Spring Valley Hydrogeologic Rebuttal Report in Response to Myers (2011a)

PRESENTATION TO THE OFFICE OF THE NEVADA STATE ENGINEER

Prepared by

SOUTHERN NEVADA WATER AUTHORITY

August 2011

Suggested citation:
Burns, A.G., Drici, W., Dixon, G.L., and Rowley, P.D., 2011, Spring valley hydrogeologic rebuttal report in response to Myers (2011a): Presentation to the Office of the Nevada State Engineer: Southern Nevada Water Authority, Las Vegas, Nevada.

Spring Valley Hydrogeologic Rebuttal Report in Response to Myers (2011a)

Submitted to:
Jason King, P.E., State Engineer
State of Nevada
Department of Conservation & Natural Resources
Division of Water Resources
901 S. Stewart Street, Suite 2002
Carson City, Nevada 89701

Pertaining to:
Groundwater Applications 54003 through 54021 in
Spring Valley
and
Groundwater Applications 53987 through 53992 in
Cave, Dry Lake, and Delamar Valleys

August 2011

Prepared by:
Southern Nevada Water Authority
Water Resources Division
P.O. Box 99956
Las Vegas, Nevada 89193-9956

Andrew G. Burns — 8·22·2011
Andrew G. Burns, Water Resources Division Manager — Date

Warda Drici — 08/23/2011
Warda Drici, Hydrologist — Date

Signatures continue on next page
Gary L. Dixon, Principal Geologist — Date

Signatures continue on next page
Peter D. Rowley, Geologist — Date

Spring Valley Hydrogeologic Rebuttal Report in Response to Myers (2011a)

Submitted to:
Jason King, P.E., State Engineer
State of Nevada
Department of Conservation & Natural Resources
Division of Water Resources
901 S. Stewart Street, Suite 2002
Carson City, Nevada 89701

Pertaining to:
Groundwater Applications 54003 through 54021 in
Spring Valley
and
Groundwater Applications 53987 through 53992 in
Cave, Dry Lake, and Delamar Valleys

August 2011

Prepared by:
Southern Nevada Water Authority
Water Resources Division
P.O. Box 99956
Las Vegas, Nevada 89193-9956

Signatures appear on previous page	
Andrew G. Burns, Water Resources Division Manager	Date
Signatures appear on previous page	
Warda Drici, Hydrologist	Date
Gary L. Dixon	Aug. 22, 2011
Gary L. Dixon, Principal Geologist	Date
Peter D. Rowley	Aug 24, 2011
Peter D. Rowley, Geologist	Date

Myers (2011a) - Hydrogeology of Spring Valley and Surrounding Areas, Part A

Myers (2011a) is entitled *"Hydrogeology of Spring Valley and Surrounding Areas, Part A: Conceptual Flow Model"*, and while not explicitly stated, the apparent purpose of the report is to present a conceptual model of the groundwater systems underlying Spring, Snake, Tippett, Hamlin, Pleasant, and Deep Creek valleys in eastern Nevada and western Utah. Myers (2011a) recites the findings of various previous investigations, but fails to perform any independent assessment as to the validity of their results. In several instances, Myers (2011a) criticizes the results of a study, yet seemingly adopts them for his analyses (e.g., PRISM, BARCASS recharge). Myers (2011a) discussions of hydrogeology and routes of groundwater flow are largely erroneous because they were taken almost verbatim, with no visible objections to, the reports of Elliot et al. (2006) and Welch et al. (2007) that were particularly flawed in their hydrogeology, as pointed out by Rowley et al. (2011).

Frequently, Myers (2011a) offers statements which are presented as authoritative scientific conclusions when, in fact, the statements are not supported by the available data, independent analysis, or previous investigations. Where authoritative published reports contain conclusions different from his, Myers (2011a) refuses to cite them. Instead, Myers (2011a) relies on a brief, simplistic, non-factual explanation of the hydrogeology and hydrology of Snake Valley and parts of Spring Valley rather than acknowledging five peer-reviewed articles (Acheampong et al., 2009; Kistinger et al., 2009; Mankinen and Mckee, 2009; McPhee et al., 2009; and Rowley et al., 2009) and a geologic map (i.e., a digital 1:250,000-scale map in Rowley et al., 2009 that included nearly the entire area of Figure 9 in Myers, 2011a) published in Tripp et al. (2009). For the hydrogeology of the rest of the area in his report, Myers (2011a) also fails to cite the text and many maps of Dixon et al. (2007). The most noteworthy aspects of Myers (2011a) are that conclusions are not backed by data or scientific reasoning, and that data and results were chosen to support predetermined conclusions. Several of these are described in this report and the rebuttal report to Myers (2011b) prepared by D'Agnese (2011).

