WELLHEAD PROTECTION PROGRAM

MOAPA VALLEY WATER DISTRICT

MARCH, 2005

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1.0 INTRODUCTION

The Moapa Valley Water District (MVWD, the District) prepared this Wellhead Protection Plan (WHPP) to ensure that the public drinking water supplies provided by the District are safe from potential sources of groundwater contamination. This section provides a brief introduction to the WHPP, its purpose, the past investigations that have been done, and the regulatory basis for the preparation and implementation of this plan.

The District serves a large area in northeastern Clark County including the communities of Overton, Logandale, Glendale, Moapa, and the Muddy Springs Area. Figure 1 is a general location map that shows the extent of the District's service area. The District relies on the five water supply sources. These sources are shown in Figure 2.

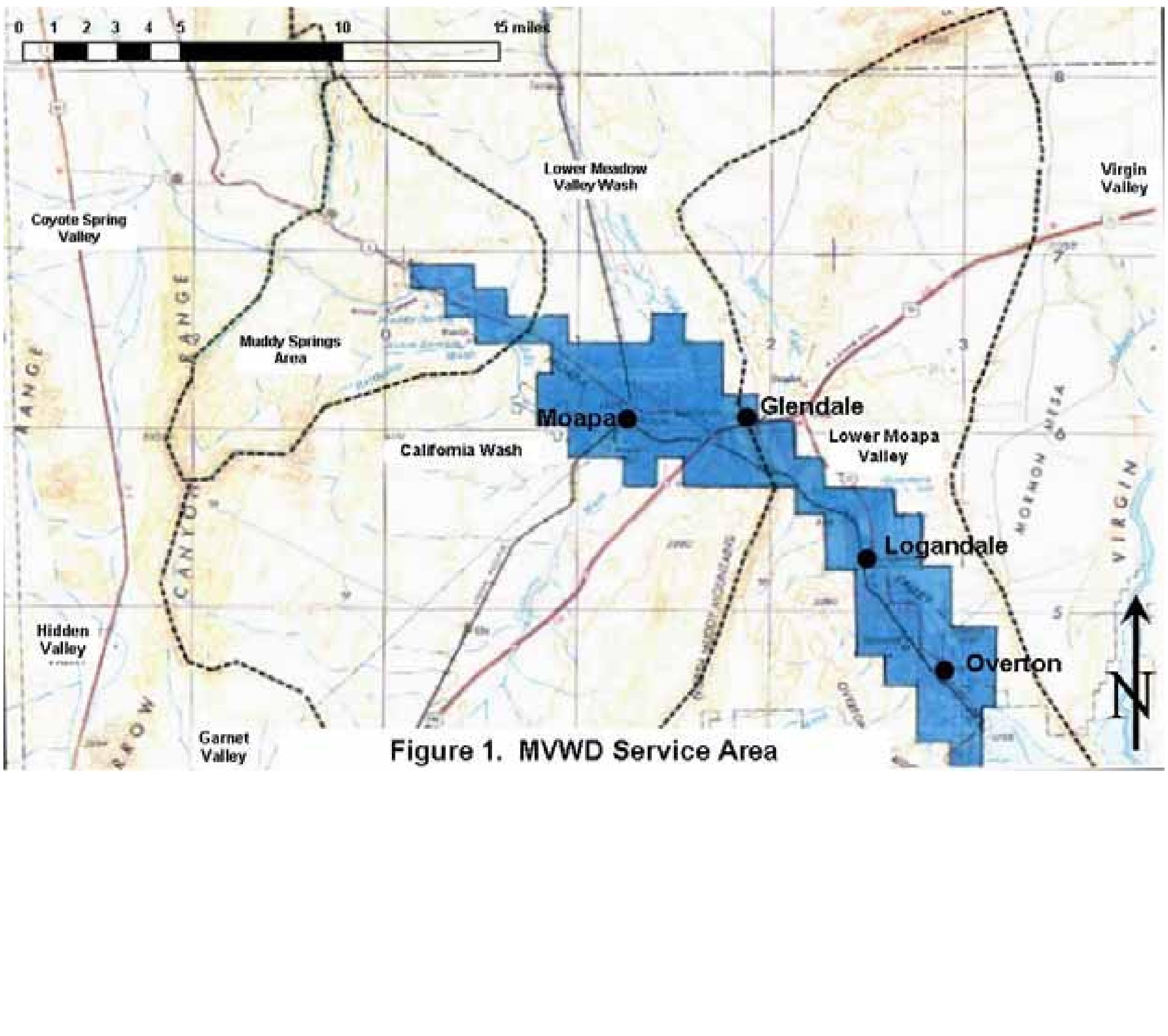


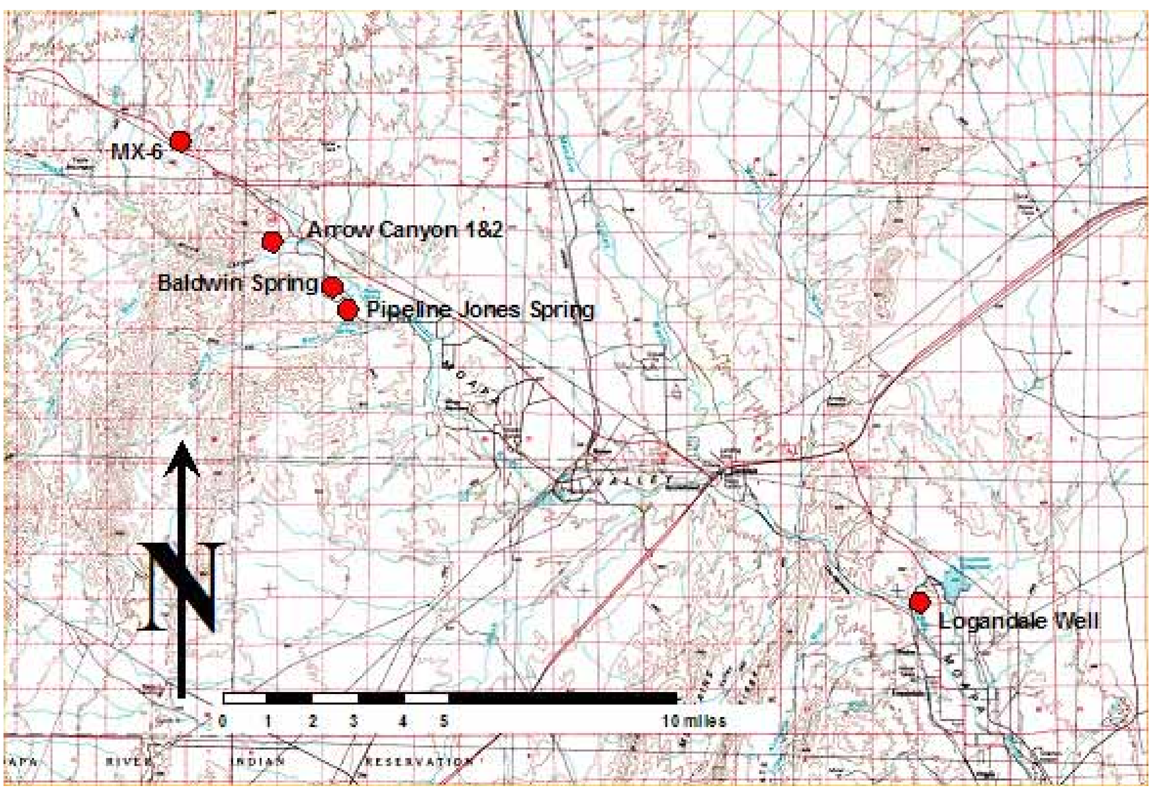
Figure 1. MVWD Service Area

1.1 Purpose

The purpose of this WHPP is to provide a framework for the long-term management and protection of the District's public water supply sources. This framework includes the following elements:

- Develop a Wellhead Protection Team and define the roles and responsibilities of the State, Federal, and Clark County agencies, the District, and communities serviced by the District;
- Define Wellhead Protection Areas that include the watersheds for springs and areas of influence of the water wells used for public water supplies;
- Conduct an inventory and risk assessment of the potential contaminant sources that could result in groundwater contamination and develop contaminant source management strategies;
- Identify sites for new water supply wells, and develop contingency plans for response to interruptions of primary water supply service; and
- Develop educational materials to improve public participation.

Figure 2. MVWD Drinking Water Sources



1.2 Past Investigations

Information used in developing this WHPP was obtained from the following sources:

- Previous WHPP planning activities including groundwater vulnerability assessments of District water supply wells performed by the Nevada Bureau of Health Protection Services;
- A hydrology and water resources study by the Moapa Valley Water District.;
- The records of the Nevada Division of Water Resources; and
- Published scientific reports by the U.S. Geological Survey, Southern Nevada Water Authority, Nevada Power Company, and others.

1.3 Regulatory Basis

The primary regulatory bases for the development of a WHPP are the 1986 Amendments to the Safe Drinking Water Act of 1974 (Section 1428). These amendments mandate that each state develop a WHPP for the purpose of protecting groundwater that serves as a source of public drinking water. In response, the Nevada Division of Environmental Protection developed the Nevada Comprehensive State Ground Water Protection Program to provide for the coordination and integration of all State and federal agencies that manage groundwater in Nevada. As a result, many of the State's public municipal water systems have already completed or are now completing their WHPPs.

2.0 WELLHEAD PROTECTION TEAM

2.1 Members

The members of the Wellhead Protection Team include representatives from the communities within the District's service area, the District, the Muddy River Irrigation Company, Clark County, and the Bureau of Land Management. The members have held one meeting thus far.

The goal of the WHPP Team is to develop and implement management strategies that are aimed at protecting the potable water supplies of the District's service area. The responsibilities of the team include updating this plan to reflect new information or data pertaining to changes in water supply sources, new potential sources of contamination, and changes in land uses.

Table 1 lists the current members of the WHPP Team. Included in the table are the identities, contact information, and corresponding roles and responsibilities of each team member.

TABLE 1
WHPP TEAM

Name	Affiliation	Contact Information	Responsibilities
Van Robinson, Manager	MVWD	P.O. Box 257 Logandale, NV 89021 702.397.6893 702.378.6150	**Lead Contact Person.** Responsible For implementing and Updating WHPP.
Mark Aston, General Manager	Muddy River Irrigation Company	P.O. Box 665 Overton, NV 89040 702.398.7310 702.398.7307 fax	Provide leadership, input on management strategies.
Milton Bullock, Member	Moapa Town Board	P.O. Box 736 Moapa, NV 89025 702.864.2522 702.493.8477 cell	Local representative.
Anna Wharton, Supervisor	Bureau of Land Management	4707 N. Torrey Pines Dr. Las Vegas, NV 89130- 2301 702.515.5095 702.515.5010 fax	Federal representative.
Cynthia Martinez	U.S. Fish and Wildlife	4707 N. Torrey Pines Dr. Las Vegas, NV 89130- 2301 702.515.5230	Federal representative.
Al Laird	Clark County Department of Planning	500 S. Grand Central Pkwy Third Floor Las Vegas, NV 89115-1741 702.455.4314.	County representative. Provide input.
Arthur Leger Staff Engineer	Bureau of Water Quality Planning	333 W. Nye Lane, St.138 Carson City, NV 89706 775.687.9430 aleger@ndep.nv.gov	State representative. Provide input.
Tom Buqo	Consulting Hydrogeologist, Inc.	P.O. Box 127 4 Private Road Blue Diamond, NV 89004 702.875.4594 BUQO@aol.com	Technical Consultant. Responsible for drafting the WHPP.
Brent Farr, P.E. President	Farr West Engineering	1310 Dalwood Ct. Reno, NV 89521 775.851.4788 775.851.0766 bjfarr45@msn.com	Technical Consultant. Responsible for drafting the WHPP.
Joe Beard, E.I. Staff Engineer	Farr West Engineering	1310 Dalwood Ct. Reno, NV 89521 775.324.3000 joebeardjr@yahoo.com	Technical Consultant. Draft assistance.

2.2 Jurisdictional Authorities

The District is based in Overton, Nevada and serves an area of about 75 square miles. The District is the purveyor of water to the communities of Moapa, Glendale, Logandale, and Overton, and the Moapa Paiute Reservation. The District also provides water for power generation by the Nevada Power Company at the Reid-Gardner Power Plant. The District has responsibility over the preparation and implementation of the Wellhead Protection Program. In this lead capacity, the District relies upon the advice and cooperation of a number of other agencies including the Muddy River Irrigation Company, the Moapa Town Board, Clark County, the Southern Nevada Water Authority, the Bureau of Land Management, and the U.S. Fish and Wildlife Service.

The Bureau of Land Management (BLM) is the steward for most of the lands that comprise the watersheds forming the source area for the groundwater. The BLM is the regulatory authority for activities on public lands.

Clark County is the primary authority for local land use planning. In this capacity, the County reviews proposed developments for conformance with land use plans including the Northwest Clark County Master Plan. The County, in conjunction with the Moapa Town Advisory Board, is also responsible for the issuance of building permits and business licenses and is ideally suited for insuring compliance with WHPP objectives.

The Muddy River Irrigation Company is the authority for diversions from the Muddy River. At present, MVWD does not use any of its Muddy River shares for municipal supplies. The District may, however, begin to augment their well and spring sources with river water at some time in the future.

The Southern Nevada Water Authority is an umbrella organization for the largest water supply systems in Clark County (Las Vegas Valley Water District, North Las Vegas, Boulder City, Henderson, and Big Bend Water District).

2.3 Goals and Objectives

The goals of the District's Wellhead Protection Program are: 1) to ensure clean drinking water supplies for future generations; 2) to reduce the risk to human health by ensuring that the District's service area has an uninterrupted supply of uncontaminated drinking water; and 3) reduce the District's operating costs by minimizing monitoring requirements. To achieve these goals, the following objectives must be met through the development and implementation of this plan:

- Delineate WHPAs by characterizing the conditions of each water supply source;
- Define critical recharge areas by characterizing the conditions in the Muddy Springs area;
- Determine potential man-made sources of contamination that could threaten water supplies;
- Recommend management procedures to prevent the degradation of drinking water sources;
- Develop contingency plans for alternate drinking water supplies if primary supplies are contaminated or otherwise rendered unusable;
- Identify new sources of water and implement measures to protect those sources; and
- Document and discuss the findings from inventories and field investigations.

By achieving these objectives, the Wellhead Protection Team will be able to implement this plan to benefit all those who rely upon the District's water system for a safe drinking water supply.

3.0 WATER SUPPLY SYSTEM OVERVIEW

The District currently has two developed springs and three potable water supply wells. Table 2 lists the wells and springs and their status. In addition to the sources shown in Table 2, the District owns another well called the Logandale Well. This source has not yet been used to supply potable water, due to poor water quality. The MVWD is currently developing a treatment plan to address water quality issues, with the intent to bring the Logandale Well online by 2006. Figure 2 shows the locations of these public water supply sources.

TABLE 2. MVWD PUBLIC WATER SUPPLY SOURCES

BHPS ID	Source Name	Average Production (gpm)	Comments
W-01	MX-6	450	Seasonal use only to meet peak demand.
W-02	Arrow Canyon 1	3,000	Primary water supply source during most of each year.
W-04	Arrow Canyon 2	1500	Drilled in 2004, not yet put on line.
S-01	Baldwin Spring	1200	Total spring discharge averages 3 cfs (1,350 gpm). Water is diverted from the springhead at a rate of 1200 gpm.
S-02	Jones Spring	450	Total spring discharge averages 1.8 cfs (800 gpm). Water is diverted from the springhead at a rate of 450 gpm.

The springs have been developed as underground sources by constructing infiltration galleries and spring works at both locations. The spring works divert some of the water into the District's system while the remaining flow is allowed to discharge into the natural drainage system.

