# PRELIMINARY ASSESSMENT OF THE HYDROGEOLOGY OF SPRING VALLEY AND SNAKE VALLEY HYDROGRAPHIC AREAS EAST-CENTRAL NEVADA AND WEST-CENTRAL UTAH AND POTENTIAL ADVERSE EFFECTS TO THE WATER RESOURCES OF GREAT BASIN NATIONAL PARK AND SURROUNDING LANDS DUE TO GROUND-WATER PUMPING AS PROPOSED BY THE SOUTHERN NEVADA WATER AUTHORITY'S WATER-RIGHTS APPLICATIONS IN SPRING VALLEY

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A wet meadow in Spring Valley (foreground), looking southeast toward Great Basin National Park and Wheeler Peak (background), May 24, 2006.

Cover Photo: South Millick Spring (foreground), a U.S. Bureau of Land Management Public Water Reserve, located in Spring Valley, looking west toward the Schell Creek Range (background), May 24, 2006.

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an
INTERPRETIVE REPORT

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**Southern Nevada Water Authority's Water-Rights Applications in Spring Valley**

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## INTRODUCTION

### Background

In 1989, the Las Vegas Valley Water District (LVVWD) filed 19 water-right applications in Spring Valley Hydrographic Area (HA) for a total of 126 cubic feet per second (cfs) and 9 water-right applications in Snake Valley HA for a total of 70 cfs with the Nevada Division of Water Resources to appropriate the underground waters of the State of Nevada for municipal purposes, principally in southern Nevada.

### Purpose and Scope

The purpose of this report is to: (1) describe the hydrogeologic setting of the area of the proposed ground-water withdrawals; and (2) evaluate the potential adverse effects to the water resources of Great Basin National Park and surrounding lands due to the ground-water pumping as proposed by LVVWD's water-rights applications in Spring Valley HA.

This report is a preliminary assessment. No field data collection was conducted as part of this investigation. The author conducted field reconnaissance of Spring and Snake valleys and the surrounding area. Most of the analysis conducted for this report and the report writing were done in May and June 2006.

### Previous Investigations

*Regional:* Comprehensive investigations of the regional aquifer system in Nevada and adjacent states were conducted by the U.S. Geological Survey (USGS) in the 1980's and 1990's, the results of which are contained in:

(1) A series of hydrologic atlases, denoted the HA-694 series, including:
   - (a) HA-694-A by Plume and Carlton (1988), regarding the regional hydrogeology;
   - (b) HA-694-B by Thomas and others (1986), regarding ground-water levels; and

(c) HA-694-C by Harrill and others (1988), regarding the major ground-water flow systems within the larger regional aquifer system.

(2) A series of professional papers, denoted the PP 1409 series, showing the results of what the USGS termed the Great Basin Regional Aquifer Systems Analysis, including:

(a) PP 1409-A by Harrill and Prudic (1998), the summary report;

(b) PP 1409-B by Plume (1996), regarding the regional hydrogeologic framework;

(c) PP 1409-C by Thomas and others (1996), regarding geochemistry and isotope hydrology; and

(d) PP 1409-D by Prudic and others (1995), regarding a conceptual evaluation of regional ground-water flow, and including a preliminary steady-state ground-water flow model of the entire carbonate-rock province.

(3) A water-resources investigations report by Schaefer and Harrill (1995), which included a preliminary regional simulation of the effects of proposed ground-water pumping from 17 basins within the regional aquifer system using a transient-state ground-water flow model based on the steady-state model of Prudic and others (1995) mentioned above.

*Local:* Several more site-specific hydrologic investigations, either entirely about Spring Valley or with at least some focus on Spring Valley, have been conducted by the USGS and by state agencies since the 1960's, including:

(1) Reconnaissance-series report number 33, by Rush and Kazmi (1965), a water-resources appraisal of Spring Valley, which was one of a number of reports prepared in cooperation between the USGS and the Nevada Department of Conservation and Natural Resources;

(2) Reconnaissance-series report number 34, by Hood and Rush (1965), a water-resources appraisal of the Snake Valley area;

(3) Hydrology reports by LVVWD, by Brothers and others (1993, 1994), regarding Snake and Spring valleys, respectively;

(4) A USGS water-resources investigations report by Nichols (2000), regarding ground-water evapotranspiration and ground-water budgets in 16 valleys of eastern Nevada, including Spring Valley but not Snake Valley; and

(5) A USGS scientific-investigations report, by Elliott, Beck, and Prudic (2006), regarding an assessment of surface-water resources in and adjacent to Great Basin National Park, and an evaluation of their susceptibility to ground-water withdrawals from Spring and/or Snake valleys.