Myers (2011a) fails to define or explain the conceptual model. The hydrogeologic information presented in the report is inadequate for the purpose of describing the hydrogeologic framework, let alone developing a 3-dimensional (3D) model of groundwater flow. No hydrogeologic unit-extent or structure-contour maps were constructed; data on faults are non-existent; no cross-sections were constructed; and no basin-specific evaluation of aquifer properties was performed. Without this information, the 3D hydrogeologic framework cannot adequately be described. Any framework description without this information is conjecture, and any numerical model without this foundation has no basis in reality, is unconstrained, and cannot be verified as noted in D'Agnese (2011).

The groundwater budget seemingly adopted in Myers (2011a) is ill-defined at best and, therefore, an evaluation of the budget components is nearly impossible. Myers (2011a) mostly recites the work of previous investigations, but fails to quantify with certainty which budget components were adopted. Only the recharge was quantified, assuming Myers (2011a) used the average of selected estimates presented in Table 2 of the report. No quantification of the groundwater ET was provided.

Interbasin-flow estimates of previous investigations were recited but largely called into question by qualifying statements excerpted from the original reports. Myers (2011a) presents no original data, data analysis, or assessment of the recited budget components to verify their adequacy for the intended purpose, nor does Myers (2011a) provide a clear definition/quantification of the budget components. Therefore, the conclusions stated in Myers (2011a) should be rejected because the groundwater budget is not defined and cannot be evaluated.

Myers (2011a) suggests that the information presented in the report is an accurate description of the hydrogeology, water-balance fluxes, and springs and streams for Spring, Snake and surrounding valleys, and that the report provides an accurate conceptualization for developing a numerical model of groundwater flow. These are extraordinary statements given the incomplete explanation of the conceptual model and the missing budget components. Several egregious flaws in the Myers (2011a) "conceptual model" are discussed in the following sections.

1. *"The valleys are part of the Basin and Range province, with thrust faulting forming the upthrust mountains and downthrust valleys."* (p. 1, last paragraph)

   This statement is fundamentally wrong. Any thrusts predate the Basin and Range province; instead, high-angle normal faults raise the mountains and drop the valleys (Rowley et al., 2011). This is an important mistake because high-angle normal faults can be more effective conduits and/or barriers to groundwater flow, and misidentifying faults could lead Myers (2011a) to suggest invalid groundwater flow paths.

2. *"The shallow well contours are higher than the contours for other well levels because the mountain-front recharge causes a downward vertical gradient. The shallow well water level shows a nadir at about 5600 ft amsl in the northern third. The intermediate and deep well contours show a gently undulating water table around 5800 ft amsl, with a distinct slope to the southeast in the far south of the valley and to the northeast toward Tippet Valley (Figures 4 and 5). The apparent gradient suggests flow paths between the northern half of Spring and Snake Valley and from west to east through the Limestone Hills area. There is also a gradient from northern Spring to Tippett Valley, shown on the shallow wells contour map (Figure 3)."* (p. 5, middle paragraph)

   The language is confusing and unclear; mountain-front recharge creates a hydraulic potential between the recharge areas within the mountain blocks and alluvial fans, and the discharge area on the valley floor. Within the groundwater discharge area, there is an upward vertical gradient caused by this hydraulic potential. This is evidenced by the numerous flowing wells and springs located in the discharge area on the valley floor (Burns and Drici, 2011; Plate 1).

   The interpreted hydraulic gradients are also flawed. References to Figures 3 through 5 apparently serve as the basis for Myers (2011a) interpretation of a hydraulic gradient from northern Spring Valley to Tippett Valley. The contours presented on Figure 3 do not support this interpretation, but support a hydraulic gradient in the opposite direction, from north to south. The contours presented on Figure 4 are derived from only two wells, one of which is plotted in the wrong location (see Figure 1A). This well, 393442114231801 (3934421142318 in Myers, 2011a), is part of the SNWA groundwater monitoring network in Spring Valley and

