D.J., Chapman J.B. and Earman S., 1998, Investigation of the Origin of Springs in the Lake Mead National Recreation Area: Desert Research Institute Publication No. 41161, 92 p.

Reno Gazette-Journal, “Settlement Reached on Water for Project in Southern Nevada,” February 15, 2002.

Rush F.E., 1964, Ground-Water Appraisal of the Meadow Valley Area, Lincoln and Clark Counties, Nevada: Nevada Department of Conservation and Natural Resources, Division of Water Resources, Ground-Water Resources – Reconnaissance Series Report 27.

Rush, F.E., 1968, Water-Resources Appraisal of the Lower Moapa – Lake Mead Area, Clark County, Nevada: Nevada Department of Conservation and Natural Resources, Division of Water Resources, Water Resources – Reconnaissance Services Report 50, 66 p.

SNWA, 1999, Water Resource Plan: Southern Nevada Water Authority, Las Vegas, Nevada.

SNWA, 2000, Draft Coyote Spring Valley Ground Water Development Plan: Southern Nevada Water Authority, Las Vegas, Nevada.

SNWA, 2008, Baseline Characterization Report for Clark, Lincoln, and White Pine Counties Groundwater Development Project, Southern Nevada Water Authority, Las Vegas, Nevada in cooperation with the Bureau of Land Management.

Thomas, J.M., Calhoun, S.C. and Apambire, W.B., 2001, A Deuterium Mass-Balance Interpretation of Groundwater Sources and Flows in Southeastern Nevada: Desert Research Institute Publication No. 41169, 35p.

Thomas, J.M., Welch, A.H., and Dettinger M.D., 1996, Geochemistry and Isotope Hydrology of Representative Aquifers in the Great Basin Region of Nevada, Utah, an Adjacent States: United States Geological Survey Professional Paper 1409-C, 100 p.

US Census Bureau. 2014 http://www.census.gov/easystats/, accessed 11/25/2014.

USFWS, 2014. http://www.fws.gov/nevada/protected_species/fish/species/moapa_dace.html, accessed 12/4/20104

USGS, 2012. National Water Information System. http://maps.waterdata.usgs.gov/mapper/.

Waterresource Consulting Engineers, Inc., 2002, Integrated Water Resource Plan.

Winograd, I.J., and Friedman, I., 1972, Deuterium as a Tracer of Regional Ground-water Flow, Southern Great Basin, Nevada and California: Bulletin of the Geological Society of America, 83, pp. 3691-3708.

Worts, G.F., Jr. and Malmberg H.F., 1966, Water-Resources Appraisal of Eagle Valley, Ormsby and Douglas Counties, Nevada: Nevada Department of Conservation and Natural Resources, Division of Water Resources, Water Resources – Reconnaissance Series Report 39.