## WATER RESOURCES OF GREAT BASIN NATIONAL PARK

Great Basin National Park is located almost entirely within the mountains of the Snake Range of east-central Nevada, and is bounded by Spring Valley to the west and Snake Valley to the east. Several small, roughly parallel streams flow through and out of the park, off the steep, west side of the mountain range into Spring Valley. These include Shingle Creek, Pine Creek, and Williams Canyon. Mean annual discharge of these creeks is approximately 1 cfs (Elliott and others, 2006, page 8, Table 2).

Several somewhat larger, roughly parallel streams flow through and out of the park, off the gentler, east side of the mountain range into Snake Valley. These include Strawberry, Lehman, Baker, and Snake creeks, and South Fork Big Wash. Mean annual discharge of these creeks ranges from less than 1 cfs to almost 10 cfs (Elliott and others, 2006, page 8, Table 2). Lehman Caves is located in the park on the east side of the mountain range also, and two large-volume springs (Rowland Spring and Cave Spring) also are located there, near the mountain/valley interface. The mean annual discharge of Rowland Spring is approximately 2 cfs (Elliott and others, 2006, page 8, Table 2). The United States holds water rights for the benefit of Great Basin National Park for Cave Springs, Baker and Lehman creeks, and associated with Lehman Caves (Lord and Aldhamari, 2006, page 1-2).

In the northern part of the park, Shingle, Pine, and Williams creeks that drain to the west into Spring Valley, and Strawberry, Lehman, Baker, and Snake creeks that drain to the east into Snake Valley are all perennial streams. In the southern part of the park, however, there are no perennial streams. For example, South Fork Big Wash is an intermittent stream, which goes dry in the autumn and winter months (Elliott and others, 2006, pages 91-92, Table B10), and Decathlon Canyon, which is a tributary to Big Spring Wash that drains south and southeast out of the park, is an ephemeral stream that typically only flows during periods of intense summer thunderstorms (Elliott and others, 2006, page 15, and pages 95-96, Table B12).

## PHYSICAL SETTING

### Physiography and Climate

*Regional:* Spring Valley is located in east-central Nevada, within the Great Basin area, which is a part of the Basin and Range physiographic province (Figure 1). The Great Basin is characterized by generally north-south trending parallel mountain ranges with intervening broad, relatively flat valley bottoms. Consequently, over 200 individual hydrographic areas (HA's) have been identified throughout the state (Figure 2). Some of these HA's are closed basins (i.e. with land surface sloping inward in all directions) and others slope generally to the north or south to an outlet to adjacent basins. The southern half of Nevada slopes generally to the south, with the lowest elevation in the far southern part of the State. In east-central and northeastern Nevada, however, most of the valleys slope to the northeast, toward the Great Salt Lake Desert.

*Local:* Spring Valley HA (#184) is a topographically closed valley about 120 miles long north-to-south and about 15 miles wide east-to-west, located in east-central Nevada (Rush and Kazmi, 1965, page 4a, Figure 2). It consists of a mildly sloped valley bottom, bounded by mountains on all sides. The highest mountain ranges are the Schell Creek Range to the west and the Snake Range to the east. The valley is also bounded by the somewhat lower mountains of the Fortification Range on the southwest, by the Wilson Creek Range on the south, and by the Kern Mountains and the Antelope Range on the northeast.

On the eastern and western edges of the valley floor, intermediate between the valley bottom and the mountains, are alluvial fan deposits that have coalesced to form an alluvial slope along most of the mountain/valley interface.

The land surface on the valley floor itself slopes from the north and south ends to low areas at two playas, one in the north-central part of the valley and another one in the south-central part, named Baking Powder Flat (Rush and Kazmi, 1965, plate 1). Land-surface altitude ranges from about 5,500 feet above mean sea level at the northern playa to about 13,000 feet at Wheeler Peak in the southern Snake Range (and within Great Basin National Park).