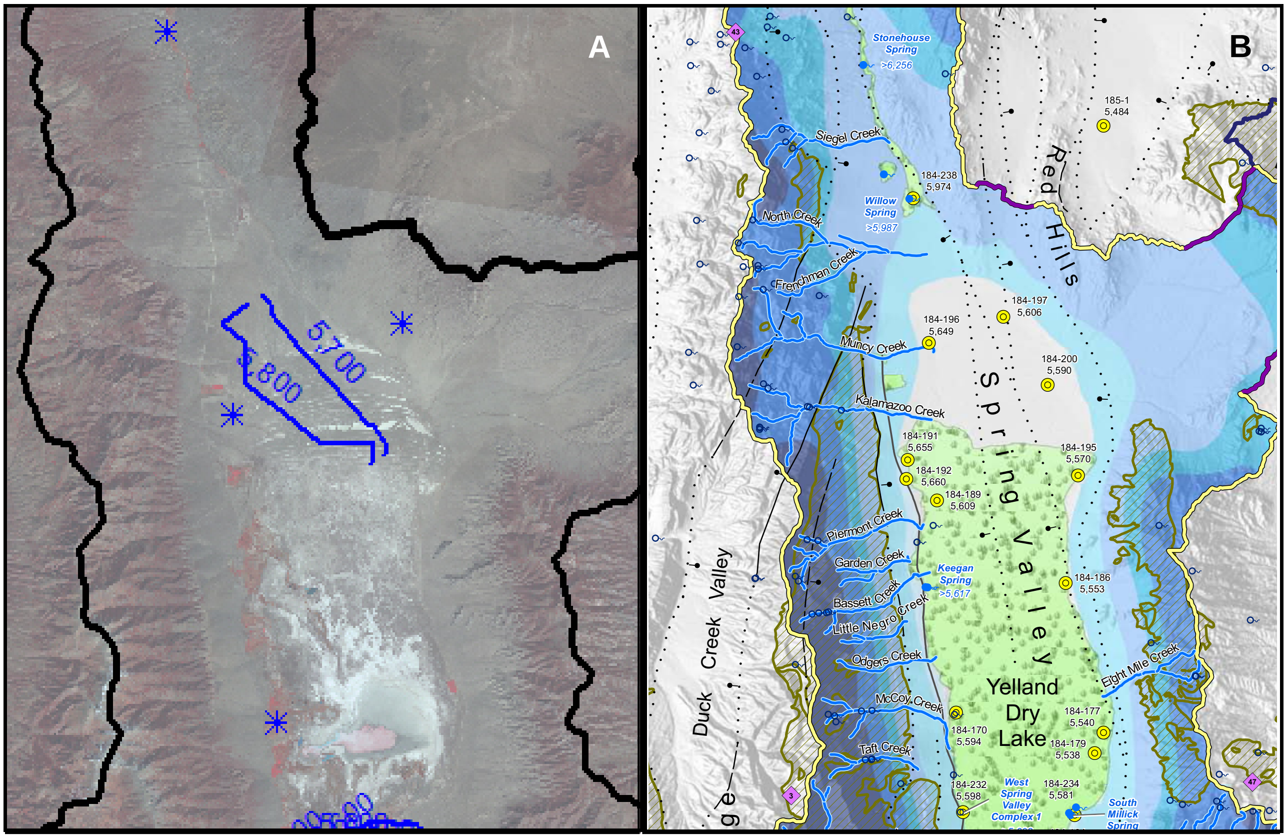

Figure 1
Comparison of Figure 4 from Myers (2011a) and Plate 1 from Burns and Drici (2011)

is actually located approximately four miles to the south (Burns and Drici, 2011, Plate 1, Map ID 184-200). The existence of the second well cannot be verified as it is not documented in Myers (2011a) or in Appendix A of Myers (2011b). The data point appears to be erroneous. Despite the apparent erroneous data, if the first well is plotted in the correct location (see Figure 1B), the hydraulic gradient is not to Tippett Valley as Myers (2011a) concludes, but in fact, to the south and to the groundwater discharge area located along the central axis of the valley (Burns and Drici, 2011, Plate 1). No evidence (data or interpreted contours) is found on Figures 3 through 5 supporting Myers (2011a) suggestion that there is an "*…apparent gradient…*" and flow path "*…between the northern half of Spring and Snake Valley…*" Myers (2011a) does not identify the location of this so-called flow path to Snake Valley because no such flow path is supported by his contour maps. This conclusion is baseless. In fact, the geologic and hydrologic features that control groundwater flow in this area do not permit such a flow path. Cambrian-Precambrian siliciclastic rocks extend along the entire western range-front of the northern Snake Range, and the range is underlain by Tertiary-Jurassic intrusive rocks (Rowley et al., 2011, Plate 6). These rocks are confining rocks of very low permeability, and prohibit groundwater flow from Spring Valley to Snake Valley. Further, the hydraulic heads within the groundwater recharge areas within the mountain block and alluvial fans are higher than those on the valley floor. The hydraulic potential created by the difference in hydraulic heads causes groundwater to flow from the recharge areas at higher elevations to the discharge areas on the valley floor. The groundwater flow suggested by Myers (2011a) would literally be uphill, against the hydraulic gradient, through impermeable rocks.