All three of the District's wells produce water from a carbonate aquifer that is believed to be hydraulically linked with a regional carbonate system. The MX-6 well is an old Air Force well that was obtained by the District and converted to municipal use by constructing a well house and pipeline to convey the water to the distribution system. Arrow Canyon Well #1 was drilled in 1991 and has been used since 1994 as the primary water supply source for the system. Arrow Canyon Well #2 was drilled in 2004 and will be used to supplement the production of the older well.

The District has applied for, and received, a variance from the Nevada State Board of Health to supply drinking water with a fluoride concentration of 2.12 ppm (a secondary standard sets the maximum contaminant level for fluoride is 2.0 ppm). The water system is presently in compliance with most other state and federal drinking water standards; the exceptions include arsenic and sodium. The arsenic concentrations of the District's sources range from 12 to 19 ppb, below the previous drinking water standard of 50 ppb, but above the new standard of 10 ppb. There is no standard for sodium but the concentrations in the District's sources are 4 to 5 times higher than the advisory level of 20 ppm. Recent water chemistry analyses are provided in Appendix A.

4.0 GENERAL HYDROGEOLOGIC CONDITIONS

An understanding of the general hydrology and geology of Moapa Valley is a prerequisite in the development of a WHPP for the District. This section provides a brief overview of the general conditions in the vicinity of the Moapa Valley.

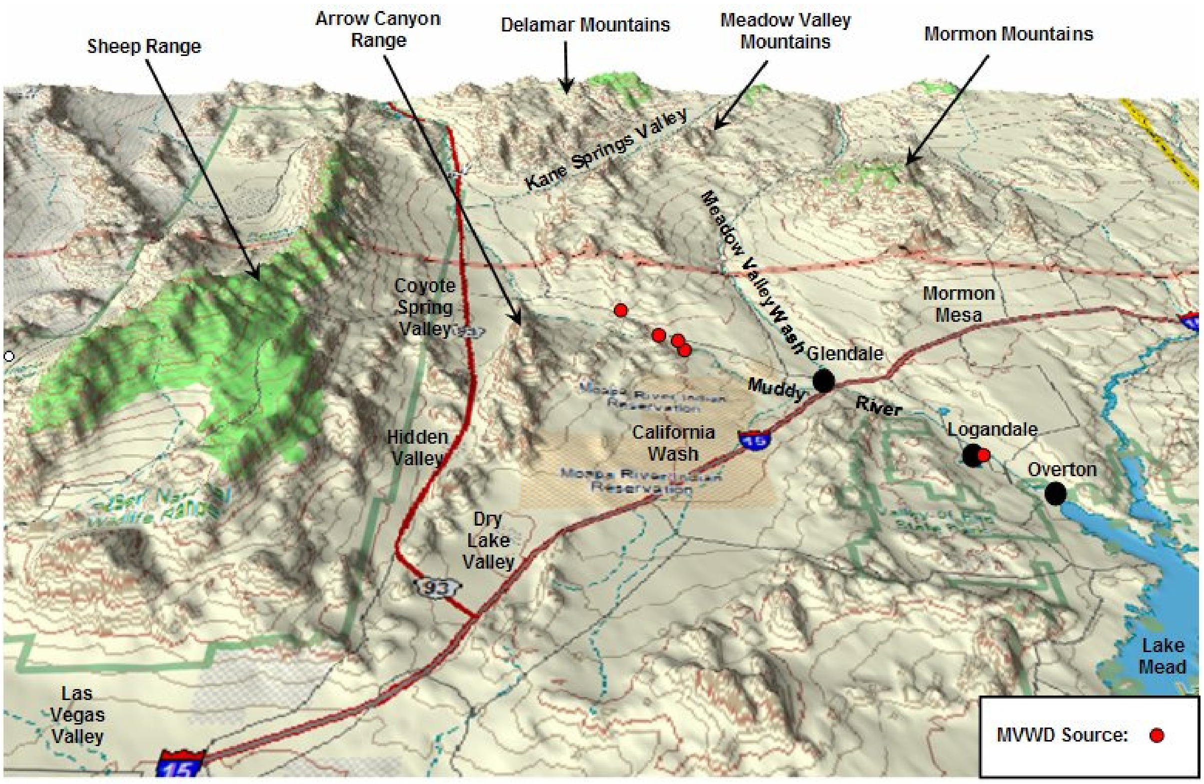


Figure 3. Major Physiographic Features of the Region.

4.1 Topography

The general topography of the region is shown as a birds-eye view in Figure 3 along with the District's water supply sources. The prominent topographic features of the region include the Arrow Canyon Range (3,000 ft to 5,100 ft elevation), Mormon Mountains (4,000 ft to 7,400 ft), and the Sheep Range (5,000 ft to 9,900 ft). The principal drainage is the Muddy River, which has three main tributaries, Pahranagat Wash, California Wash, and Meadow Valley Wash. Under normal lake conditions, the Muddy River discharges into Lake Mead at Overton. Under the current drought conditions, the river is tributary to the Virgin River about ten miles down gradient of Overton.

4.2 Climate

There are two precipitation stations in the Moapa Valley area, at Logandale and Overton. The average annual precipitation at the Logandale station for the period 1968 to 1992 was 5.14 inches with average monthly precipitation ranging from 0.06 inches in June to 0.74 inches in March. The average annual snowfall is 0.6 inches. The average annual precipitation at the Overton station for the period 1948 to 2003 was 4.19 inches with average monthly precipitation ranging from 0.07 in June to 0.62 inches in February. The average annual snowfall is 0.3 inches.

4.3 Conceptual Hydrogeology

Figure 4 shows the conceptual hydrogeologic conditions in the region of the District's service area. Unlike most basins in the arid Great Basin, very little of the water resources in the study area are derived locally. Precipitation over the Muddy Springs Area is limited and contributes very little to the groundwater regime. The source of most of the water resources is outside of the basin, specifically from recharge over the Sheep Range, about 20 miles west of the Muddy Springs area and subsurface recharge from Pahranagat Valley. Groundwater flows through the carbonate rocks of the Arrow Canyon Range and discharges to the surface at Muddy Springs. Significantly lesser quantities of groundwater are contributed from the California Wash and Meadow Valley Wash systems. Secondary recharge is probably limited in the greater Moapa Valley area to irrigated parks, agricultural lands, reservoirs, and septic systems.

Natural groundwater discharge occurs in the Muddy Springs Area, along the Muddy River and Meadow Valley Wash bottoms. Additional groundwater is discharged to pumping for agriculture, mining, municipal purposes, and power generation in the Muddy Springs area, lower California Wash, Lower Moapa Valley (Logandale and Overton areas).

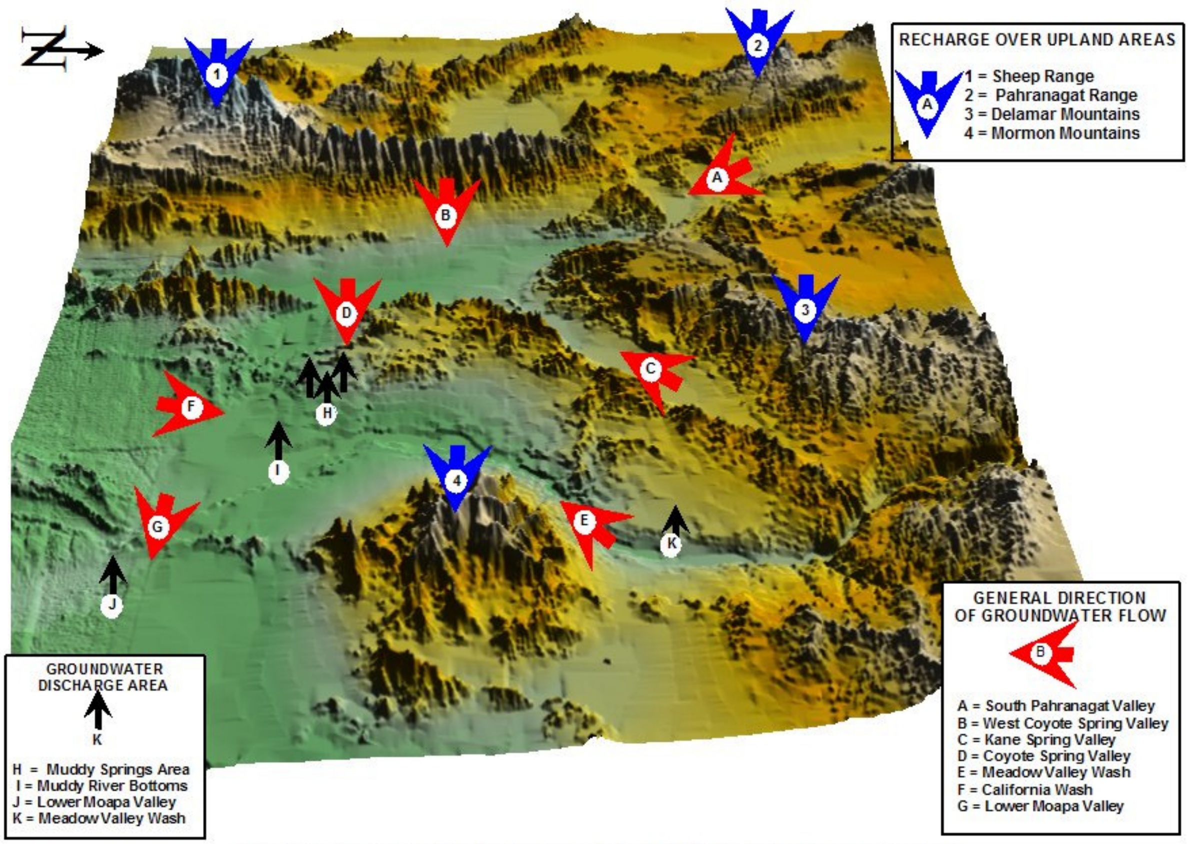


Figure 4. Conceptual Hydrogeology of the Muddy Springs Area (not to scale)

4.4 Groundwater Occurrence and Movement

Groundwater occurs under the entire service area and adjacent lands. Shallow groundwater (less than 25 ft below land surface) is present under the bottomlands of the Muddy River. The shallowest groundwater occurs between Muddy Springs and White Narrows where the depth to water ranges from 4 to 12 ft. The depth to groundwater increases away from these bottomlands toward the bounding hills and mountains. The greatest reported depth to water is 460 ft at the District's MX Well. In the Meadow Valley Wash area, the depth to groundwater ranges from 50 ft (north of the railroad siding at Rox) to less than 30 ft (in the Glendale area).

A general potentiometric surface map (top of the water table or artesian level, whichever is higher) for the service area and vicinity, and the inferred directions of groundwater flow are depicted in Figure 5. As shown, groundwater flows generally from the upland areas on the north and west toward the bottomlands of the Muddy River where flow then goes southeast toward Lake Mead. The elevation of the groundwater drops almost 600 ft over the service area. Water level elevations exceed 1800 ft above sea level in the Arrow Canyon area to about 1540 ft in the Glendale area, 1350 ft at Logandale, to 1230 ft south of Overton near Lake Mead. Overall, the hydraulic gradient (drop in water level per unit distance) across the service area is about 0.004. There are areas where the water level data and geologic conditions suggest that partial barriers to groundwater flow are present and gradients are somewhat steeper in these areas and in the vicinity of pumping wells.

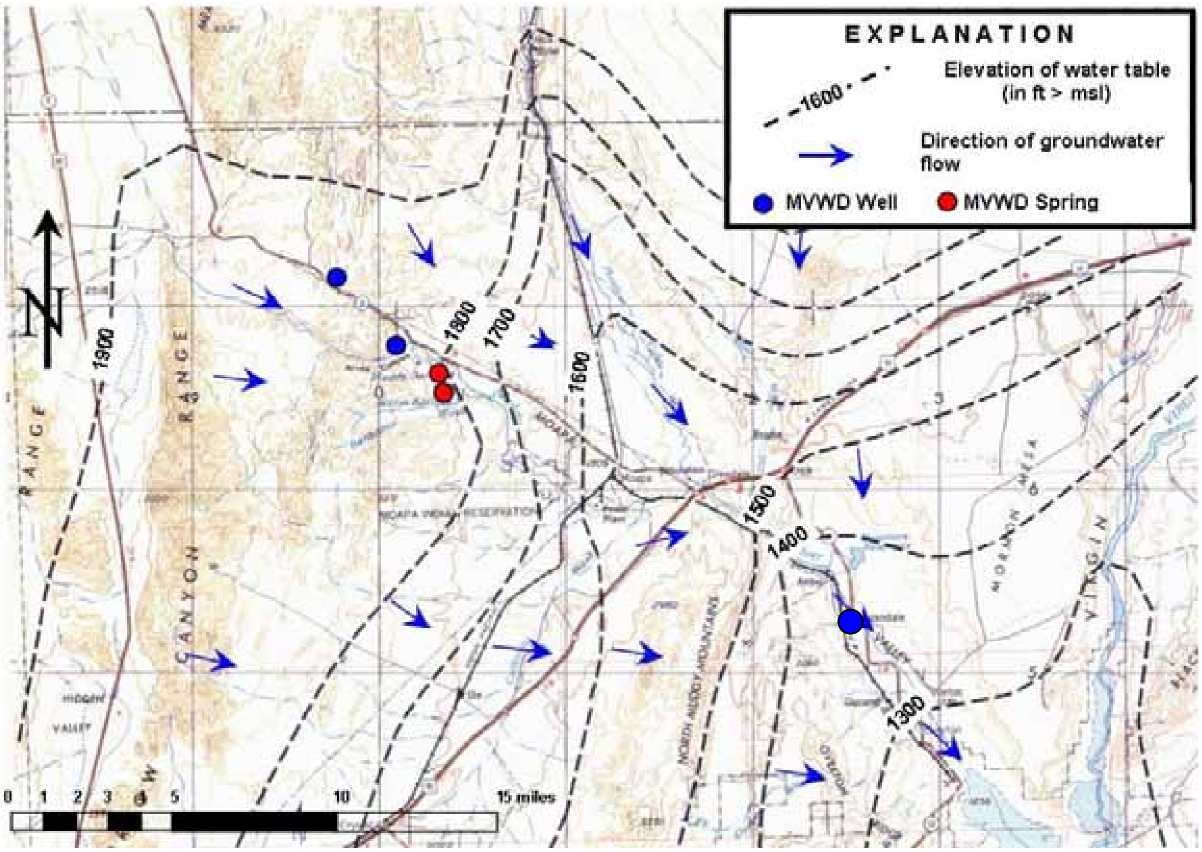


Figure 5. Potentiometric Map of the Muddy Springs Area

There is evidence of a pronounced upward vertical gradient in some locations. In these areas, groundwater is moving upward from deep aquifers to shallow aquifers. According to unpublished U.S. Geological Survey water level data, three observation wells located about 2 miles northwest of Glendale are completed to depths of 119 ft, 181 ft, and 255 ft. Water in the intermediate well was 1.4 ft higher than the shallow well for observations made in 1990. Such a gradient is to be expected in the vicinity of a major regional drain such as the Muddy River Springs area. As noted by Mifflin (1968), a downward gradient is typically present in recharge areas like the Sheep Range while an upward gradient is typical of discharge areas like the Muddy Springs area and Muddy River bottoms. The significance of this vertical gradient is that a large volume of groundwater could be moving upward and contributing to the water resources.

4.5 Aquifers and Aquitards

There are a number of geologic units present under and in the vicinity of the service area that serve as both aquifers and aquitards. Figure 6 graphically presents the sequence of aquifers and aquitards of the region along with summary information on each unit. Figure 7 shows the portions of the County geology map in the Muddy Springs region. For convenience, these units may be divided into three groups: 1) River Alluvium; 2) Valley-Fill Deposits; and 3) Consolidated Rock.

The River Alluvium includes the recent alluvial deposits of the Muddy River and Meadow Valley Wash bottomlands. The River Alluvium aquifer exhibits typical grading of this type of deposit i.e., cobbles and coarse gravels overlain by more fine-grained sediments. Most of the well production from this aquifer comes from the coarse gravels at the bottom of the unit. The thickness of River Alluvium ranges from 50 to 60 ft in the Muddy Springs area and from 40 to 130 ft thick in the lower portion of the Meadow Valley Wash. The width of the deposit is usually restricted to one-half mile or less. This aquifer serves as the single most important source of groundwater in the area for water users not supplied by the District.