The climate in the valley of Spring Valley is semiarid, whereas the climate in the mountains adjacent to the valley is subhumid to humid (Rush and Kazmi, 1965, page 4; Elliott and others, 2006, page 3). In general, annual precipitation increases with increasing altitude in this area. Mean annual precipitation at Lehman Caves Visitor Center within Great Basin National Park (in Snake Valley adjacent to Spring Valley) from 1971-2000 was 13.61 inches (Elliott and others, 2006, page 3).

<u>Hydrogeologic Framework</u>

*Regional:* Spring Valley and Great Basin National Park lie within the Great Basin Regional Aquifer System, as defined by USGS. The Great Basin Regional Aquifer System contains three principal hydrogeologic units: basin-fill deposits, carbonate rocks, and non-carbonate rocks (Figure 3). The basin-fill deposits are composed of unconsolidated clay, silt, sand, gravel, and in places volcanic ash. The carbonate rocks are massive, consolidated rocks of Paleozoic age. The non-carbonate rocks are principally volcanic rocks, which consist mostly of indurated ash-flow tuffs and basalt-flow rocks of Tertiary age.

The Great Basin is an area of Cenozoic crustal extension. The generally parallel north-south trending mountain ranges have been formed by normal faulting due to the extensional forces in the Earth's crust, and the intervening valleys, the downthrown blocks, have filled with basin-fill detrital sediments washed off the mountain blocks.

*Local:* The Snake Range is composed largely of Paleozoic carbonate rocks, except for the northern part of the southern Snake Range, which is composed principally of metamorphic rocks. Lehman Caves and the Baker Creek cave system on the east side of the Snake Range are formed in the Pole Canyon Limestone of Paleozoic age (Elliott and others, 2006, page 6). Elliott and others (2006) also report (page 6) that: "Caves have formed not only in the Pole Canyon Limestone, but also in every exposed carbonate unit throughout the park." The Fortification and Wilson Creek Ranges are composed mostly of lava flows and volcanic tuffs of Mesozoic and Tertiary ages. The central Schell Creek

Range is composed largely of sedimentary rocks and metamorphic rocks of early Paleozoic and Precambrian age, including some carbonate rocks (Figure 17, and Rush and Kazmi, 1965, page 8).

The older alluvium (late Tertiary to Quaternary), which occurs mostly along the alluvial slopes of the valleys (Rush and Kazmi, 1965, plate 1), is composed mainly of detritus from the adjacent mountains, consisting of poorly sorted sand and gravel that are usually unconsolidated to poorly consolidated. These deposits are reported to yield "small to moderate supplies of water to wells" (Rush and Kazmi, 1965, page 8 and plate 1). In many areas, younger, coarse-grained alluvium overlies the older alluvium on the alluvial slopes at the side of the valley.

The younger alluvium on the flat areas and gentle slopes of the valley floor is more well-sorted and generally finer-grained than the alluvium that occurs on the alluvial slopes on the sides of the valley. This alluvium has two different depositional environments, and thus two different compositional types, as follows: (1) stream deposits, which generally tend to be composed of sand, silt, and some clay, and are relatively well sorted by the moving water that deposited them; and (2) lake deposits, consisting mostly of clay and silt, deposited during the Pleistocene epoch.

Pleistocene lake deposits are reported to have covered about 300 square miles of the valley floor of Spring Valley, and are reportedly 200-300 feet thick (Rush and Kazmi, 1965, page 9). These deposits are probably of very low permeability. Beneath the lake deposits, relatively well sorted deposits of sand and gravel have been noted, which probably could yield large quantities of water to wells.

## HYDROLOGY

### Surface water

Precipitation on the valley floor of Spring Valley averages approximately 4-8 inches per year. On the alluvial slopes at the sides of the valley, precipitation averages about 8-12 inches per year. In the mountains bordering the valley, annual precipitation is roughly 20 inches and probably more in the highest altitude locations.