3. *"These observed water levels demonstrate a gradient west to east at depth that is similar to the gradient in the carbonate aquifer found in BARCAS (Figure 6). Carbonate aquifer groundwater contours support the concept of a deep aquifer gradient from Spring towards Snake Valley (Figure 6), with an east to west gradient supporting flow from North Spring to Tippett Valley, Tippett to Deep Creek Valley, and Spring to Snake Valley."* (p. 5, last paragraph)

   These contour maps are not similar. The BARCASS contour map is a regional interpretation of groundwater potentials in the carbonate aquifer using 500-ft contour intervals. The Myers (2011a) maps reflect an interpretation of composite water-levels in wells arbitrarily classified by well-completion depths, using 100-ft contour intervals. The only apparent similarity is in the interpretations, each of which excluded consideration of geologic and hydrologic controls that affect the groundwater potentials. These include the presence of confining units and fault structures at the water table, recharge areas within the mountain block, and discharge areas on the valley floor. These controls affect the direction and movement of groundwater. If flow lines were drawn on the BARCASS map, groundwater would flow through the entirety of the Snake Range, despite the fact that the Snake Range, which includes the 2nd highest peak in Nevada, is underlain by siliciclastic and intrusive confining units and is an area of significant groundwater recharge due to the high rates of precipitation (Burns and Drici, 2011, Plate 1; Rowley et al., 2011, Plate 6).

   The BARCASS map offers little value, if any, in describing the dynamics of groundwater flow in Spring Valley. Myers (2011a) offers no other supporting data or evidence for his postulated flow paths through the Snake Range. In fact, Figures 3 through 5 of Myers (2011a) indicate the hydraulic gradient is to the groundwater discharge areas of Spring Valley. Only Figure 5 of Myers (2011a) supports a hydraulic gradient from Spring Valley to an adjacent basin, Hamlin Valley in this instance. However, this figure also defines a groundwater divide between the two 5,800 ft contours at the very southern extent of the map. This divide is consistent with the groundwater divide described in Burns and Drici (2011, Figure 8-1) and Rush and Kazmi (1965), and coincident with the gravity high presented in Mankinen and McKee (2011) and Rowley et al. (2011), and the sub-basin boundary delineated on the BARCASS potentiometric map (Wilson, 2007). Because of this divide, the source of potential groundwater flow to Hamlin Valley is limited to the small area of southern Spring Valley.

4. *"Now, it is accepted, and utilized in this study, that interbasin flow leaves Steptoe Valley and enters Spring Valley either directly or by passing through Lake Valley (Welch et al., 2008)."* (p.12, last sentence of 1st paragraph)

   Myers (2011a) provides no references to support the claim that the postulated BARCASS flow path is *"accepted."* Even the BARCASS authors recognized that the purpose for creating such a flow path was to rid excess water in Steptoe Valley that was derived from the imbalance of their estimated groundwater budget (i.e., excessive recharge). Welch et al. (2007) state the following:

"The surplus of water in Steptoe Valley is the source of inter-basin ground-water flow to multiple valleys—to the north where ground water exits the study area, to the southeast toward Lake and southern Spring Valley, and to the west toward Jakes and northern White River Valleys. The latter two flow paths from southern and western Steptoe Valley have not been proposed in previous investigations."

Not only has this flow path never been postulated, no data were collected as part of the BARCASS to support or validate such a path. Myers (2011a) does not provide any credible reference that "*accepts*" this flow path. The hydrogeologic evidence against these two flow paths is provided in Rowley et al. (2011, Sections 6.2.1.3 and 6.2.1.4).

5. Myers (2011a, p. 14, Figure 9) and Myers (2011b, p.10)

The map presented in Figure 9 of Myers (2011a) is not a professional product and is largely illegible. The bar scale (at least 1:1,000,000 scale, perhaps 1:2,000,000) is in the middle of the geology of Utah. There are no faults on the map, the extent of which is entirely within the Basin and Range which was created by extensional faulting. Only Spring and Snake valleys are identified, and no State or County boundaries are named; some hydrographic-area boundaries are shown but not identified. Rock units are largely illegible and so generalized that even a summary of the geology or hydrogeology, let alone their modeling, would seem to be impossible. Legend units are not arranged with respect to time or in any other logical order, and some, referred to as "marshland," "region," and "unclassified," are inappropriate for a hydrogeologic map and would seem to be impossible to model. At least one unit on the map is not given in the legend, and several units given by Sweetkind et al. (2007) are not on the map or legend, perhaps due to the overly-coarse scale.