The River Alluvium is bounded on both sides and underlain by Valley-Fill Deposits. The Valley-Fill Deposits comprise a number of recognized units including Quaternary Alluvium, Muddy Creek Formation, Overton Fanglomerate, Horse Spring Formation, and Thumb Formation. The thickness of Valley-Fill Deposits is not well defined but is probably greater than 7,000 ft in many areas and may exceed 12,000 ft in some parts of the region. The Valley-Fill Deposits generally serve as aquitards that effectively isolate the carbonate aquifers from the river alluvium.

Consolidated Rocks outcrop in the bounding mountains and underlie the river valley at depth. Only at the margins of the valleys are the Consolidated Rocks shallow enough to be suitable for groundwater development but, in some areas, large well yields can be achieved from fractured rock aquifers. In general, non-carbonate clastic rocks (sandstone, siltstone, and shale) predominate east and south of Glendale while carbonate rocks (limestone and dolomite) predominate to the west.

The oldest rocks are carbonates of Ordovician to Devonian age that outcrop in the Arrow Canyon Range and are at depth under the Muddy Creek Formation in the Tale Mountain area. These rocks include the Ely Springs Dolomite, Lone Mountain Dolomite, and Sultan Limestone all of which are favorable aquifers where fractured and faulted. To the east, in the Muddy Springs area, younger carbonate rocks, the Monte Cristo Limestone and the Bird Spring Formation outcrop in the Arrow Canyon Range. These units provide the source for two of the largest producing water wells in the state of Nevada, the Air Force MX well in Coyote Spring Valley, and the District's Arrow Canyon Well #1. Properly sited wells that are completed in these units have been found capable of producing well yields in excess of 3,000 gallons per minute with very high transmissivities (greater than 200,000 ft^2/day) at total depths of 700 feet or less.

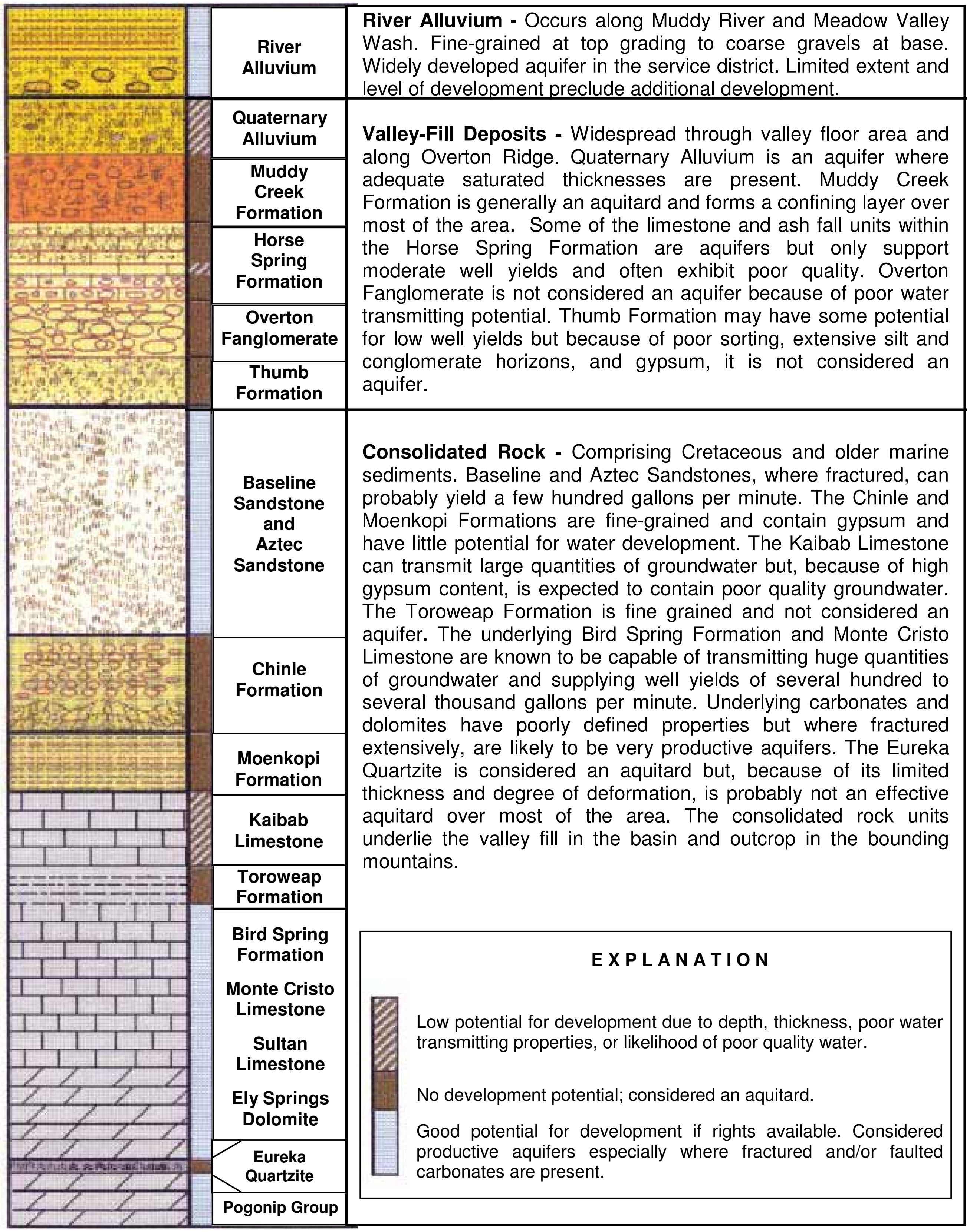


Figure 6. Hydrostratigraphic Column of the Muddy Springs Area.

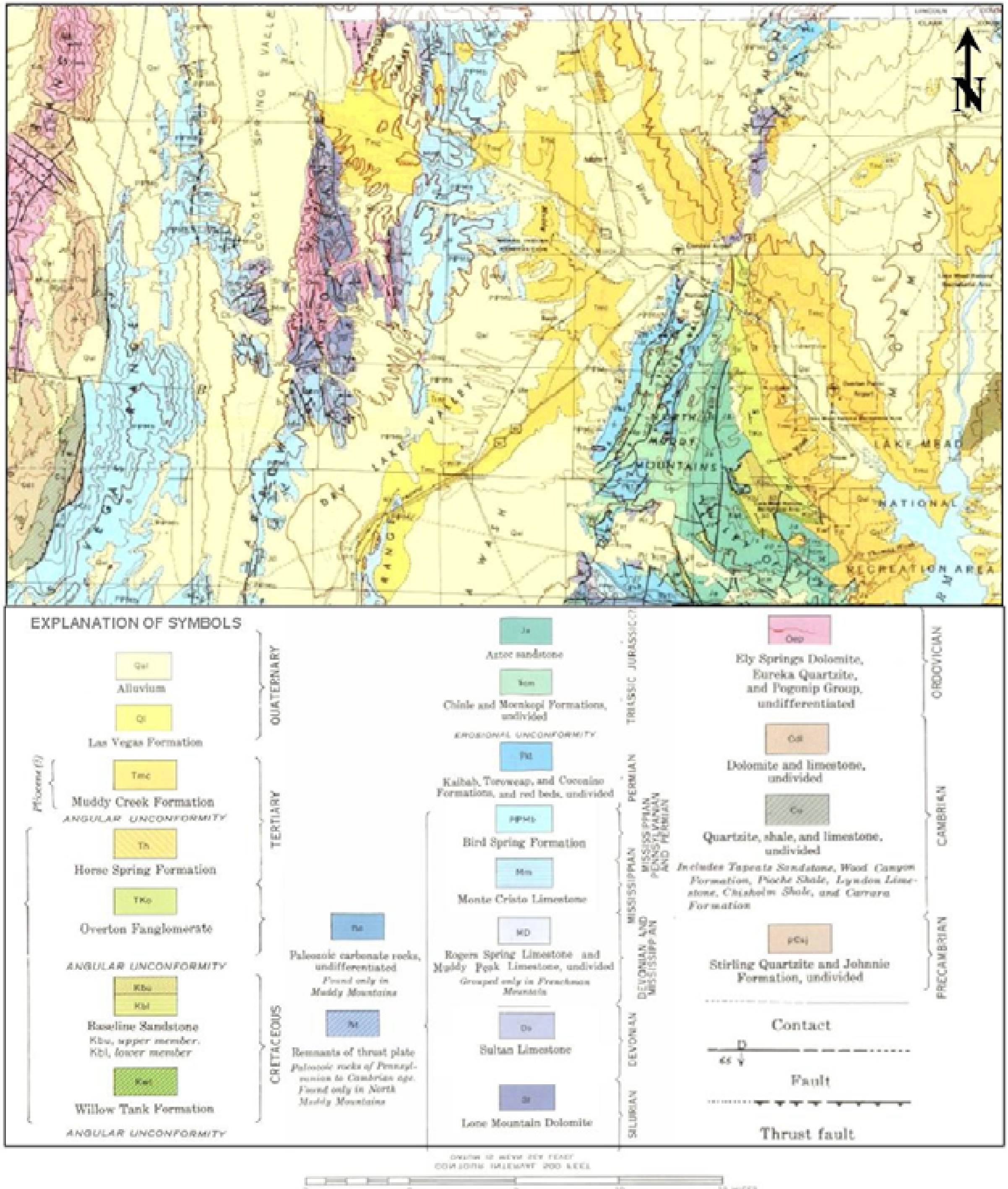


Figure 7. County Geologic Map of the Muddy Springs Area
Scanned and modified from Longwall et al (1965)

4.6 Springs

The District's service area is within the Great Basin Carbonate Rock Province, which extends from northeastern Utah to California. Since their deposition, the carbonate rocks have been folded, thrust faulted, normal faulted, fractured, dissolved, intruded, and overlain by both volcanic and valley-fill deposits. The net result of this tectonic activity has been to break the carbonate aquifers into discrete compartments. Compartmentalization occurs at various scales and has resulted in boundaries between flow systems, regional discharge areas up gradient of shear zones, spring lines in the mountains and valley floors, and zones of very high transmissivity between compartment boundaries.

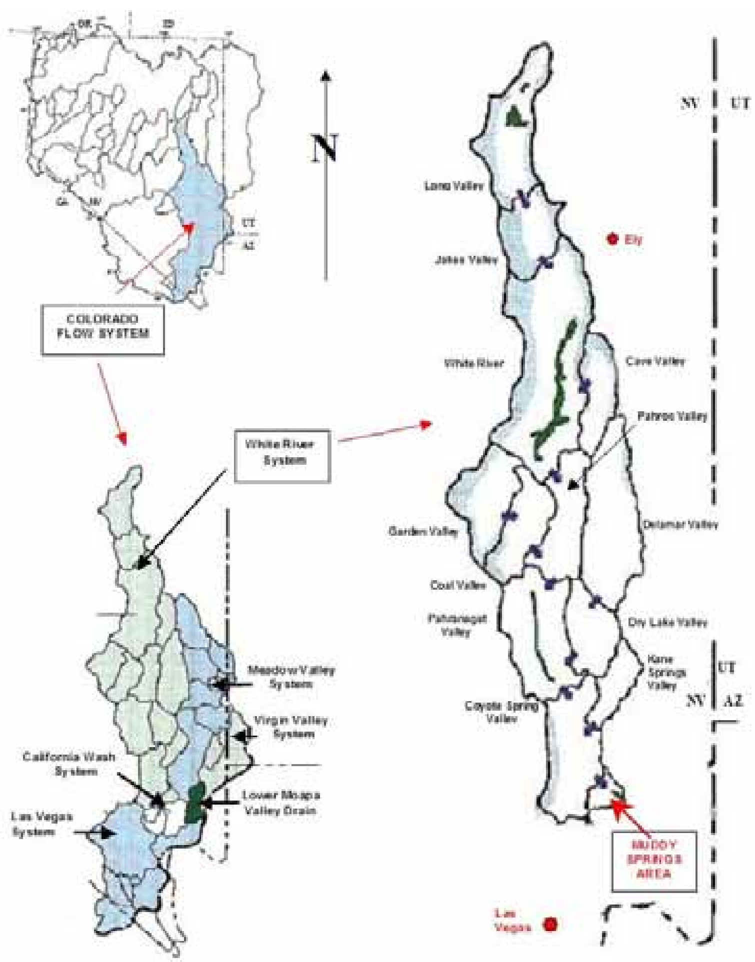


Figure 8. The White River Flow System

The District's service area is located within the Colorado flow system, a sub-unit of the Great Basin Carbonate Rock Province. The key recharge area that feeds the springs and carbonate aquifer wells within the District is the White River system, a subdivision of the Colorado flow system.

The numerous springs in the Muddy Springs area are among the most important springs in Nevada. Eakin (1964) characterized the springs as the dominant hydrologic feature of the area. The springs discharge water from the carbonate aquifer into a thin sequence of saturated alluvium that is underlain by the Muddy Creek Formation.

Groundwater that flows through fractures in the limestone aquifers of the Arrow Canyon Range is likely impeded by the low permeability sediments of the Muddy Creek Formation and seeks the path of least resistance (through the alluvium) in discharging to the surface. The groundwater flows over the top of the Muddy Creek Formation and discharges at Muddy Springs, Iverson Spring, Pederson Spring, Warm Springs, and a number of unnamed springs (Buqo, 1993).

5.0 SPRING AND WELLHEAD PROTECTION AREAS

In this section, the Wellhead Protection Areas (WHPAs) are defined for the District's source springs and water supply wells. The delineation of the WHPAs is one of the primary objectives of the District's Wellhead Protection Program. This section provides background information on WHPAs and details the approach to defining the WHPAs for the springs and for each of the District's water supply wells. The rationale behind the selection of specific methods is presented along with maps of the WHPAs.

Because of the differences between springs and wells, different methods are employed in establishing the WHPAs. For springs, the extent of the WHPA depends upon the source of the water discharging to the springs, the groundwater travel times in the aquifer, and the specific geologic and hydrologic characteristics and features. For supply wells, the WHPAs are based upon numerical methods using the model developed by the U.S. Environmental Protection Agency (WHPA Model, RSSQC package).

Figure 9 shows a conceptual WHPA for a typical water supply well and for the Muddy Springs area. As shown, the WHPA for a water supply well is defined as the surface and subsurface area that surrounds the well in which potential contaminants, if present, would likely move toward the well. The WHPA for a given well depends upon the hydrologic characteristics of the aquifer and the operating characteristics of the well.