The surface-water resources of the major stream drainages that drain Great Basin National Park, flowing both westward to Spring Valley and eastward to Snake Valley, are described in detail by Elliott and others (2006, pages 7-27). On the west side of Spring Valley, draining the Schell Creek Range, the largest stream is Cleve Creek, which had an annual mean discharge of about 8.7 cfs during 1960-1964 (Rush and Kazmi, 1965, page 13. table 3). Miscellaneous streamflow measurements of the 13 major streams that drain into Spring Valley, conducted by the USGS in summer 1964, yielded a total streamflow of about 50 cfs, which equals about 36,000 acre-feet per year (afy) (Rush and Kazmi, 1965, pages 14-15 and table 4).

Average total runoff into Spring Valley was estimated to be about 90,000 afy, which equals about 125 cfs (Rush and Kazmi, 1965, pages 14-14a and table 5). Rush and Kazmi (1965) further estimated that about 80% of this runoff occurs on the western side of the valley, with over 60% of the total coming from the central Schell Creek Range. Conversely, only about 3% of the total was estimated to runoff the southern Snake Range.

Ground water

*Ground-water recharge:* In the Great Basin Regional Aquifer System, recharge to the ground-water aquifers occurs principally in the mountainous areas in the east-central part of the State of Nevada (Figure 4). Precipitation, much of it snowfall: (1) infiltrates directly into exposed carbonate rocks; and (2) runs off the mountain slopes and infiltrates into permeable basin-fill sediments at the valley margins.

In Spring Valley, the same recharge mechanisms apply. Most or all of the ground-water recharge to the basin-fill of Spring Valley probably comes from precipitation within the basin, and recharges the basin-fill aquifer by the second mechanism described above. Rush and Kazmi (1965, pages 20-21 and table 6) used the Maxey-Eakin method to estimate ground-water recharge to Spring Valley as 73,000 afy.

*Ground-water movement:* In the Great Basin Regional Aquifer System, ground-water movement occurs in all directions, emanating principally from the main recharge area in the east-central part of Nevada, as evidenced from contours of regional ground-water flow potential (Figure 5).

The patterns of ground-water movement in the Great Basin are generally of two types. Ground water in basin-fill aquifers, which are the uppermost aquifer, moves generally in response to local topography. In topographically closed basins such as Spring Valley, ground-water movement is mostly radially inward. Ground-water movement in the fractured carbonate-rock aquifer moves in response to regional topography. As discussed above, regional topography in the area of Spring Valley slopes generally downward to the northeast, toward the Great Salt Lake Desert. Therefore, regional, inter-basin ground-water movement also is generally toward the northeast to the Great Salt Lake desert. This flow system is called the Great Salt Lake Desert Ground-Water Flow System (Figures 7, 8, and 9).

In Spring Valley, ground-water movement in the basin-fill deposits is toward the two topographically low areas of the valley, as indicated by the closed contours on the water-level contour map shown as Figure 18. There is some evidence that there may be a low-permeability hydrogeologic unit, probably of volcanic lithology, present in mid-Spring Valley, at the approximate location of the water-level saddle there, near the location of U.S. highway 6 and 50 (Alan Welch, USGS, verbal communication, May 23, 2006). Indeed, Spring Valley might really be two separate basins hydrologically, at least as far as the basin-fill aquifer is concerned. There is a great deal more uncertainty regarding ground-water movement in the carbonate-rock aquifer in the Spring Valley area, due to paucity of carbonate-rock wells in the area. This is reflected in the potentiometric-surface map of Spring Valley and vicinity (Figure 19). The potentiometric-surface contours shown on Figure 19 indicate that there is the potential for ground-water movement from the southern end of Spring Valley toward Snake Valley, where there are carbonate rocks present, through which ground-water flow likely could occur. In southern Spring Valley, the potentiometric surface of the carbonate-rock aquifer is about 5800 feet altitude; in southern Snake Valley, it is about 5600 feet altitude. This conceptualization is supported by the information displayed on Figure 20, regarding interbasin ground-water movement in the consolidated rocks in this area.

Rush and Kazmi (1965, pages 18-20 and Figure 5) show well and water-level data from the basin-fill aquifer in southern Spring and Snake valleys that supports the idea of interbasin flow in this area, and indicates that the basin-fill and carbonate-rock aquifers likely behave as one aquifer system in this area. Rush and Kazmi's figure 5 (reproduced in this report as Figure 21) and plate 1 (included, with markings, in this report as Figure 22) show the location of the existing ground-water divide for ground-water movement between Spring and Snake valleys. As drawn on Figure 22 (from information contained in Rush and Kazmi, 1965, page 20), the divide is in southern Spring Valley, just south of Baking Powder Flat.