APPENDIX A

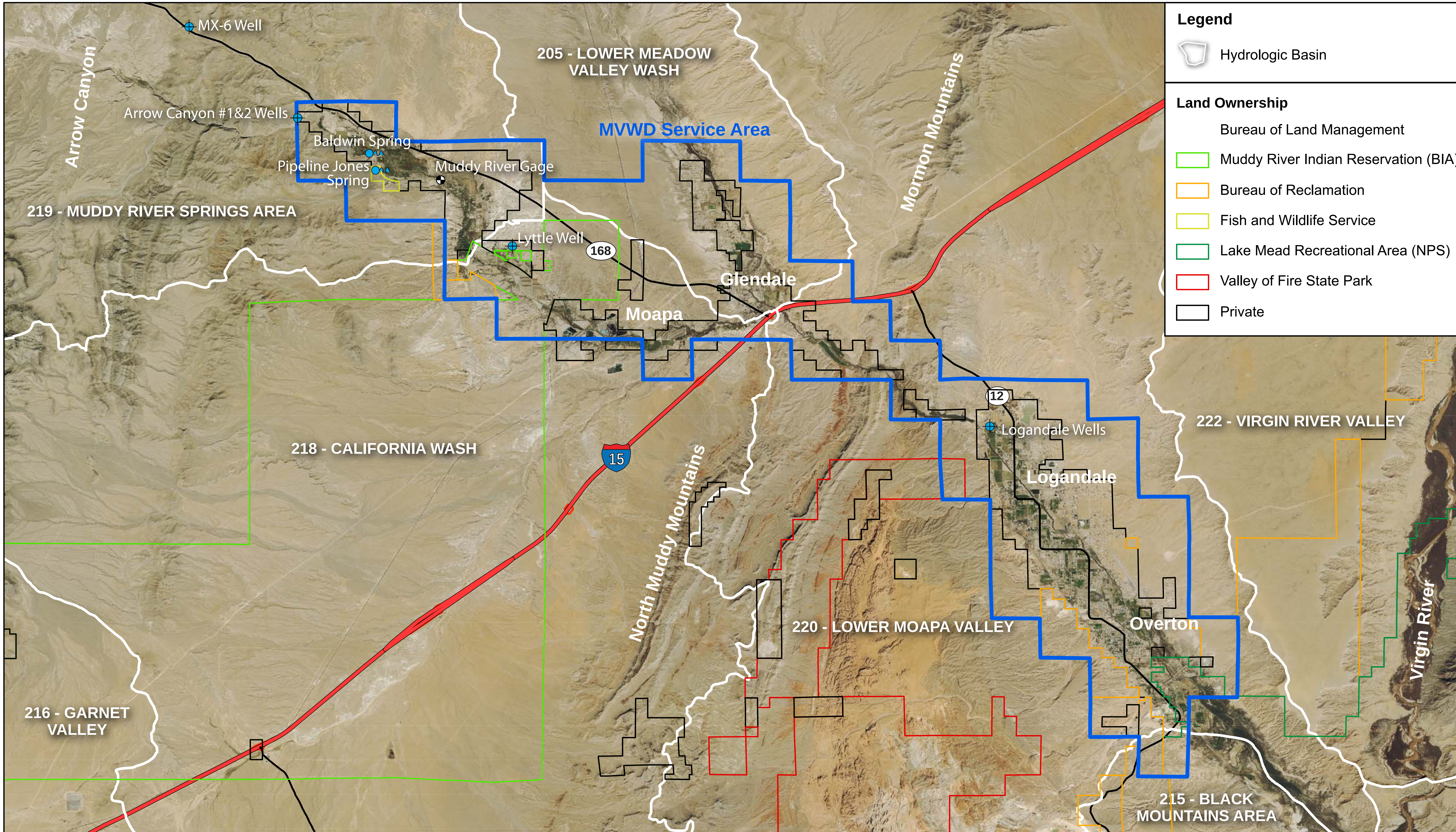

Figure A.1: Moapa Valley Water District Overview Map

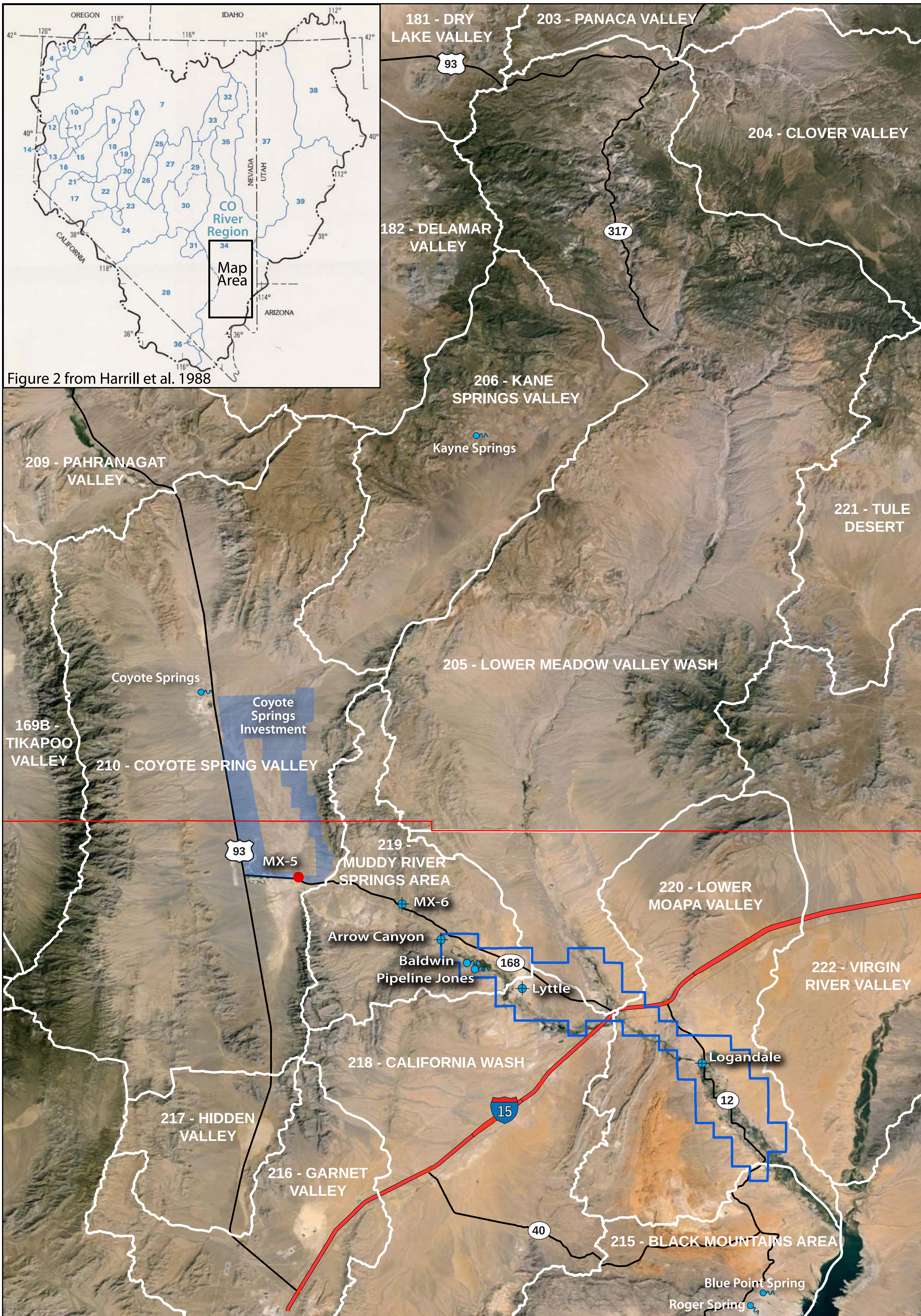

Figure A.2: Hydrologic Basin Map

Moapa Valley Water District Service Area

Miles 0 2.5 5 10