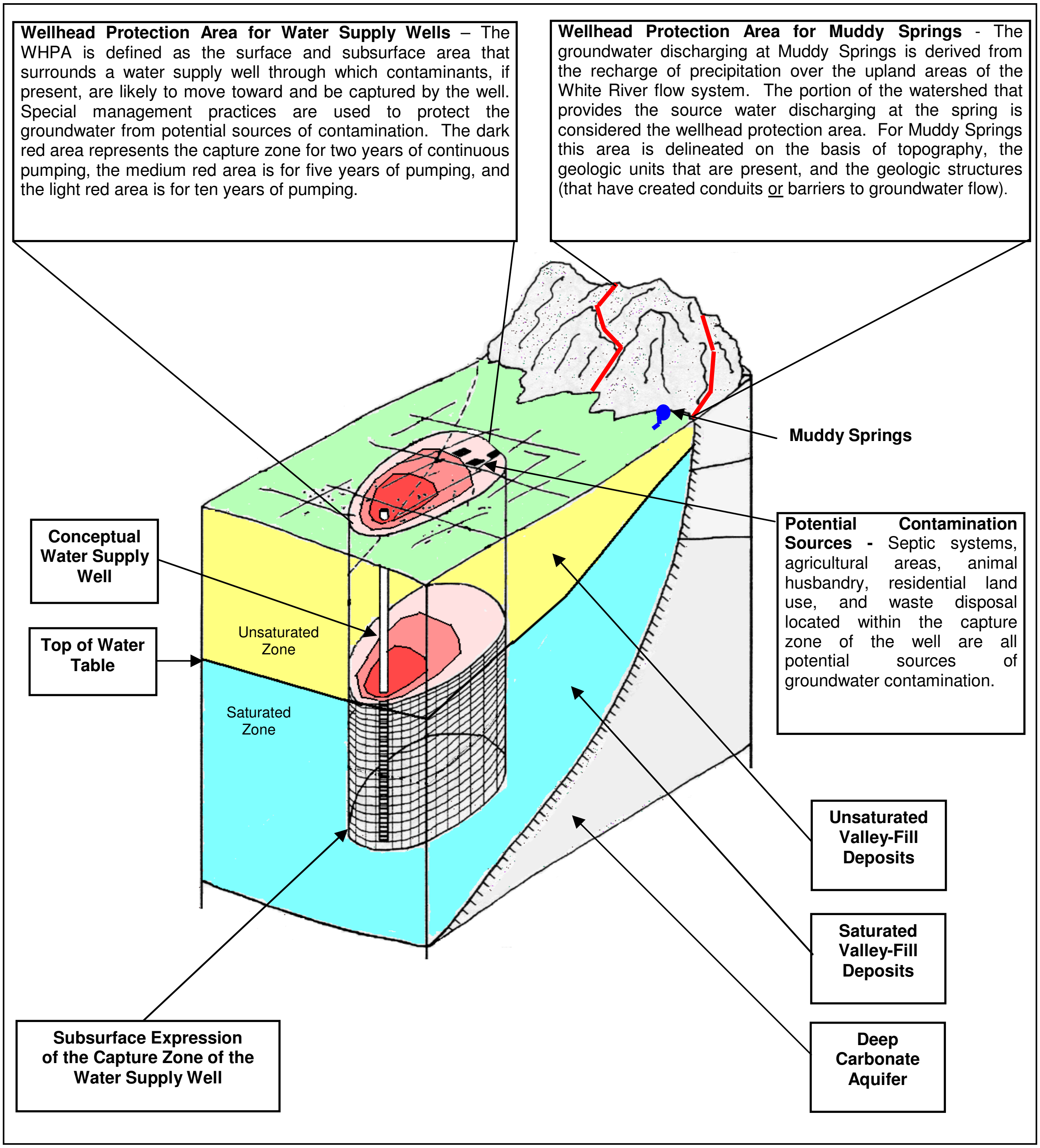


Figure 9. Conceptual Drawing of the Wellhead Protection Areas for District Water Supply Wells and Springs. Modified from Bureau of Water Quality Planning Guidance Document.

For springs, the WHPA is generally the portion of the watershed that provides the source water for the spring. For high-altitude springs in the upland areas, the contributing watershed is typically small, only a portion of a mountain range. But for major regional springs in lowland area, such as the Muddy Springs, the source area can, technically be enormous, encompassing several basins and mountain ranges which all contribute water to the system.

As noted in the previous section, the Muddy Springs area discharges groundwater from a vast flow system that stretches more than 200 miles to the north. Because of the distance of the Muddy Springs area from the watershed that provides its source water, it is not feasible (nor necessary) for the District to define and implement WHPA measures for the entire flow system, in this case the White River flow system. Therefore, an evaluation was conducted to determine the distances that groundwater travels through the source aquifer over different time frames, ranging from six months to ten years. The results allow the definition of specific management zones over a reasonable geographic area.

5.1 Information Review

The first step in the definition of WHPAs is the review of the hydrogeologic information that is available from a number of sources. The main information resources consulted during this study was a District hydrology report by Buqo (1993), the results of testing at the District's supply wells and other wells in the region, the Well Driller's Reports on file with the Nevada Division of Water Resources, published reports by the U.S. Geological Survey, and the District's files. Information concerning the manner of development within the Muddy Springs area is also on file with the Clark County Department of Planning. Additional information on the water supply sources and potential contaminant sources is available in the files of the Nevada Division of Environmental Protection, Bureau of Health Protection Services, and Bureau of Water Quality Planning. These files include the results of groundwater vulnerability assessments conducted in 2003. For the evaluation of the Muddy Springs area, published geologic maps and satellite imagery of the area were reviewed and field studies were conducted.

5.2 Methods and Threshold Selection

The methods used in developing this plan were in accordance with the *State of Nevada Wellhead Protection Program Guide, 4th Revision, January, 2002,* prepared by the Nevada Division of Environmental Protection, Bureau of Water Quality Planning. As the District is dependent upon both springs and water supply wells for their water supplies, different procedures were used in evaluating the WHPAs for these two types of sources. For both cases, the WHPAs were delineated in accordance with the State of Nevada guidance. This guidance details four methods for determining the WHPA for a water supply well or a spring: 1) Calculated Fixed Radius Method; 2) Analytical Methods; 3) Hydrogeologic Mapping; and 4) Numerical Flow and Transport Models. The calculated fixed radius method is the simplest method and was used in the groundwater vulnerability assessments previously conducted for the District's water supply wells. The Analytical Methods approach uses the uniform flow equation to determine the capture zone configuration associated with a pumping water well. The Hydrogeologic Mapping method comprises the identification of flow boundaries and travel times and may use sophisticated data collection efforts such as geophysical surveying, dye tracer tests, and/or field mapping of fractures. The final method, Numerical Flow and Transport Models, requires a great deal of site-specific data and technical expertise and can be both costly and time-consuming.

For the Muddy Springs area, the Hydrogeologic Mapping and time of travel approaches were used. The Southern Nevada Water Authority provided a 1:24,000 scale map of the Moapa West Quadrangle by Schmidt et al (1996) and a 1:12,000 scale map of the Muddy Springs area. To augment these published sources, satellite imagery was used and field studies were conducted. The studies focused on investigating the hydrologic nature of the geologic units that are present in the watershed that supplies the Muddy Springs area and the geologic structures that likely affect groundwater flow in the areas up-gradient of the springs.

For the delineation of WHPAs for the District's water supply wells, the Analytical Methods approach was selected. Specifically, the EPA's WHPA model was used to define the capture zone associated with each production well. This method was selected because the necessary data is available, the method is well documented and widely used, and the source code for the computer model is efficient. The Modular Semi-Analytical Model RESSQ package was used to delineate the WHPAs for the water supply wells. This package requires information on both the hydrologic conditions of the area and the operational characteristics of the well. Required information includes the hydraulic gradient, the direction of flow, the transmissivity of the aquifer (a measure of the rate of flow), the porosity of the aquifer (the percentage of void space), the thickness of the aquifer that contributes water to the well, the well radius, and the pumping rates. The input values that were used are listed in Table 3.

TABLE 3. INPUT VALUES FOR CAPTURE ZONE ANALYSES

BHPS Groundwater Vulnerability Assessment Source Number Well #	Flow Gradient (ft/ft)[1]	Flow Direction (WHPA azimuth)[2]	Aquifer Transmissivity (ft^2/day)[3]	Pumping Rate (gpm)[4] ft^3/d	Well Radius (ft)	Porosity (percent)	Aquifer Thickness Screened Interval (ft)[5]
W01-MX-6	0.003	272°	8,000	450 87,000	0.7	0.10	612
W02-Arrow Canyon #1	0.0003	342°	230,000	2,900 558,000	1.2	0.55	350
W04-Arrow Canyon #2	0.003	342°	12,400	650 125,000	1.3	0.25	90
W03-Logandale Well	.004	303 °	2,700	300 52,132	0.5	0.10	100

Notes: 1) Flow gradient based upon stressed aquifer system (See Chapter 5); 2) WHPA azimuth is based on due West = 0 degrees and then counterclockwise (due South = 90°, due East = 180°, due north = 270°); 3) Transmissivity values were 8,000, 230,000, and 2,700 ft^2/day for W-01, W-02, and W-03, respectively. Test data and results are provided in Appendix A; 4) Pumping rates are from District records. Under normal conditions, the Arrow Canyon #1 and #2 wells will meet the bulk of the District's water demand. The MX-6 well will only used during peak demand season; and 5) Aquifer thicknesses were set to the actual screened interval(s) in each well that is in the saturated zone.

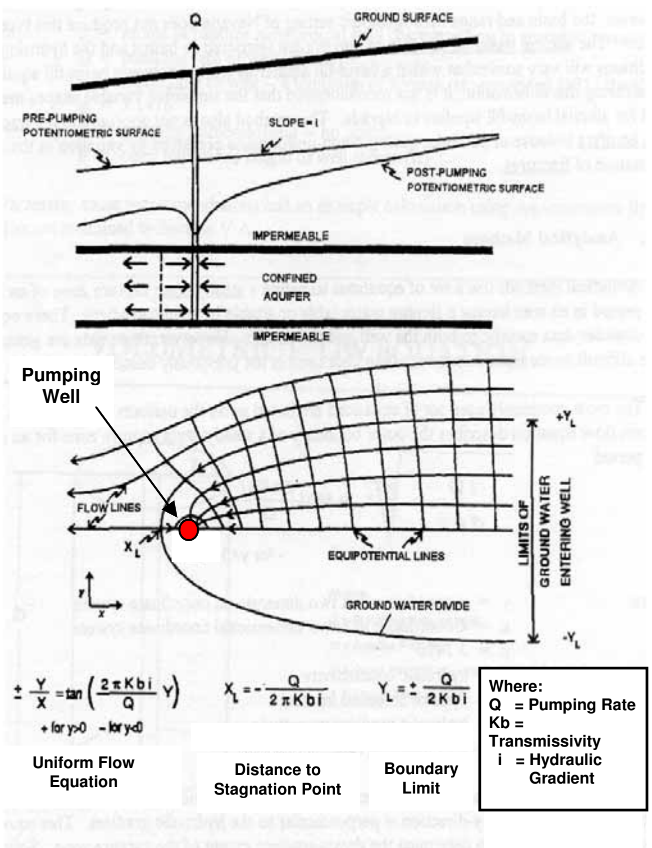


Figure 10. Mathematical Basis for the Capture Zone Analysis of the District's Wells. Modified from Bureau of Water Quality Planning Guidance (1995)

While most people know about the cone of depression around a pumping well, the concept of a capture zone is not as widely understood. In an area where the water table is flat (there is no gradient), then the draw down of the water table in the vicinity of a pumping well will be shaped like a cone, hence the term cone of depression. In natural conditions, however, the water table is seldom flat; rather it slopes steeply in the mountainous areas, less steeply under the alluvial fan area, and even less steeply under the lowland areas. When the water table slopes, the effects of a pumping well can be represented mathematically as the intersection of a plane with a cone. The result is a parabola as shown on Figure 10. This parabola-shaped depression in the groundwater is called the capture zone. The capture zone varies in width and length depending upon the volume of pumping, the duration of pumping, and the hydrologic parameters.

In the selection of input values, a conservative approach was employed that tends to overestimate the size of the capture zone. The most significant parameters in capture zone analyses for any given pumping rate are the transmissivity, the duration of the pumping period, and the aquifer thickness. The transmissivity for the Arrow Canyon Wells and MX-6 Well is based upon a 121-day constant discharge test of the Arrow Canyon Well. The transmissivity for the Logandale Well is based on information obtained from a 1984 Desert Research Institute study by Mifflin and Zimmerman entitled *Groundwater Availability in the Lower Meadow Valley Wash Near Glendale, Nevada*. Four continuous pumping periods were modeled: six-month, two-year, five-year, and ten-year pumping periods.

5.3 Wellhead Protection Area Delineation for Spring Sources

The WHPA for Baldwin Spring and Jones Spring is based on the watershed from which recharge to the spring is derived, the geology of the watershed, and the topography. The WHPA is shown in Figures 11 and 12 and includes three zones:

Zone 1 - Stringent Protection Zone – This zone encompasses each spring and all areas located within 4320 ft up gradient from the spring, the distance that groundwater will travel in one year while the District's wells are being pumped (see Figure 10). Zone 1 is the area of greatest concern with respect to the protection of each spring as any groundwater or surface water contamination has the potential to quickly reach the spring. The thin alluvial cover in the canyon bottoms and the underlying fractured limestone and sandstone aquifers probably provide fast pathways for groundwater flow toward the spring.

The definition of Zone 1 is based upon the Time of Travel (TOT) method developed by the U.S. EPA as set forth in two U.S. Environmental Protection Agency guidance documents: 1) *Handbook Ground Water and Wellhead Protection,* and 2) *Delineation of Wellhead Protection Areas in Fractured Rocks.* The TOT method is based upon Darcy's Law:

$$V = \frac{Ki}{\eta}$$

Where: V = average groundwater velocity in ft per day;
k = horizontal hydraulic conductivity in ft per day;
i = hydraulic gradient in ft per ft (dimensionless); and
η = porosity in percent.

The hydraulic conductivity is not known for all of the consolidated rock aquifers up gradient of the Muddy Springs Area. The hydraulic properties of the carbonate aquifers of southern Nevada range considerably with Belcher et al (2002) reporting transmissivity ranges of 0.03 to 2690 ft/d for faulted and fractured units to .0003 to 14 ft/d for relatively undisturbed carbonates. There have been seven tests conducted to determine the hydraulic properties of the carbonate aquifer in the vicinity of the Muddy Springs area, with three tests at the Arrow Canyon location and four tests in Coyote Spring Valley. The results of these tests are summarized in Table 4. All of these tests were conducted in either the Bird Spring Formation or the Monte Cristo Limestone. The hydraulic conductivities vary considerably, even between closely spaced wells. At Arrow Canyon #1, the hydraulic conductivity was 639 ft/d while at Arrow Canyon #2, only about 75 ft away, the hydraulic conductivity was 63 ft/d, a factor of ten lower. Similarly, the hydraulic conductivity at the four wells in Coyote Spring Valley ranged from 8 to almost 900 ft/d, two full orders of magnitude. Because of the large observed variability in this important parameter, five conductivity values were selected for the TOT calculations, 1, 10, 100, 500, and 1000 ft/d. These values bracket all of the test results in the region.

TABLE 4. SUMMARY OF AQUIFER TEST RESULTS

Well	Year	Test Length (days)	Pumping Rate (gpm)	Open Interval Thickness (ft)	Depth to Water (ft)	T (ft2/d)	k (ft/d)	References
AC #1	1994	121	2900	360	41	230,000	639	MVWD (1994)
AC #2	2004	5	900	192	44	12,000	63	MVWD (2004)
CE-DT-4	1980	10	540	315	353	40,000	127	Bunch and Harrill (1984)
CE-DT-5	1981	34	3400	278	350	250,000	899	Bunch and Harrill (1984)
CE-DT-6	1986	3	472	480	457	8000	17	Belcher et al (2002)
CE-VF-2	1986	0.6	77	371	604	2900	8	Belcher et al (2002)
CSV-2	1986	0.9	100	87	391	1500	17	Belcher et al (2002)

T = Transmissivity

k = Hydraulic Conductivity

Porosity values must be estimated because direct field evidence is lacking. Values for porosity range from 5 to 55 percent for limestone aquifers (Walton,1985, p. 19). In general, the porosity of carbonate rocks will be appreciably lower in fine-grained unfractured units and in units in which the fractures have been largely filled through mineralization or the precipitation of calcite. The wells in Table 3 with low transmissivity values (W01, W04, W03) are generally screened in fine-grained and shale and/or chert rich. For the TOT calculations, five porosity values were selected to correspond with the hydraulic conductivity zones. The corresponding porosities are 1, 10, 25, 40, and 55 percent, respectively. These values bracket the published values and are believed to reasonably represent the actual conditions of the carbonate aquifer, which ranges from very tight with limited transmissivity and porosity to karstic (cavernous) with a very high degree of secondary permeability and hence, very high transmissivity and porosity.