*Ground-water discharge:* In the Great Basin, ground-water discharge occurs principally to large regional springs on valley margins and to areas of evapotranspiration in valley bottoms. As shown on Figures 6 and 10, the principal discharge areas in the Great Salt Lake Desert Flow System are: (1) locally to springs and seeps at the mountain/valley interface (at many locations); and (2) regionally to the Great Salt Lake desert (evaporation from the salt playa) and to discharge at regional large-volume springs such as Fish Springs, Utah.

In Spring Valley, ground-water discharge occurs to evapotranspiration (ET), to springs, and to interbasin ground-water outflow. ET includes two principal processes: (1) evaporation from the soil zone; and (2) transpiration from phreatophytic plants. The total ground-water ET in Spring Valley was estimated by Rush and Kazmi (1965, page 23, table 7) to be about 68,000 afy. Nichols (2000, page C34) estimated the total ground-water ET in Spring Valley to be about 90,000 afy. The principal areas of springs in Spring Valley are along the mountain/valley interface on the sides of the valley, especially adjacent to the two highest mountains ranges that border Spring Valley: the central Schell Creek Range on the west side of the valley and the southern Snake Range on the southern part of the east side of the valley. Springflow is not tabulated in addition to ground-water ET discharge when totaling ground-water discharge from the valley, because the outflow from springs ultimately leaves the basin as ET. Interbasin ground-water outflow from Spring Valley to Snake Valley around the southern end of the Snake Range has been estimated by Rush and Kazmi (1965, page 24) to be about 4,000 afy. Nichols (2000, page C34) stated that the estimate by Rush and Kazmi (1965) "…can be increased easily by a factor of two or three to an estimated 8,000 to 12,000 acre-ft/yr", due to assuming a more representative value for transmissivity in the calculation.

*Water Budget:* Conceptually, the annual water budget of Spring Valley is delineated by a flow chart shown in Rush and Kazmi (1965, page 26a, figure 6). Precipitation in the mountains that border Spring Valley flows toward the valley; total runoff is estimated to be approximately 90,000 afy. Some of this streamflow infiltrates into the basin-fill aquifer and some of it flows out on top of the lake deposits of clay and silt in the valley bottom and ET's off the playas. Ground-water discharge has been estimated to range from about 68,000 afy (Rush and Kazmi, 1965) to about 90,000 afy (Nichols, 2000). In addition, ground-water flow out of the basin has been estimated to range from about 4,000 afy (Rush and Kazmi, 1965) to up to 12,000 afy (Nichols, 2000). Brothers and others (1994, page 28-29 and page 55) incorporated the 4,000 afy estimate in their stead-state ground-water modeling work in Spring Valley.

## WATER AVAILABLE FOR APPROPRIATION

### Perennial Yield

The annual ground-water budget is approximately 68,000 to 90,000 afy. If large-scale ground-water pumping were to occur, then perhaps some of the surface water (streams) that flow from the mountains across the alluvial slopes out onto the valley might be able to be captured and induced to recharge the aquifer. This could increase the ground-water budget by the amount captured, because the surface water would have flowed out onto the playas and ET'd off to the atmosphere. Once the surface water has flowed out onto the 200-300-feet-thick playa sediments of clay and silt, it is doubtful that this water could be captured by pumping from the more permeable zones deeper in the basin-fill aquifer.

### Existing Water Rights and Pending Water-Right Applications

A tabulation of all existing water rights and pending water-right applications in Spring and Snake valleys are contained in Appendix C herein. Table 1 lists a summary of all existing water rights and pending water-right applications filed prior to the subject applications by LVVWD.

### Water Available for Appropriation

Although Rush and Kazmi (1965, page 26) estimate that roughly one-third of the estimated 90,000 afy of surface-water runoff at the mountain/valley interface might be able to be captured by an efficient ground-water pumping scheme, there are over 100,000 afy of existing surface-water rights already permitted in Spring Valley (Table 1). In addition, there are approximately 33,000 afy of existing water rights and pending water-right applications filed prior to the subject applications by LVVWD for ground water and about 21,000 afy for springs.