N

MOAPA VALLEY WATER DISTRICT

GLORIETA GEOSCIENCE, INC.

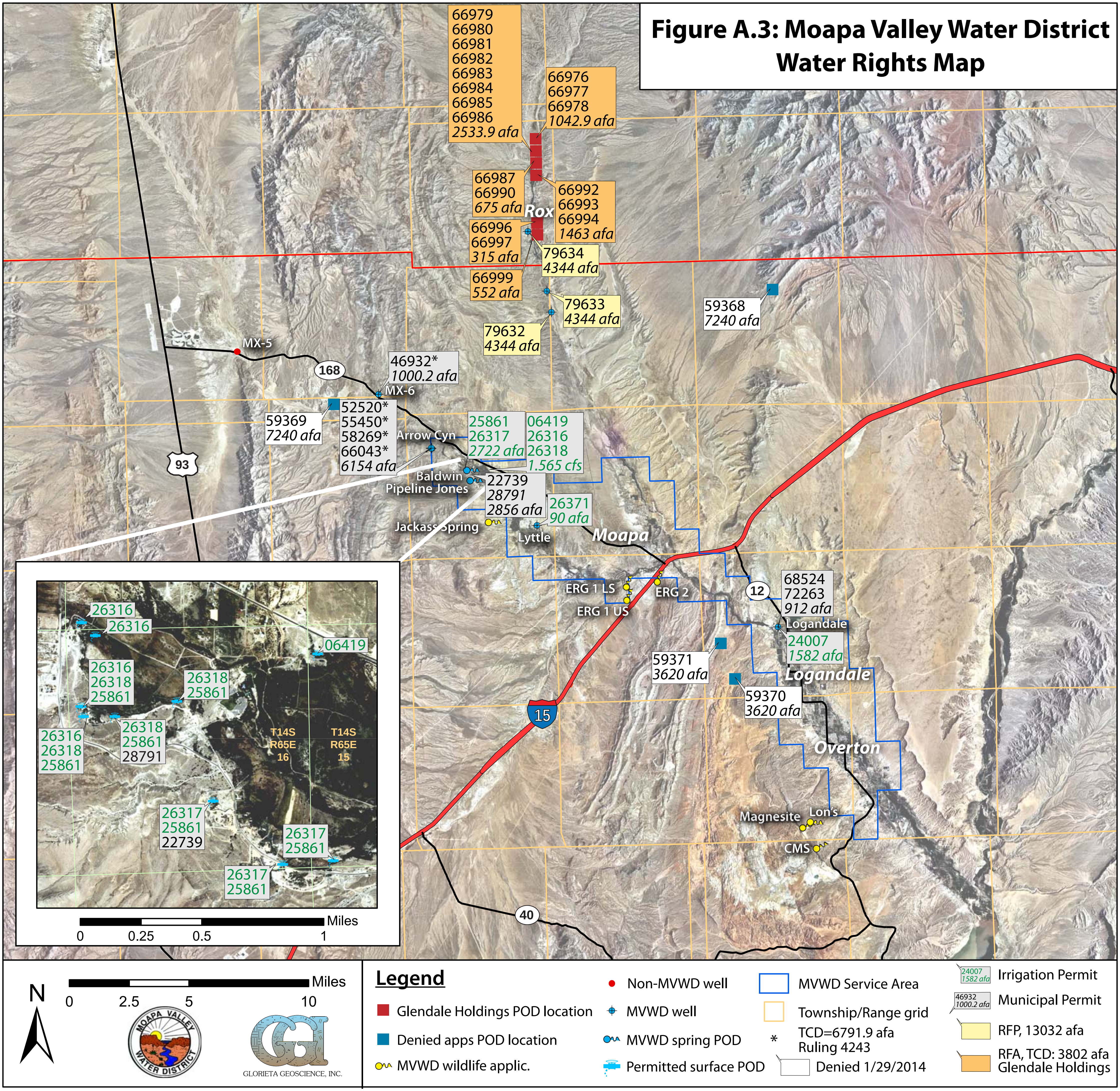

Figure A.3: Moapa Valley Water District Water Rights Map

APPENDIX B

Water Conservation Plan

APPENDIX C

Water Resource Development Strategy