The hydraulic gradient value was measured using the elevations of the groundwater at two long-term carbonate monitoring wells, CE-DT-4 in Coyote Spring Valley and EH-5b, located in Arrow Canyon Wash a short distance from the two Arrow Canyon Wells (Figure 2). The difference in head between the two wells was 5.89 ft in February 1987. The horizontal distance between the two wells is 49,210 ft as measured using the US Geological Survey coordinates for each well and DeLorme Topo-3D® software. The difference between elevations divided by the distance between the two wells equals the hydraulic gradient and was calculated to be 0.00012. The ranges of values for transmissivity and porosity and the measured hydraulic gradient were used with Darcy's Law to calculate the daily TOT for the carbonate aquifer. The results are presented in Table 5.

Based upon these calculations, the fastest natural flow rate toward the Muddy Springs area ranges between 0.012 and 0.22 ft/d, with annual rates ranging from less than five ft to about 80 ft. The slow travel times reflect the low hydraulic gradient between Coyote Spring Valley and the Muddy Springs area under natural conditions. While the natural travel times for the groundwater that feeds the springs are slow, they may be accelerated by the effects of pumping wells. Because of the potential connection of fractures in the carbonate aquifer, these effects may occur even though the springs are located in a different watershed. To evaluate the effects of groundwater pumping on the TOT rates, calculations were performed using the gradients associated with observed drawdown at the two MVWD pumping wells. The results are shown in Table 6.

TABLE 5. SUMMARY OF TOT CALCULATIONS: NATURAL CONDITIONS

Parameter	Value 1	Value 2	Value 3	Value 4	Value 5
Conductivity (k)	1000	500	100	10	1
Gradient (i)	0.00012	0.00012	0.00012	0.00012	0.00012
Porosity (η)	0.55	0.40	0.35	0.10	0.01
Time of Travel (TOT) ft/d	0.22	0.15	0.034	0.012	0.012

TABLE 6. SUMMARY OF TOT CALCULATIONS: STRESSED CONDITIONS

TOT = Time of Travel DOT = Distance of Travel

Parameter	Case 1a	Case 1b	Case 2a	Case 2b	Case 3a	Case 3b
Conductivity (k)	1000	1000	500	500	100	100
Gradient (i)	0.0003	0.003	0.0003	0.003	0.0003	0.003
Porosity (η	0.55	0.25	0.55	0.25	0.55	0.25
Time of Travel (TOT) ft/d	0.55	12	0.27	6.0	0.055	1.2
DOT 6 months (ft)	98	2,160	49	1,080	10	216
DOT 1 year (ft)	196	4,320	98	2,160	20	432
DOT 2 years (ft)	398	8,760	199	4,380	40	876
DOT 5 years (ft)	995	21,900	498	10,950	100	2,190
DOT 10 years (ft)	1,992	43,824	996	21,912	199	4,382

Case 1a,2a,3a – Based on observed 8 ft of drawdown at Arrow Canyon #1 plus natural gradient
Case 1b,2b,3b – Based on observed 130 ft of drawdown at Arrow Canyon #2 plus natural gradient

As shown, the effects of pumping wells are significant with the daily TOT ranging from 0.6 to 12 ft/d. for Cases 1a and 1b, respectively. These groundwater flow rates are 50 times faster than those calculated for natural conditions (i.e., with no pumping stresses). Given that the District's primary production wells pump almost continuously during the peak months, a conservative distance of travel of 4320 ft for one year was selected for the Zone 1 limit.

Zone 2 – Surface and Groundwater Contributory Zone – This zone includes the local watershed directly up gradient of the springs beyond the boundary of Zone 1. Surface water drainages in this zone contribute runoff directly to the spring head and may also contribute some small quantity of recharge to the spring area (see Figure 11). This area warrants protection because it is vulnerable to any potential sources of contamination especially spills related to a traffic incident along Warm Springs Road. Zone 2 is relatively small, only about 300 acres (less than one-half square mile). Surface water to the northwest of Zone 2 drains into Arrow Canyon, while runoff to the south and southwest of Zone 2 is to Battleship Wash.

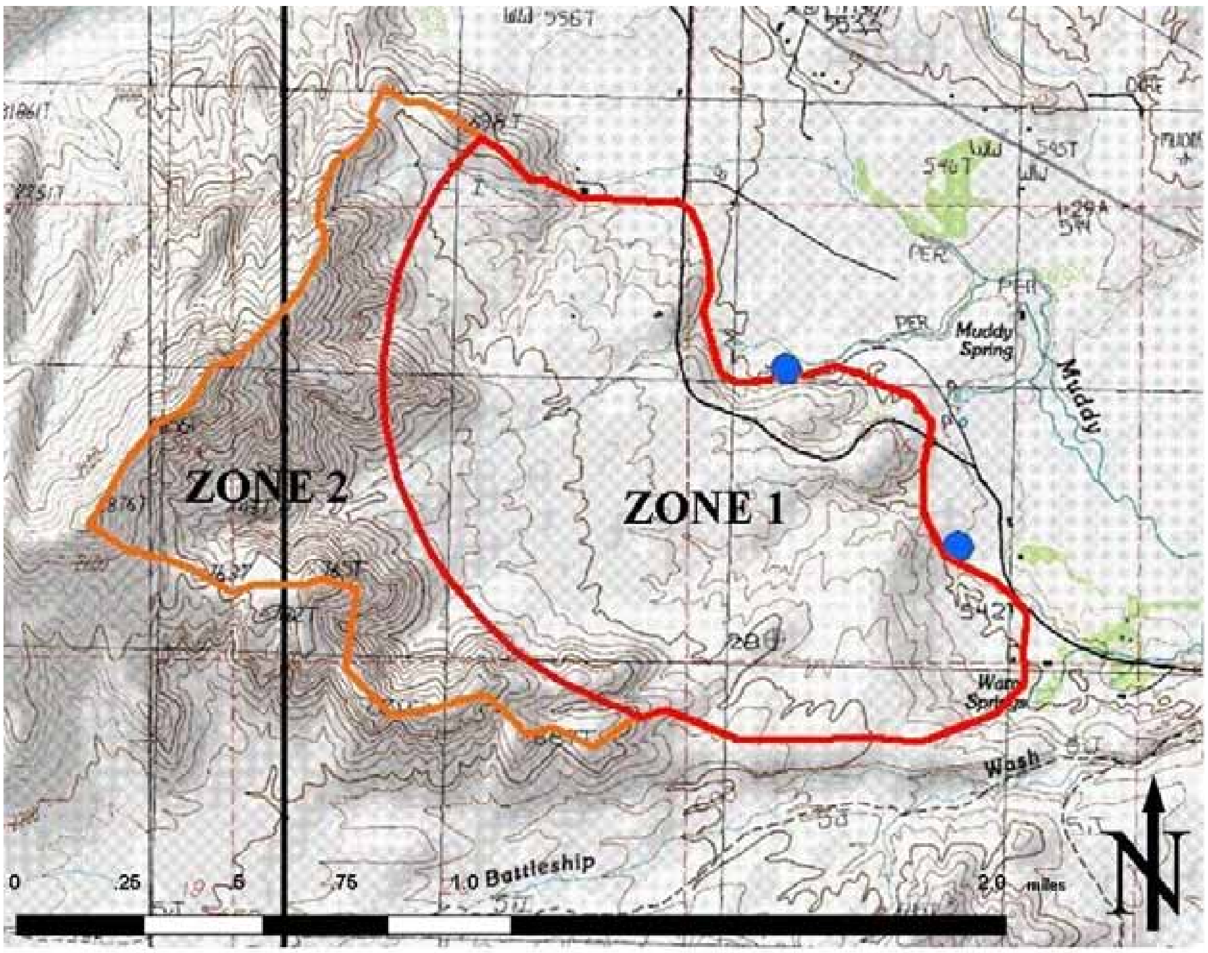


Figure 11 – Spring WHPA Zones 1 and 2

Zone 3 – Potential Groundwater Contributory Zone – This zone includes the area that likely contributes the groundwater to Baldwin Spring and Jones Springs. This large area is shown in Figure 12 (along with Zones 1 and 2). The primary source of water to both springs is mostly via groundwater flow between Arrow Canyon and Battleship Wash (Figure 11). Zone 3 extends about eight miles to the northwest, roughly equal to the 10-year Distance of

Travel calculated above, and is generally three to four miles wide. In total, Zone 3 encompasses about 26 square miles (16,000 acres).

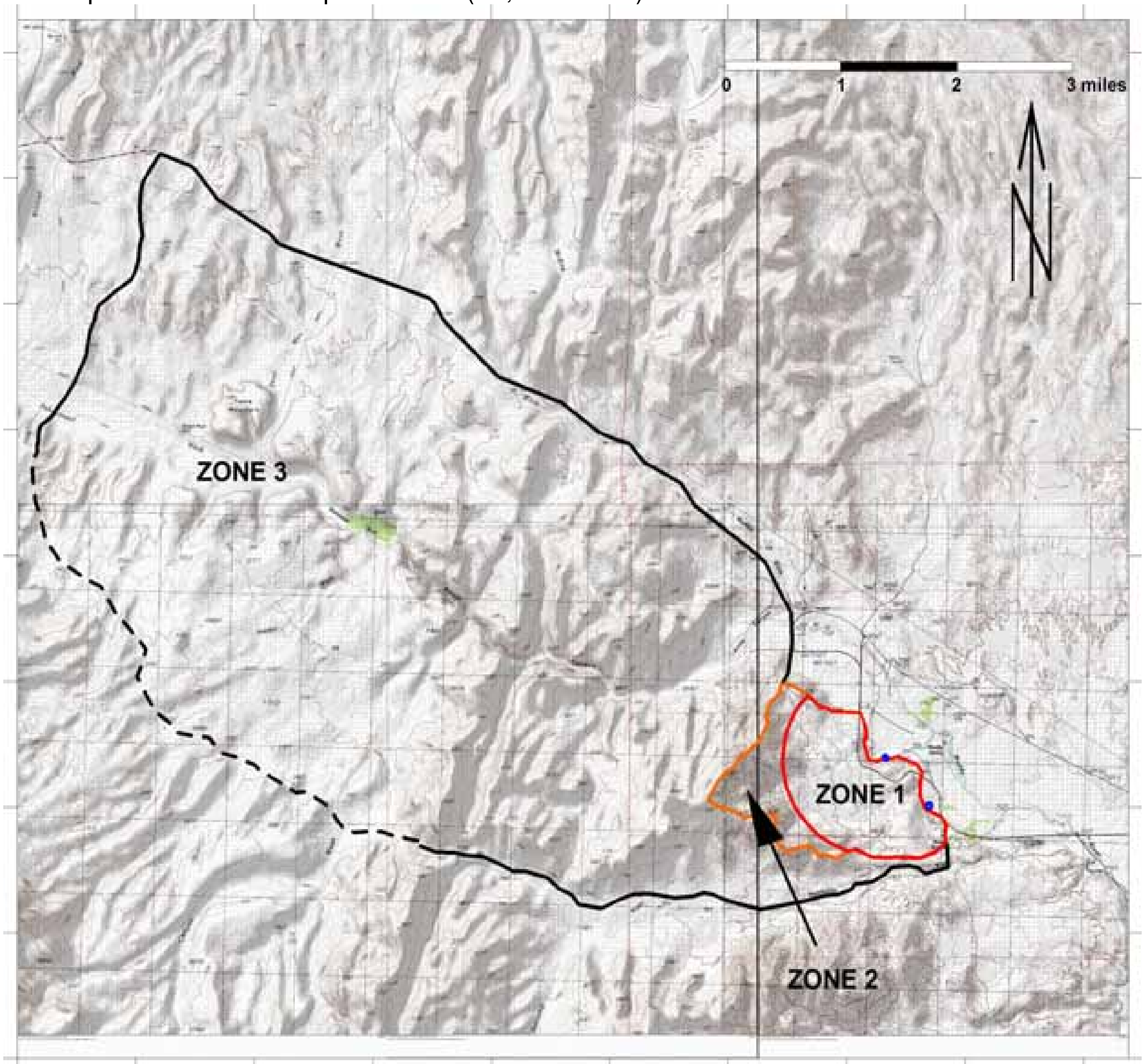


Figure 12. WHPAs for the District's Springs. Base map is 1:24,000 shaded topographic coverage that has been digitally reduced.

There is considerable uncertainty associated with the exact path or paths that ground water takes as it flows from Coyote Spring Valley to the Muddy Springs area. A prominent geologic feature, the Arrow Canyon Syncline (Figure 13) is located between the crest of the Arrow Canyon Range and the Muddy Springs area. The strata on both sides of this fold dip toward the axis of the syncline and probably result in very limited hydraulic communication between Coyote Spring Valley and the Muddy Springs area south of Highway 168 except via the Pahranagat Wash/Arrow Canyon and Muddy Wash areas.

While it may not be necessary to extend the WHPA into the east limb of the Arrow Canyon Syncline, it is considered prudent to do so. In addition to the southeast trending washes, there are a number of north-northeast trending faults shown on the 1:24,000 scale geologic quadrangle map by Schmidt et al (1996) that likely act as fast path conduits in the carbonate aquifer. These faults cross cut the major washes; geologic structures associated with the washes then channel the water toward the springs discharge area

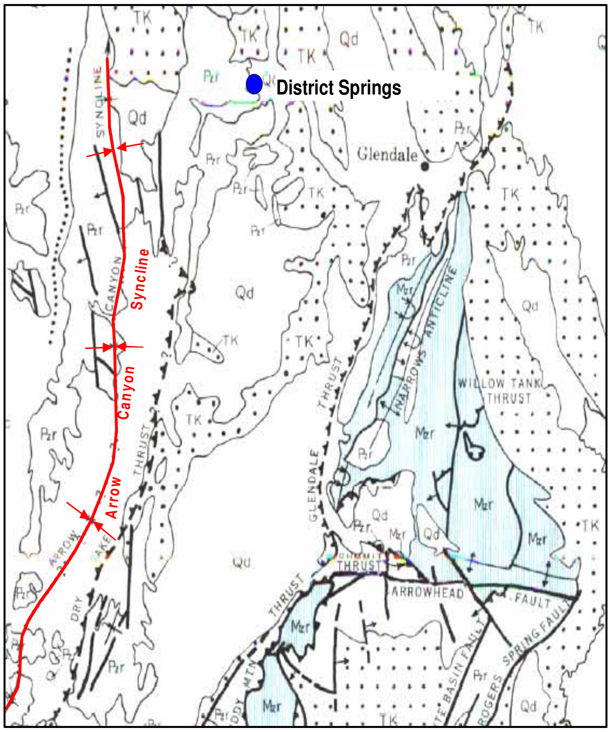


Figure 13. Arrow Canyon Syncline

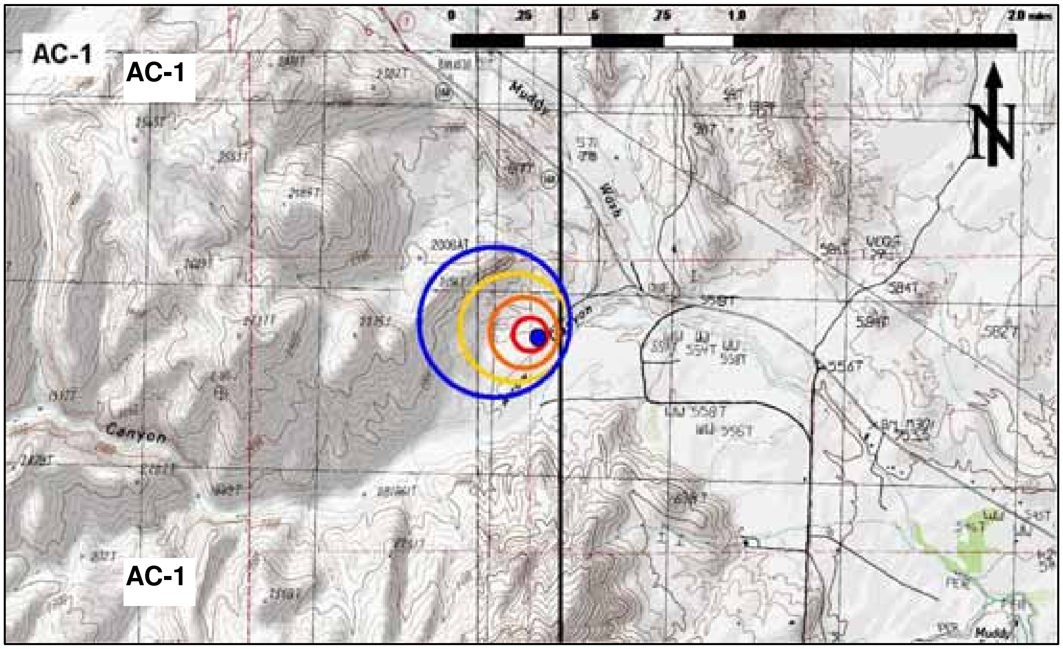
This map is a scanned portion of the county tectonic map prepared by Longwell et al (1965). The Arrow Canyon Syncline has been highlighted and the location of the District's spring sources added. This geologic feature (a large fold shaped like a trough with sloping sides) may exert control on regional groundwater flow paths by restricting flow to the area north of the syncline.