Thus, if the lower limit of annual ground-water budget of 68,000 afy is used, and the "existing water rights and prior pending applications" for ground water and springs of 54,000 afy (i.e. 33,000 + 21,000 afy) are subtracted, then a lower limit for the amount of annual water budget that might be "available" would be 14,000 afy. It is acknowledged herein that there is a great deal of uncertainty in all the aforementioned estimates, and that larger water budget estimates than this lower limit have been made.

Even though it has just been stated that 14,000 afy might be "available" for appropriation, that does not mean that ground-water pumping of 14,000 afy (or any amount, for that matter) would have zero adverse effect. As stated by C.V. Theis (1940): "All water discharged from wells is balanced by a loss of water somewhere." Pumping of even 14,000 afy would deplete the water resources and water-dependent resources of Spring Valley by 14,000 afy. The source of any water pumped would either be ground-water storage, induced increased ground-water recharge, or induced decreased ground-water discharge. The last two items have been termed "capture" by Bredehoeft (1997). That is, even if 14,000 afy of the renewable water resources of Spring Valley is deemed "available" (i.e. having no existing senior water rights), it does not mean that it won't be depleted eventually by large-scale, long-term ground-water pumping. Likely, it will. Stated another way, perennial yield does not equal perennial discharge. This is what Sophocleous (1997), Bredehoeft (1997, 2002, and 2004), and Sophocleous and Devlin (2004) discuss as the fallacy of "safe yield" or "sustainable yield," and what Bredehoeft (1997, 2002) has termed "the water-budget myth."

## POTENTIAL FOR DEPLETION OF EXISTING WATER RESOURCES

The USGS (Elliott and others, 2006) has described and delineated surface-water resources in and adjacent to Great Basin National Park that would likely be susceptible to capture by ground-water withdrawals in Spring and Snake valleys. A map of these "susceptible" areas is included herein as Figure 23.

### Spring Valley

The potential for capture of springflow from along the spring-line on the west side of the southern Snake Range (on the east side of Spring Valley), adjacent to the park (on BLM and/or private land) has been identified (Elliott and others, 2006). Also, it is reasonable to assume that the spring-line on the west side of Spring Valley at the base of the central Schell Creek Range might be similarly susceptible to long-term ground-water pumping in the valley. The magnitude and timing of any such depletion of springflow would depend on the location, rate, and duration of the ground-water pumping within the valley.

### Snake Valley

In addition, surface-water resources in Snake Valley might be susceptible to long-term ground-water pumping from Spring Valley, due to the apparent hydrologic connection of the two valleys through permeable rocks and/or sediments around the southern end of the Snake Range. Large-scale, long-term pumping in Spring Valley, especially in the southern part of the valley, could eventually capture the interbasin ground-water discharge that is currently moving out of Spring Valley and into Snake Valley, cause it to cease entirely, and if pumping continues at a large enough rate and long enough, cause ground water in Snake Valley to drain back into Spring Valley. According to the USGS, resources in Snake Valley that eventually are likely susceptible to depletion due to ground-water pumping include Big Springs, Big Springs Creek, Spring Creek Spring (near the fish hatchery adjacent to Snake Creek), Rowland Spring, and Cave Spring, and some reaches of Snake Creek, Baker Creek, Lehman Creek, and Strawberry Creek (Figure 23). The closest of these resources to the subject proposed pumping in Spring Valley are Big Springs and Big Springs Creek. Based on field reconnaissance by the author, it appears that Big Springs and Big Springs Creek are likely hydrologically connected with both the basin-fill aquifer and the carbonate-rock aquifer in this area.

Distal Resources

Distal flow-system resources in the Great Salt Lake Desert Regional Ground-Water Flow System that eventually are likely susceptible to large-scale, long-term ground-water pumping include Fish Springs in Utah (Figure 15) and the Great Salt Lake desert saltpan. However, due to the great distances between the proposed pumping locations in Spring Valley and these resources in Utah, and other closer surface-water features that most likely would be captured first, depletion of these distal resources might not occur for a very long time.