5.4 Wellhead Protection Areas for the District's Wells

The District currently has three water supply wells, the MX-6 well and the Arrow Canyon #1, and #2 wells. The methods used in delineating the WHPAs for these wells have already been described and discussed. Based upon these methods, the 6-month, 2-year, 5-year, and 10-year capture zones were delineated for each well. The 6-month capture zone represents the area of influence for each well during normal conditions. The other zones represent much longer pumping periods that might occur if an interruption of discharge were to occur at Pipeline Jones or Baldwin Springs. The WHPAs for each well are shown on Figures 14a and 14b.The Logandale Well was modeled in the same manner.

The fact that the capture zones have somewhat different dimensions and orientations reflects the differences in groundwater flow directions, aquifer characteristics, well construction, and pumping rates at each location. The capture zone associated with each well is divided into four management zones: (See Figures 14 and 14a)

Zone 1 – Stringent Protection Zone – These zones correspond with the 6-month capture zone for each well and represent the maximum area of influence associated with the normal operations of the wells. It is in these zones that the most stringent protection measures are necessary. Any contaminant sources located within these zones have the potential to result in groundwater contamination that could reach the well within six months. Management strategies for these zones must be aimed at eliminating existing and prohibiting future high-risk contaminant sources such as automotive, industrial, and commercial operations like auto repair shops, junkyards, dry cleaners, and photo shops. Residential sources such as septic systems and storage facilities should be prohibited, along with municipal waste disposal, agriculture, and miscellaneous sources (See Table 7).



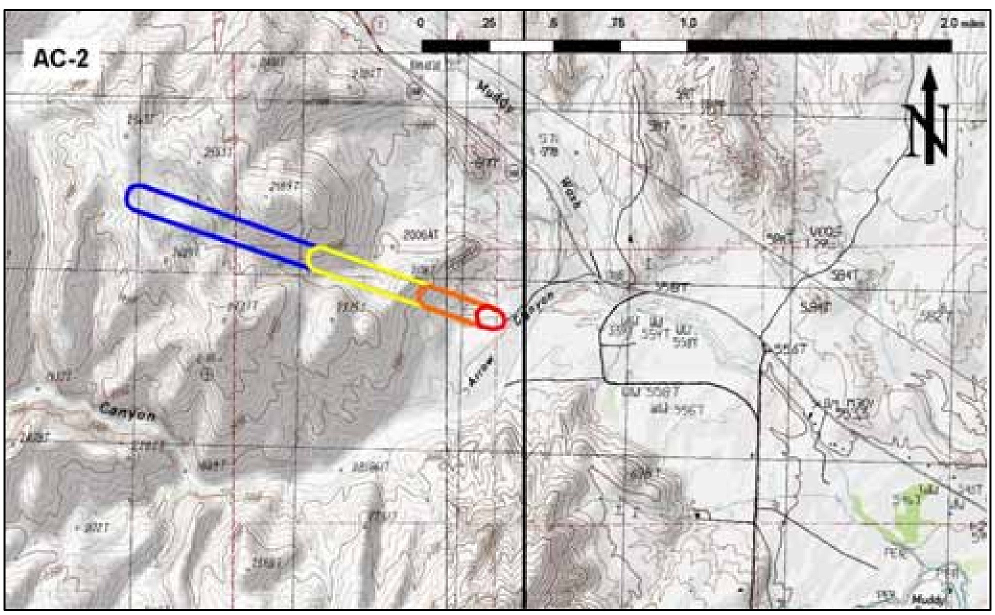
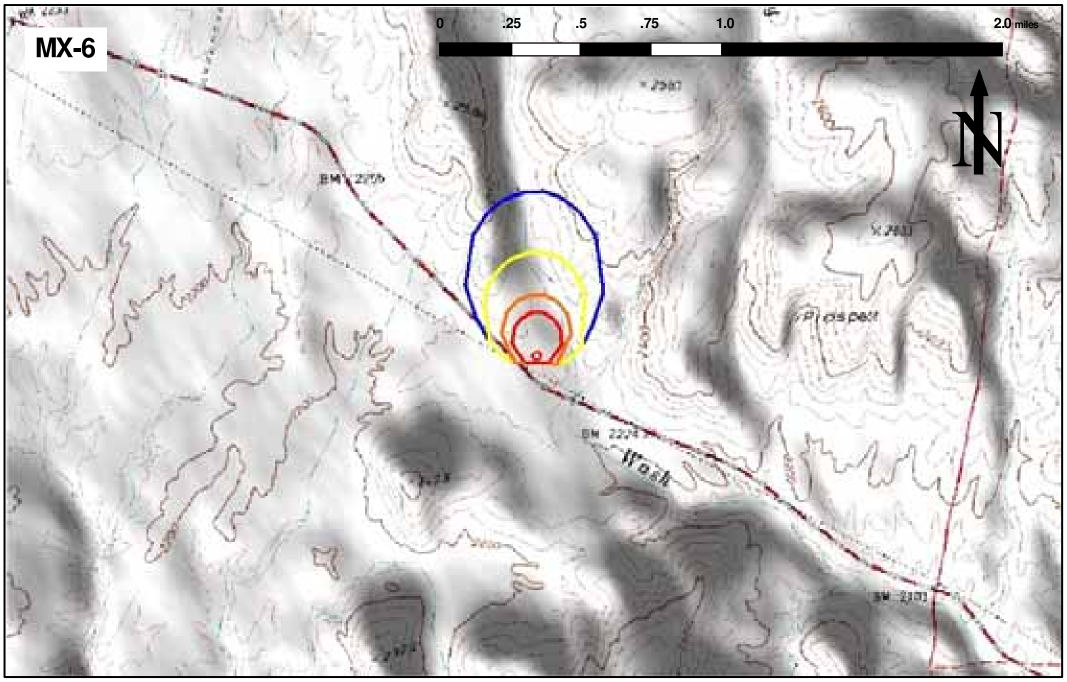


Figure 14. Capture Zones for the Arrow Canyon wells.

red = 6 mos orange = 2 yrs yellow = 5 yrs blue = 10 yrs

Note: Grids shown on maps are latitude and longitude



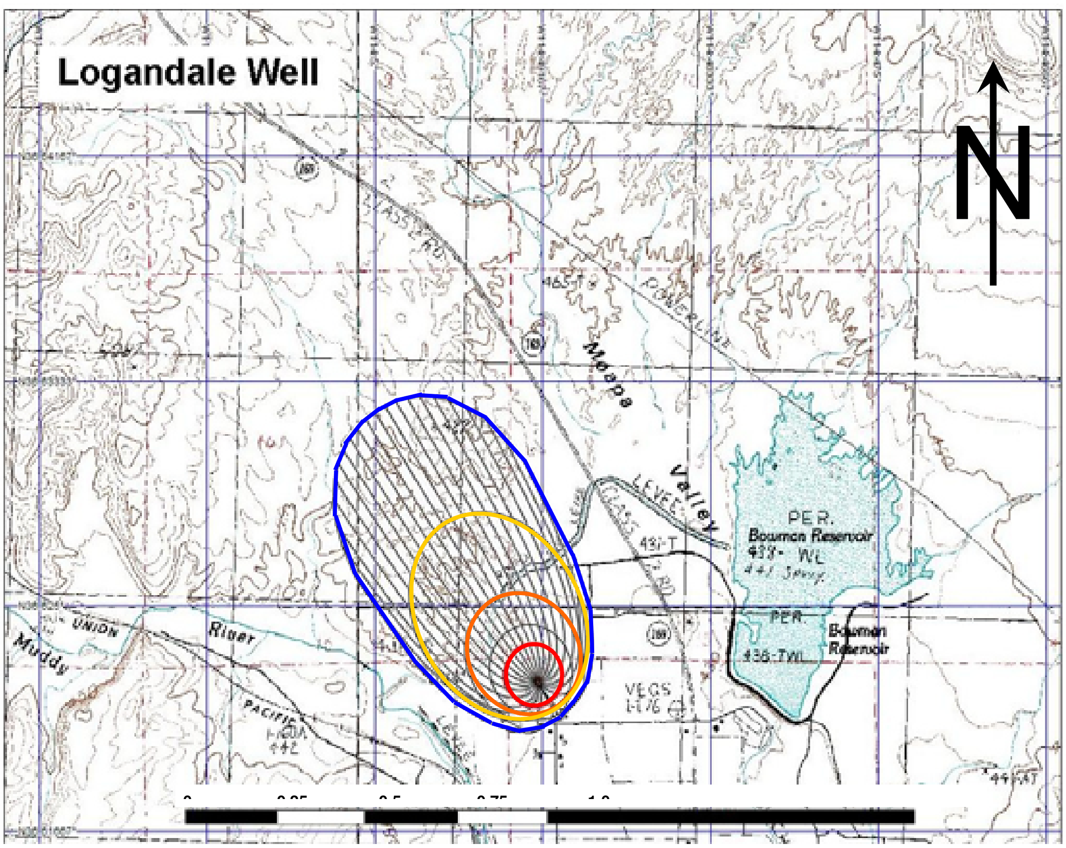


Figure 14a. Capture Zones for the MX-6 and Logandale wells.

red = 6 mos orange = 2 yrs yellow = 5 yrs blue = 10 yrs

Zone 2 – Active Management Zone - These zones correspond with the 2-year capture zone for each well. These zones require management strategies that are protective but not as stringent as those for Zone 1. Certain types of activities should be prohibited within these zones including high-risk automotive, industrial, and commercial operations, and municipal waste disposal, animal feedlots, manure spreading areas, and fuel storage.

Zone 3 – Passive Management Zone – These zones correspond with the 5-year capture zone for each well. Continuous pumping in excess of two years would result in an expansion of the area of influence of each well into these zones. While any contaminant sources under these conditions might contribute to the wellheads, the long travel times and attenuation of the contamination would significantly reduce the potential for contamination at levels of concern. Nonetheless, certain types of activities should be restricted within these zones including municipal waste disposal, and the high-risk automotive, industrial, and commercial operations.

Zone 4 – Watch Zone – These zones correspond with the 10-year capture zone for each well. Continuous pumping in excess of five years would result in an expansion of the area of influence of each well into these zones. Although potential contaminant sources within these zones would not likely result in significant impacts on the water supply wells, the zone should be watched and certain high-risk activities, such as automotive, industrial, and commercial operations, should consider alternate locations beyond the boundaries of the Zone 4 areas.

5.5 Accuracy of the Wellhead Protection Areas

The delineation of WHPAs is not an exact science and the accuracy of the areas defined depends upon the level of information that is available, the natural variability of the hydrologic environment, and other factors. Because of these uncertainties, a conservative approach was employed in the development of the WHPAs for all of the District's water supply sources. For Baldwin Springs and Pipeline Jones Spring, the WHPAs are based upon the geology and topography of the watershed, and inferences based upon the interpretation of the hydrologic conditions.

For the water supply wells, the uncertainty was also addressed by taking a conservative approach. The aquifers that provide the source of water are not uniform. Channel deposits, fractures and faults, and other geologic features may result in fast pathways for groundwater flow in directions that simply cannot be predicted. As was previously discussed in the section on methods, assumptions were made regarding input parameter values for the well analyses that resulted in capture zones that are likely to be too large. Sensitivity analyses were done to determine the capture zones that would result using different input parameters. For the final analyses presented in this plan, best professional judgment was used to interpret the results of the sensitivity analysis and uncertainties. The resulting WHPAs for the water supply wells are significantly different than those defined previously using the calculated fixed radius method. Because of the methods used and the conservative approach, the WHPAs delineated for the District's water supply wells are more protective of human health.

6.0 POTENTIAL CONTAMINANT SOURCE INVENTORY

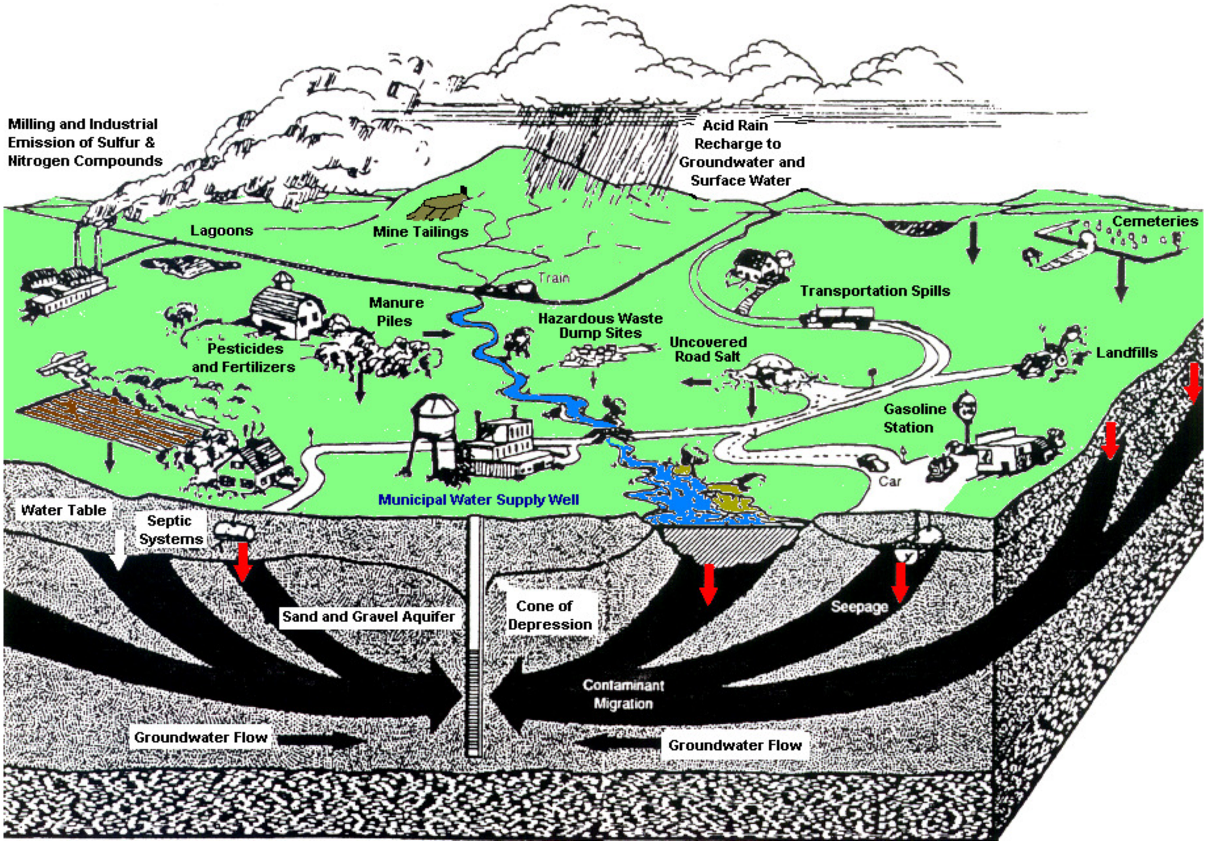


Figure 15. Potential Sources of Groundwater Contamination
Modified from Protecting Nevada's Ground Water, Information, Ideas and Resources for Your Community, Nevada Ground Water Protection Task Force, April 1997.

The identification of potential contamination sources in the vicinity of existing wells or springs is a critical component of this program. An accurate knowledge of the potential threats to groundwater quality will allow the District to create the best plan to protect local water resources.

Figure 15 shows some of the types of activities that can result in groundwater contamination. Many of these types of sources are present in or near the District, and other potential sources also exist. Many common household products that we rely on have the potential to impact groundwater. The tables on the following pages provide lists of the types of activities that may result in groundwater contamination and the types of contaminants and risks that may be associated with those activities.

6.1 Data Source Summary

In conducting the source inventory, a number of information sources were used. These sources included the U.S. EPA's RCRA and CERCLA databases, the Nevada Division of Environmental Protection Corrective Action Case List and Underground Storage Tank List, the Envirofacts on-line database, Bureau of Health Protection Services file data, and a field survey of the community and environs.

6.2 Inventory and Mapping

To identify the potential sources of groundwater contamination in the District, a comprehensive contaminant source inventory was conducted. For most WHPP applications, only those potential contaminant sources within the WHPAs for water supply wells or springs are inventoried. This approach was taken to provide District planners with the most comprehensive information on the locations and status of potential sources of concern in the community.

TABLE 7. ACTIVITIES THAT MAY CONTAMINATE DRINKING WATER
Residential Uses: *(viruses, bacteria, nitrates, chemical compounds)* • Failing septic systems, chemical septic system cleaners • Improper storage and application of fertilizers, pesticides and lawn care chemicals • Disposal of household cleaners, automotive products, poisons, waste oil, paint thinners, gasoline, pet waste into septic systems, backyard pits and storm drains • Driveway runoff of oils, gasoline, heavy metals, de-icing chemicals • Leaking underground heating oil tanks
Schools and Institutions: *(chemical compounds, solvents, nitrates)* • Disposal of oil, paints, chemicals into floor drains, sinks or directly to the ground • Contaminated runoff from parking areas • Improper fertilization of recreation fields • Equipment wash waste water
Municipal Uses: *(sodium chloride, heavy metals, petroleum)* • Improper storage and application of deicing chemicals • Street sweeping • Public works garages; auto maintenance, equipment wash waste water • Uncapped/Unlined landfills, open dumps • Leaking sewer lines/oil lines • Improper storage/application of pesticides and fertilizers • Contaminated runoff from roads, parking lots
Commercial, Industrial Uses: *(heavy metals, petroleum, sodium chloride)* • Improper storage, disposal and management of hazardous materials/waste • Abandoned or leaking underground storage tanks • Spills and releases that go unattended • Floor drains which discharge directly to the ground • Exposed bodies of water from mining, sand and gravel operations • Waste storage lagoons • Transportation spills and releases
Agriculture Uses: *(nitrates, bacteria, viruses)* • Improper use/storage of pesticides, herbicides, animal manure, fertilizers • Improper irrigation methods • Animal burial • Storage lagoons • Concentrated animal feedlot operations • Contaminated runoff and equipment wash waste water

TABLE 8. POTENTIAL CONTAMINANT SOURCES

CODE	CLASS	SOURCE	CATEGORY A	B	C	D	E	RISK RANKING
1	Agricultural	Animal burial areas			X	X		High
2		Animal feedlots		X	X	X		Moderate to High
3		Chemical application (e.g. pesticides, fungicides, & fertilizers)		X	X			High
4		Chemical mixing & storage areas (including rural airports)	X	X	X			High
5		Irrigated fields		X				Moderate
		Irrigation ditches			X			High
6		Manure spreading & pits	X		X			Moderate
7		Unsealed irrigation wells	X		X			High
8	Industrial	Chemical manufacturers, warehousing/distribution activities	X	X	X			High
9		Electroplaters & fabricators			X			High
10		Electrical products & manufacturing			X			High
11		Machine & metalworking shops	X					High
12		Manufacturing sites	X	X	X			High
13		Petroleum products production, storage & distribution centers	X					High
14	Commercial	Dry cleaning establishments	X					High
15		Furniture & wood stripper & refinishers	X					High
16		Jewelry & metal plating			X			High
17		Laundromats						Low
18		Paint shops	X					High
19		Photography establishments & printers			X			High
20	Automotive	Auto repair shops	X					High
21		Car washes	X		X	X		Moderate
22		Gas stations	X					High
23		Road deicing operations: storage & application areas (e.g. road salt)			X			Moderate
24		Road maintenance depots	X		X			High
25	Residential	Household hazardous products	X	X	X			Moderate
26		Private wells	X	X	X	X		Moderate
27		Septic systems, cesspools		X	X	X		Moderate to High
28	Medical / Educational	Educational institutions (labs, lawns, & chemical storage areas)		X	X			Moderate
29		Medical institutions (medical, dental, vet offices)				X		Low
30		Research laboratories	X	X	X	X		High
31	Storage	Aboveground storage tanks	X					High
32		Underground storage tanks	X					High
33		Public storage	X					Low
34		Radioactive materials storage					X	High
35	Municipal Waste	Dumps and landfills (historical/active)	X	X	X	X	X	High
36		Municipal incinerators		X	X	X		Moderate
37		Recycling & reduction facilities			X			High
38		Scrap & junkyards	X		X			High
39		Septage Lagoons, wastewater treatment plants		X	X	X		High
40		Sewer Transfer Stations		X	X	X		High
41	Miscellaneous	Airports	X					High
42		Asphalt plants	X					High
43		Boat yards	X					High
44		Cemeteries				X		Moderate
45		Construction areas	X					Moderate
46		Dry wells	X			X		High
47		Fuel storage systems	X					High
48		Golf courses, parks & nurseries (chemical application)		X	X			High
49		Mining (surface & underground)	X		X			High
50		Pipelines (oil, gas, coal slurry)	X					High
51		Railroad tracks, yards & maintenance	X	X	X	X		High
52		Surface water impoundments, streams/ditches				X		High
53		Stormwater drains & retention basins	X	X	X	X		High
54		Unplugged abandoned well	X	X	X	X		High
55		Well: operating	X	X	X	X		High – Low

Contaminant Categories:
A = V.O.C.
B = S.O.C.
C = I.O. C.
D = MICROBIOLOGICAL
E = RADIONUCLIDES

Table 8 provides the District with a fairly comprehensive list of potential contaminant sources. In the table, each PCS is classified according to code, class, category, and risk ranking. The code numbers (1-55) uniquely identify each type of PCS. Similar code numbers are grouped into classes. Further information is related by categorizing the types of risk presented by each PCS, according to the A through E system shown at the bottom of the table.

Table 9 lists the potential contaminant sources within each WHPA. These are the key potential contaminant sources of concern.

TABLE 9. POTENTIAL CONTAMINANT SOURCES IN WHPAs.			
Water Supply Source	Potential Contaminant Sources		
	ID. No.	Nature of Source	WHPA Zone
Source W01 MX Well	None	No Sources Identified Within 10-Year Capture Zone	N/A
Source WO2 Arrow Canyon 1	None	No Sources Identified Within 10-Year Capture Zone	N/A
Source WO4 Arrow Canyon 2	None	No Sources Identified Within 10-Year Capture Zone	N/A
Source SO1 Baldwin Spring	None	No Sources Identified Within Watershed Area	N/A
Source SO2 Jones Spring	None	No Sources Identified Within Watershed Area	N/A
Source W03 Logandale Well	None	**Feed Lot and Septics**	All

No fixed contaminant sources were identified within the WHPA zones for the MX Well, the Arrow Canyon Wells, Baldwin Spring, or Jones Spring. However, The WHPA established to protect the Logandale well does contain several potential contaminant sources.

Records provided by the BHPS indicate that the Moapa Valley Water District Community Water System applied for and was granted a variance from the Nevada State Board of Health to supply drinking water with a Fluoride concentration of 2.12 parts per million (ppm). The maximum contaminant level (MCL) for Fluoride is presently 2.0 ppm. The water system is presently in compliance with all other state and federal drinking water MCLs.

Based on comments and information provided in the BHPS Public Supply Groundwater Vulnerability Information report (last modified on July 21, 2003), the water system is considered to have low vulnerability to contamination.

6.3 Current Land-Use Zoning

Current land-use zoning in Clark County is set forth in Title 30 of the Clark County Unified Development Code.

6.4 Updates

Updates to the contaminant source inventory will be made every five years, resources permitting. Land use changes will also be tracked and updated every five years, again, resources permitting.
Standard forms describing each PCS can be found in Appendix D. A blank form is also provided to facilitate the revision of the PCS inventory. The completion of this review should be performed by the Manager of MVWD, and recorded in the Annual Review Form in Appendix E. The Manager of MVWD is Brad Huza, at P.O. Box 257 Logandale, NV 89021. He can be reached at 702.397.6893.

7.0 CONTAMINANT SOURCE MANAGEMENT STRATEGIES

This section identifies and evaluates the various contaminant source management strategies that are available to the District. The State of Nevada provides specific guidance concerning the types of management tools that are available for implementation by communities such as those located within the District's service area. According to this guidance, the level of risk associated with potential contaminant sources should be taken into account along with the acceptable risk and the degree of management the community is willing to support.

Table 10 summarizes the types of management tools that are available and their applicability to the District's water supply sources. Table 11 lists specific management approaches for various categories of potential contaminant sources.

TABLE 10 – CONTAMINANT SOURCE MANAGEMENT TOOLS

Regulatory Options	Suggested Management Approach	Applicability to the District WHPP
Sanitary Ordinances Zoning Ordinances Source Prohibitions Land Use Planning Master Planning Special Use Permits Subdivision of Land Parceling of Land	Local governments may use these regulatory options as management tools to protect their communities' underground drinking water resources. These tools will be most effective if they become part of the WHPP.	State regulations govern sanitary services. Subdivision and parceling ordinances are already adequate to protect WHPAs. A land use plan is in place and is consistent with WHPP. Source prohibitions within Zone 1 of WHPAs are appropriate.
Non-Regulatory Options	**Suggested Management Approach**	**Applicability to the District WHPP**
Land Acquisition	The community or utility can acquire land within a WHPA through donation, purchase or trade development rights, and/or conservation easements restricting use of land.	The District does not have the financial wherewithal to acquire land specifically for WHPA protections.
Groundwater Monitoring	A groundwater monitoring program consists of regular sampling of wells for contaminants. It helps the community to measure the effectiveness of its source controls and compliance with drinking water standards.	Groundwater monitoring should be conducted at one or more locations within the Logandale Well WHPAs and up gradient of Baldwin and Jones Springs, if financial assistance can be obtained.
Local Business Owner Education	Encourage local business owners to take advantage of the Business Environmental Program offered by Nevada Small Business Development Center (NSBDC).	Local business owner education is appropriate to the implementation of the WHPP.
Household Hazardous Waste Collection	A good management tool to reduce the amount of hazardous waste going to the landfill or septic systems. Coordinate with local government to implement a Household Hazardous Waste Collection Day. Funding is available through NDEP's Solid Waste Program. This option helps to educate the public about the types of household products which are toxic or hazardous. It encourages public involvement. Educate the citizens in your community by distributing NDEP's flyer about Safer Alternatives to Hazardous Household Products.	This management tool is appropriate if funding can be obtained.
Wellhead Protection Sign	Place signs on perimeters of WHPAs. A sign would reduce the risk of an accident. It serves as notification in case of an accidental spill of contaminant. Signs help to educate the public.	Signs need to be placed in the Baldwin and Jones Springs watersheds. Signing of the MX, Arrow Canyon, and Logandale Wells WHPAs should be considered if funding is available.
Public Education	Public education is a key aspect of any WHPP. Public education efforts are important in building public support for regulatory changes and local funding. NDEP has prepared a flyer listing the available sources for getting ground water protection related public education materials. Use this source to educate the public about WHPP. The Nevada Rural Water Association (NvRWA) conducts free workshops to educate small communities. Encourage citizens in your community to participate in NvRWA's workshops.	Public education through the public school system is appropriate and a set of educational materials has been obtained from the U.S. Geological Survey for use by schools within the District's service area.

TABLE 11 – SUGGESTED MANAGEMENT APPROACHES		
Contaminant Sources	**Suggested Management Approach**	**Applicability to the District WHPP**
Service Stations (auto repair shops, car wash, gas stations, etc.) Class V Disposal Wells	The disposal of hazardous materials through wells is illegal and can cause serious threats to groundwater. Permits must be obtained from NDEP to dispose of non-hazardous liquids through these wells. When identified, all activities cease and contact the Underground Injection Control (UIC) program at NDEP. Educate local business owner/operator by distributing NDEP's UIC fact sheets.	No permits issued or injection wells used within District WHPAs.
Auto Salvage Yards	Automotive fluids should be properly collected, contained and disposed of according to local regulations. Monitor activities near wellhead protection area (WHPA) to detect for violations. Encourage recycling and take advantage of NDEP's recycling program by calling Nevada Recycling Hotline (1-800-597-5865).	No salvage yards are located within District WHPAs.
Abandoned Water Wells	Poorly constructed wells and improperly abandoned wells can act as a 'direct route' for groundwater contamination. State regulations require proper plugging of water wells. Educate the citizens in your community by distributing NDEP's Abandoning Unused Water Wells fact sheets. Coordinate with NDEP for financial assistance to plug your unused wells.	No abandoned water wells are located within District WHPAs.
Illegal Dumping	Monitor WHPAs to detect illegal dumping. Use Nevada's Recycling Hotline (1-800-597-5865) to report illegal dumping.	An on-going effort in this area is needed.
Accidental Spills	Monitor WHPAs for accidental spills. Place wellhead protection signs on perimeters of WHPAs. Have an emergency response/contingency plan ready if an accidental event threatens your water supply.	Emergency response plan and signs are needed to provide more effective protection of both well and spring WHPA.
Underground Storage Tanks (USTs) / Home Heating Oil Tanks	All USTs and home heating oil tanks should be monitored and tested according to the requirements of NDEP. Leaking tanks should be removed as soon as possible and corrective actions should be taken for site remediation. Coordinate with NDEP for financial assistance from the State Petroleum Fund. Educate the citizens in your community by distributing NDEP's Home Heating Oil Tanks fact sheets.	This approach is appropriate and should be implemented if funding can be obtained.
Aboveground Storage Tanks	Coordinate with local Fire Department about siting and construction of aboveground storage tanks.	This approach is appropriate and should be implemented if funding can be obtained.
Septic Systems	Proper design, construction and maintenance of septic systems are vital for your water quality. It is important not to dispose of common household hazardous materials into your septic system. Educate the citizens in your community by distributing NDEP's Domestic Septic Systems fact sheets.	The WHPA established to protect the Logandale Well contains several lots served by septic systems.
Chemical Storage Facilities	Avoid storage or use of chemicals/hazardous activities within WHPAs. Storage and transportation of chemicals/hazardous materials should comply with all applicable laws.	This approach is appropriate and should be implemented if funding can be obtained.
Feed Lots	Feed lots are recognized as a PCS in Federal and State documents regarding WHPPs and classification of PCSs, due to potential releases to the environment	The WHPA established to protect the Logandale Well contains feed lots.

7.1 Regulatory Management Options

7.1.1 Subdivision Ordinances and Zoning

Ordinances for the District and other unincorporated areas of the county are set forth in Title 30 of the Clark County Unified Development Code.