In summary, the surface-water flows that are the most likely to be the first to be captured by ground-water pumping in southern Spring Valley are the spring-line along the southern end of the east side of Spring Valley (near Minerva), and Big Springs and Big Springs Creek in southern Snake Valley. The magnitude and timing of any such capture and thus depletion of springflow or streamflow would depend on the location, rate, and duration of the ground-water pumping within Spring Valley, and whether the pumping was from the basin-fill aquifer or the carbonate-rock aquifer.

Quantitative Analyses

Preliminary analyses of the magnitude and timing of any capture and thus depletion of surface-water resources has been conducted by Congdon (2006), based on the USGS screening-level numerical ground-water flow model of Schaefer and Harrill (1995). Regarding the proposed ground-water pumping associated with the subject applications in Spring Valley, Congdon (2006) concludes that: "Water table levels in the alluvial aquifer could decline by 200 feet or more following 200 years of pumping at the proposed rates." It is the professional experience of the author that most large-volume springs in the carbonate-rock province are supported by on the order-of-magnitude of 10 feet of hydraulic head. Drawdowns in the aquifer of greater than 10 feet magnitude would likely cause complete cessation of the flow of many, if not most, large-volume springs in this area.

A case study was conducted by the U.S. Bureau of Land Management (Summers, 2001) regarding the capture and subsequent cessation of springflow at Needle Point Spring in southern Snake Valley due to ground-water pumping for irrigation nearby. The study and report by Summers (2001) shows that springflow depletion at Needle Point Spring is well correlated, both in timing and in magnitude, with the ground-water pumping. The report also showed that once the spring had stopped flowing, even after pumping ceased periodically (i.e. for the winter season), the springflow did not return. This information provides further evidence that once capture and depletion of springflow or streamflow occurs, the process is likely not easily reversible.

## CUMULATIVE EFFECTS

The USGS (Schaefer and Harrill, 1995) published an evaluation of the potential effects (i.e. drawdown in aquifers) due to ground-water pumping in 17 hydrographic areas within the carbonate-rock aquifer system, using a 2-layer, numerical ground-water flow model. Schaefer and Harrill (1995) simulated ground-water pumping totaling 180,800 afy, but the simulations included pumping of only 50,000 afy from Spring Valley and 25,000 afy from Snake Valley (the subject applications are for 91,200 afy in Spring Valley and similar pending applications by LVVWD in Snake Valley total 50,000 afy).

The results of the model simulations by Schaefer and Harrill (1995) indicated that: "…the proposed pumping would cause water-level declines in many ground-water basins, decreased flow at several regional springs, and decreased discharge by evapotranspiration from the basins." It is important in the judgment of this author, therefore, to evaluate the subject applications in the larger context of the large volume of existing water rights and thus potential ground-water withdrawals in adjacent basins, and in all other basins within the major regional ground-water flow systems of the carbonate-rock province.

## NEEDS FOR ADDITIONAL STUDIES

The reconnaissance report of Rush and Kazmi (1965) was an important preliminary work intended: "…to provide water-resource information to the public and to assist the State Engineer in the administration of the water law by making preliminary estimates of the average annual recharge to, the discharge from, and the perennial yield of the ground water in the valleys and basins" (Rush and Kazmi, 1965, page 2).

This work was conducted and published in the 1960's, and techniques of water resources investigations have improved greatly since then. Updated, more refined estimates of the renewable resources of Spring and Snake valleys are needed before additional water rights are allocated. Needed work includes: (1) an evaluation of the geologic framework; (2) refined estimates of recharge and discharge, including updated information regarding ground-water – surface-water interactions; (3) an evaluation of ground-water movement, both in magnitude and directions; (4) updated information regarding water use in Spring and Snake valleys; and (5) and evaluation of water quality, to help in understanding the hydrologic system, ground-water flow paths, etc.

ACKNOWLEDGMENTS

Most of the figures in this report were derived from figures in published USGS reports. Mohamed Aldhamari, National Park Service Research Associate, compiled the existing-water-rights-and-pending-water-right-applications information included in Appendix C.

## SUMMARY AND CONCLUSIONS

The purpose of this report is to describe the hydrology of Spring Valley, east-central Nevada, and to evaluate the potential for adverse effects to the water resources of Great Basin National Park and surrounding lands due to proposed ground-water pumping associated with the Las Vegas Valley Water District's 19 water-right applications for up to 91,200 acre-feet per year in Spring Valley, filed in 1989. This report is preliminary in scope, based on existing information and the author's professional experience and judgment.

Spring Valley is a topographically closed basin, with a semi-arid valley bottom at about 5,500 feet altitude and surrounded by subhumid to humid mountains up to 13,000 feet altitude. Precipitation, falling mostly on the mountains, produces streams that flow inward off the mountain slopes to the valley floor, and infiltration into basin-fill and carbonate-rock aquifers. Basin-fill sediments consist of: (1) relatively permeable coarse-grained deposits of sand, silt, and gravel deposited by streams, located on the valley sides and at depth; and (2) relatively impervious fine-grained deposits of clay and silt deposited by Pleistocene lakes, located in the center of the valley to depth 200-300 feet.

Average annual runoff in Spring Valley is about 90,000 acre-feet per year (afy). Ground-water recharge has been estimated by the Maxey-Eakin method to be approximately 73,000 afy. Ground-water movement is predominantly toward two playas on the valley floor, one in the south and one in the north, indicating that Spring Valley might actually be two separate hydrologic basins. Ground-water discharge is predominantly to evaptranspiration (ET), and has been estimated to range from about 68,000 to 90,000 afy. In addition, ground-water outflow from Spring Valley to Snake Valley has been estimated to range from about 4,000 to 12,000 afy.

The annual ground-water budget is approximately 68,000 to 90,000 afy. Large-scale ground-water pumping might induce some increased ground-water recharge from the streams that flow across the alluvial slopes at the mountain/valley margin. This could increase the annual ground-water budget by the amount of streamflow captured, because otherwise the surface water would have flowed out onto the playas and evaporated or transpired to the atmosphere. Although it has been estimated that roughly one-third of the estimated 90,000 afy of surface-water runoff at the mountain/valley interface might be able to be captured by an efficient ground-water pumping scheme, there are over 100,000 afy of existing surface-water rights already permitted in Spring Valley, so this water is not available to the applicants. In addition, there are approximately 33,000 afy of existing water rights and pending water-right applications filed prior to the subject applications by LVVWD for ground water and about 21,000 afy for springs. Thus, a lower limit for the amount of annual water budget that might be "available" for appropriation would be about 14,000 afy (68,000 – 54,000 afy). There is a great deal of uncertainty in all the aforementioned estimates.

Even though 14,000 afy of ground water might be "available" for appropriation, that does not mean that ground-water pumping would have no adverse effects. The source of any water pumped would either be from ground-water storage, induced increased ground-water recharge, or induced decreased ground-water discharge (the last two items have been termed "capture"). That is, even if 14,000 afy of the renewable water resources of Spring Valley are deemed "available", it does not mean that it won't be captured and eventually depleted by large-scale, long-term ground-water pumping. Perennial yield does not equal perennial discharge. This concept has been termed "the water-budget myth." The Las Vegas Valley Water District's applications are for ground-water withdrawals for up to 91,200 acre-feet per year, allowed every year, with no specified termination date. Eventually, if pumping continues long enough, it is reasonable to assume that capture and depletion of existing surface-water resources will occur somewhere. The most likely areas where existing surface-water resources might eventually be captured by large-scale ground-water pumping in southern Spring Valley are along a spring-line on the west side of the southern Snake Range (on the east side of Spring Valley) and at Big Springs and along Big Springs Creek in southern Snake Valley.

Preliminary, screening-level numerical modeling analysis indicates the possibility of water-level drawdown in places of roughly 200 feet after 200 years due to the proposed ground-water pumping. Needle Point Spring in southern Snake Valley, a perennial spring, dried up in 2001 after ground-water pumping for irrigation nearby. Preliminary predictive numerical modeling indicates that the subject applications for ground-water withdrawals in Spring Valley need to be evaluated in the larger context of all existing water rights and pending applications in all basins within the major regional ground-water flow systems of Nevada and adjacent states.

Many existing water rights and resources exist in Spring Valley. Updated, more refined estimates of the renewable water resources of Spring and Snake valleys and the potential effects of large-scale, long-term ground-water pumping are needed before additional water rights are allocated.

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