7.1.2 Source Prohibitions

Source prohibitions are regulations that prohibit the presence or use of chemicals or hazardous activities within a given area. The following prohibitions should be put into effect for Zone 1 of all WHPAs and should include:

1. Storage of sludge and septic wastes

2. Storage of sodium chloride, chemically treated abrasives, or other chemicals used for the removal of ice and snow on roads
3. Storage of commercial fertilizers
4. Storage of animal manure
5. Storage of liquid hazardous materials
6. Removal of soil, sand and gravel or any other mineral substance within 50 ft of the historical high groundwater level.
7. Land uses that result in the paving of more than 15% of any lot.

Source prohibitions should be promulgated through the development of an overlay zone consistent with the Clark County Land Use Plan. Approval of the Clark County Planning Commission will be needed to implement these prohibitions.

7.1.3 Design and Operating Standards and Review

Reviews of subdivision and parcel maps, and master plans are already provided for in municipal ordinances. Required state reviews provide another level of checks for subdivisions. A number of state agencies regulate and are the permitting authority for a number of activities that use, store, or dispose of hazardous materials and wastes. In this capacity, the NDEP, BHPS, and NDWR already insure that proposed projects will not pose a risk to groundwater resources.

7.2 Non-Regulatory Management Options

<u>Abandoned Wells and Wells Without Surface Seals</u>. Any well without a surface seal, or unplugged, abandoned, or unused wells in the area could provide a route for contaminants to reach the aquifer used by the county. There are many private wells and improperly abandoned wells in the LCU service area. In order to determine the extent of this problem and to develop a management approach, LCU should request implementation funding from NDEP to conduct a well survey. The well survey will identify privately owned wells that exist within the service area. Some of the wells will no longer be in use and should be abandoned. The well survey report will include a map showing the locations of the well, a database of well owners and management plan. The following recommendations are applicable to wells that might be located near the WHPAs established herein:

- Educate private well owners in the protection area about proper well plugging and abandonment procedures.
- Water wells should be properly sealed and cased to prevent inundation from surface runoff.
- Ensure that all abandoned wells are properly plugged by the owner. Proper decommissioning of abandoned wells is required by State law.
- Collect information from private well owners via form letter, and incorporate this information into the WHPP. (See Appendix E)

7.2.1 Public Education

Best Management Practices will be encouraged by education aimed at three groups: 1) private citizens with regard to septic systems and home heating oil; 2) commercial operations with respect to materials management; and 3) the children of communities within the District's service area on the importance of protecting their water supplies. Fact sheets, reports, and education materials are available from a number of sources including the NDEP and BHPS as well as Internet sites for out-of-state agencies and organizations. The compilation and distribution of suitable materials to groups within the District's service area provides an effective and low cost management option.

7.2.2 Water Supply Monitoring

Monitoring in the Muddy Springs area and at the District's water supply wells is a costly but essential part of the overall WHPP. At present, these sources are monitored for a number of suites of chemicals including major trace elements, metals, and a number of organic compounds. This monitoring is done in accordance with the Safe Drinking Water Act and the requirements of the Nevada Bureau of Health Protection Services. Current monitoring for the water supply wells is considered adequate based upon the number and locations of potential contaminant sources and the well construction characteristics.

7.2.3 Waste Management

Reducing the nature and volume of wastes generated in the household can be an important management approach, especially for households with domestic wells and septic systems. Substituting safer alternatives for cleaners, polishes, mothballs, insecticides, and solvents can help reduce the threat of groundwater contamination. Copies of a fact sheet on safer alternatives to hazardous household products have been made for distribution.

7.2.4 Updates

The contaminant source management plan should be updated yearly, beginning one year after State endorsement. The completion of this review should be performed by the Manager of MVWD, and recorded in the Annual Review Form in Appendix E. The Manager of MVWD is Brad Huza, at P.O. Box 257 Logandale, NV 89021. He can be reached at 702.397.6893.

8.0 SITES FOR NEW WATER SUPPLY WELLS

Any new public water supply well for the District or environs must be drilled and constructed in accordance with the regulations and requirements of the Nevada Division of Water Resources and the Bureau of Health Protection Services. The location for any new water supply well will be reviewed by the Wellhead Protection Team with respect to the guidelines for all of the WHPP elements. All new wells will be incorporated into this plan and best management practices implemented to insure that the well is safe from the risk of contamination.

8.1 Environmental Considerations in Selecting Well Locations

In the selection of new well locations, all of the potential contaminant sources should be avoided with a minimum setback of 1,000 ft from all industrial and automotive sources, existing and closed landfills and sewage treatment works, concentrated animal feedlot operations, and animal burial areas. A 500-foot setback should be maintained from all other commercial, agricultural, and miscellaneous sources. A 250-foot setback should be maintained from all domestic septic systems. These setback distances, coupled with properly constructed water supply wells, should eliminate or greatly reduce the potential for contamination.

8.2 Water Quality Issues

Beyond the risks associated with potential contaminant sources, there are other environmental considerations. These include streams, springs and wetland areas (and their associated habitats), National Forest and Parks, Native American Tribal Lands, and locations designated by the Bureau of Land Management as Areas of Critical Environmental Concern.

From a regulatory and permitting point of view, well sites should also be selected that pose the fewest constraints to the acquisition of rights-of-way and easements. Sites should be accessible by existing roads and within a reasonable distance of existing power sources.

8.3 New Wells

The Bureau of Health Protective Services mandates that the horizontal distance between a supply of water and any source of pollution must be as great as practical, but no less than one hundred feet. However, this distance is generally inadequate for wellhead protection. WHPAs should be delineated for all proposed or new wells in the same manner as for existing wells. The only difference being that the delineations and potential contaminant source inventories will be completed prior to the construction of the wells.

8.4 Tentative Schedule for Well Use

A 10-year plan has been established for new water supply wells. For at least the next five years, no new wells are needed unless a catastrophic release occurs in the Muddy Springs WHPA. In that unlikely event, a new water supply well could be brought on line in less than one year. Table 12 summarizes the elements of the Source Development Plan for new water supply wells.

TABLE 12 - SOURCE DEVELOPMENT PLAN ELEMENTS		
Element	**Considerations**	**Status**
Estimate Projected Supply Needs	Current capacity is adequate in terms of production, storage, and treatment.	Projected demand can be met with existing sources.
Identify Undeveloped Water Sources	Spring development is costly especially if Surface Water Rule must be met. Suitable sites exist for future water supply well.	Suitable areas identified for additional water supply wells to augment or replace Muddy Springs.
Examine Steps Required to Obtain Water Rights	The District has adequate water rights to provide for future expansion of system.	Change in point of diversion filed with NDWR after final well site selection.
Define WHPAs for New Well Sites	Site-specific data will not be available but existing data for region as a whole is considered adequate.	Deferred to final well location selection. Adequate information already exists for delineation of preliminary WHPA. Final definition based on results of well tests.
Identify Potential Contaminant Sources		New sources will be monitored through NDEP, BHPS, and WHPP Team.
Select Management Strategies and Options	Site-specific data will be required.	None
Perform Compliance Studies	Obtain permits and access and file environmental documentation. Can cost $5K to $50K depending on location and NEPA requirements. Sample water and test for chemical constituents to demonstrate compliance with Safe Drinking Water Act. Costs can approach $5K per source for sampling, analyses, reporting, and contractor fees. Conduct aquifer test of new source well.	Permitting, rights-of-way and NEPA documentation initiated after funds secured. Sampling is typically done following well completion and development or during drilling of a pilot borehole. Will include Safe Drinking Water Act parameters for chemistry. Aquifer test needed for final WHPA delineation; to be done at time of well completion.
Evaluate Financial Needs and Procure Funding	10-year planning horizon. Priority needs are 2-3 monitoring wells and signs. Second priority is development of new groundwater source or sources over five to 10-year timeframe. ($200K$\pm$).	Potential funding sources identified for monitoring wells and grant proposals will be prepared. Funding sources for new supply wells will be sought.

9.0 CONTINGENCY PLANNING

Contingency planning within the context of the WHPP means being prepared to take action in response to a threat to the quality or quantity of the drinking water supply. For example, what action would MVWD take if the primary source of drinking water for the community became contaminated?

In addition to the Contingency Plan, there may be several other plans in existence that provide useful information relative to drinking water supply and protection. Some, or all of these plans can be used in conjunction with the Contingency Plan depending on the situation. Copies of these documents may be on file in the MVWD Office.

Operation and Maintenance Manual.
The O & M Manual provides information on the normal operation and maintenance of the MVWD water system.

Cross Connection Control Plan.
This document provides information on how to prevent unauthorized connections to the water system that could potentially contaminate the system during a loss of pressure.

Emergency Response Plan
Emergency Response Plans are short-term solutions to an immediate shutdown, either due to quantity problems, response to contaminant threat, or natural disaster. Public water suppliers in Nevada work with the Nevada Division of Emergency Management (DEM) through County emergency management representatives if an emergency response is required. The DEM assists with short-term problems, such as spill response and coordinating the trucking of water to the afflicted community.

Water System Security Vulnerability Assessment
This tool describes the security improvements that should be made to individual well sites. It also describes the action that should be taken in the event of a malevolent act at any of the District's facilities.

Water Conservation Plan
The Water Conservation Plan outlines procedures to be followed in the event of water shortages due to drought, overuse, or contamination. Water meters have been installed by MVWD in an effort to encourage water conservation, as well as manage supply. The Water Conservation Plan also outlines proposed water conservation enforcement measures.

9.1 Type of Incidents

The primary types of incidents of concern are spills within the Zone 1 of each WHPA, especially a transportation accident related spill upgradient of Baldwin Springs. The wellheads are secured and fenced and a fence has been constructed around the spring works at both springs preventing spills in the immediate vicinity of each source. While this fencing provides the first level of security for the WHPAs, it is not possible to fence the entire WHPA for each source. Another type of incident would result from releases from potential contaminant sources in Zone 1 of the Arrow Canyon well sites. However, this is highly unlikely as the location is remote and not open to general traffic.

9.2 Emergency Response

In the event of an incident, the Clark County Emergency Response Coordinator will be contacted and will work with the Nevada Division of Emergency Management. The WHPP Team will assist the coordinator by concentrating on evaluating the nature of the release, identifying the responsible party or parties, and in coordinating water supply provisions within the community.

TABLE 13
CHAIN-OF-COMMAND

Organization	Contact Person	Work Phone	Other Phone
MVWD	Brad Huza	702.397.6893	702.371.0428
BHPS	Main Number	775.687.4750	
NDEP	Main Numbers	775.687.4670	775.687.9480

9.3 Water Supply Provisions

The need for water supply provisions will depend largely upon the location and timing of an incident. If the Arrow Canyon wells, the District's primary water source, are threatened between October and May, then only minor interruptions in service are likely, as the spring sources and other water supply wells should be capable of meeting the demand for water. If, however, the Arrow Canyon Wells are threatened between June and September, then the supply springs and wells may not be able to meet the demand for water unless additional actions are taken.

Additional actions include water rationing, deliveries of fire and potable water, and alternate water supply sources. Water rationing measures will include restrictions on lawn and agricultural irrigation commensurate with the level of disruption to the water supply. In the unlikely event that the disruption of service is more severe, then arrangements will be made with local mining interests and/or the Las Vegas Valley Water District to temporarily share water supplies (via truck or temporary pipeline) until a new source can be brought on line.

Backup Generators: In the event of an extended power failure in the Moapa area, MVWD should have backup generators for enough wells to meet average day demand.

9.4 Source Decontamination

In the event that a water supply source is contaminated as a result of any action by a third party or parties, the WHPP Team will coordinate with NDEP to insure that the contamination is quickly remediated or the source is replaced in a timely fashion. In the unlikely event that the contamination is a result of actions by the District, then the WHPP Team will coordinate with NDEP to evaluate the need, cost, and timing of remediation versus the cost and timing of source replacement, secure short-term funding, and implement the selected alternative. Under most incident scenarios, source replacement will be the likely alternative of choice and development plans have already been outlined for such a contingency.

9.5 Water Supply Decontamination

Water supply decontamination is well beyond the technical and financial capabilities of the District. With a relatively small customer base and severe budget constraints, it is not possible to generate and dedicate funding for a response to a hypothetical incident that may or may not occur in the future.

9.6 Source Development

Within the framework of this WHPP, the elements of a source development plan have been identified along with the corresponding costs and times required for implementation.

9.7 Restoration of Services

In the event of a contamination incident, the appropriate course of action will be determined. The nature of the contaminant will dictate specific actions. Upon successful completion of remedial activities, water service will be restored to the community as soon as possible.

10.0 PUBLIC PARTICIPATION

The primary goal regarding public education and participation is to raise the awareness of local citizens to wellhead protection issues and enlist their support and involvement. Public participation is one of the keys to the success of any WHPP**.**

10.1 Citizens Advisory Council

In their capacity on the Wellhead Protection Team, each of the members represents a different agency including the District, County, and NDEP.

10.2 Notification

Residents within the District will be notified of the availability of this WHPP and will be encouraged to participate in the process of implementing and updating this plan. It is important that the WHPP continue to be a community based effort.

10.3 Public Education

The following educational materials should be distributed within one year of State endorsement.

For private septic owners and home heating oil users, the following materials are suggested:

"Domestic Septic Systems Fact Sheet"; Author: NDEP Bureau of Water Quality Planning

"Assessing the Risk of Water Contamination from Household Wastewater Treatment";
Protecting Nevada's Water; Worksheet to identify management concerns and rate the concerns to set priorities; Author: University of Nevada, Reno, Cooperative Extension

"The Risk of Water Contamination from Household Wastewater Treatment"; Protecting Nevada's Water Special Publication on how a septic works, avoiding ground and surface water contamination, and best uses; Author: University of Nevada, Reno, Cooperative Extension

"Fact Sheet 6 – Reducing the Risk of Ground Water Contamination by Improving Household Wastewater Treatment"; Oklahoma Farm & Ranch *A* Syst; Oklahoma Farm and Ranch Assessment System
Author: Oklahoma Cooperative Extension Service – Division of Agricultural Sciences and Natural Resources – Oklahoma State University

"Home Heating Oil Tanks Fact Sheet"; Author: NDEP Bureau of Water Quality Planning

For commercial and agricultural users:

"Local Authority for Ground Water and Wellhead Protection"; Author: NDEP Bureau of Water Quality Planning

"Ground Water Protection Public Education Materials"; Author: State of Nevada

"Assessing the Risk of Groundwater Contamination from Water Well Condition"; Protecting Nevada's Water Worksheet for well condition and management priorities; Author: University of Nevada, Reno, Cooperative Extension

"The Risk of Groundwater Contamination Related to Water Well Condition"; Protecting Nevada's Water Special Publication to separate your well from contamination, well safety, well testing, and closing wells.
Author: University of Nevada, Reno, Cooperative Extension

"Managing Agricultural Fertilizer Application to Prevent Contamination of Drinking Water"; Source Water Protection Practices Bulletin; Author: EPA – Office of Water

"Managing Livestock, Poultry, and Horse Waste to Prevent Contamination of Drinking Water"
Source Water Protection Practices Bulletin; Author: EPA – Office of Water

For the Clark County School District, educational materials can be obtained from the U.S. Geological Survey and NDEP:

> **"All the Water in the World"; Grades K – 3, 4 – 6; Objective: Not all the water in the world can be used for drinking and other water supply needs.**
>
> **"Deep Subjects – Wells and Ground Water"; Grades 3-6; Objective: Knowledge about groundwater in terms of how it exists in the ground.**
>
> **"Non-Point Source Pollution"; Environmental Education; Grades 4-7; Author: EPA – Office of Water**
>
> **"Build Your Own Watershed"; Environmental Education; Grades 8-12; Build Your Own Watershed Author: EPA – Office of Water**
>
> **"Source Water Protection: Surface Water Sources"; Objective: Identify sources of contamination to water.**
>
> **"Source Water Protection: Groundwater Sources"; Objective: Define a Wellhead Protection Program.**

Other suggested resources include:

> **Watershed – Where We Live**
>
> **How Do We Treat Our Wastewater?**
>
> **Water: The Resource That Gets Used and Used and Used for Everything!**
>
> **Hazardous Waste: Cleanup and Prevention**

11.0 REFERENCES

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