"Faults were included in the model according their state geology mapping location (Part A)." Myers (2011b, p. 10)

In fact, no faults are shown on in any map provided in Part A. The only geologic map presented in Part A is Figure 9 (Myers, 2011a, p. 14), on a single 8×11" page. This map, which shows the hydrogeology cobbled and reduced from the obsolete 1:500,000-scale Nevada and Utah state geologic maps, has an unknown scale, presumably 1:1,000,000 to 1:2,000,000. The map provides no information on faults or calderas. No cross-sections are included, which would provide information on thickness of hydrogeologic units, their elevation above the surface and depth below the surface, and their amount of offset by faults.

6. "*Hydraulic conductivity also decreases with depth due to the compression caused by the overlying material. Durbin (2006) found the following relationship of K_z to K_o, where K_z is conductivity at depth z and K_o is conductivity at the surface:*

$$K_R = \frac{K_z}{K_o} = 10^{a_1 z + a_2 z^2}$$

Here, a_1 is -1x10-3 and a_2 is 2.5x10-7 with all units in feet. The relation obviously only applies to about 2,000 feet bgs because the ratio decreases from 1 to about 0.1 at that point after which it begins to increase (Figure 11)." (p. 15, last paragraph)

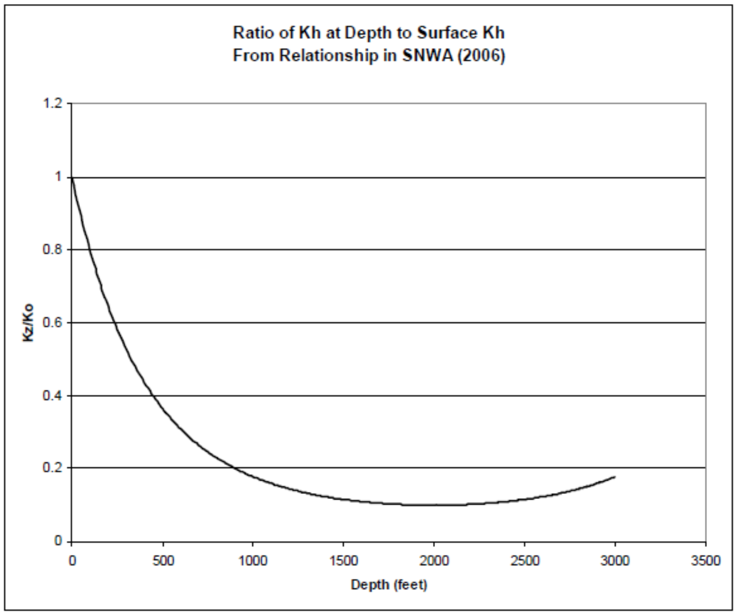

Figure 11: Variation of conductivity with depth for upper valley fill (Durbin, 2006).

Figure 11 of Myers (2011a) is wrong. Myers (2011a) specifies Durbin (2006) as the source, but Durbin (2006) does not include depths greater than 2,000 ft in the equation as depicted in Myers (2011a; Figure 11). In Durbin (2006), Kr (Ratio of Kh at Depth to Surface Kh) is constant for depths greater than 2,000 ft. Therefore, the equation is only valid for depths less than or equal to 2,000 ft. Durbin (2006) even stated that the minimum point for this relationship is at a depth of 2,000 ft with Kr = 0.1 at that depth (p. 4-10).

While it is likely that overburden pressure compacts and seals the voids spaces within basin-fill materials, it is beyond comprehension why Myers (2011a) would display a relationship in which the hydraulic conductivity of these materials would decrease with depth, and then suddenly increase at greater depths. The relationship presented in Figure 11 of Myers (2011a) is flawed, and its use in Myers (2011 b and c) and how it affects the results should be disclosed.

7. *"Basinwide recharge is the total recharge within a basin to the regional aquifer. Recharge to perched aquifers is not included unless a stream discharging from these aquifers recharges secondarily further downslope. Secondary recharge of streamflow percolating back into groundwater after having discharged into a stream also is not counted."* (p.17, 2nd paragraph)

   The purpose of the analysis should determine the scope of the recharge estimate. If the recharge estimate is for modeling the regional groundwater flow system, then this definition may be correct, yet too convoluted. However, if this estimate is for the purpose of assessing the available groundwater resources, then all recharge, even recharge to perched systems, if significant, should be included, as it is part of the perennial yield of the basin.

8. "*Outflow from a basin is groundwater evapotranspiration (GWET) which includes spring discharge and transpiration from the phreatophytes*." (p.17)

   Outflow from a basin also includes subsurface and surface flow across basin boundaries.

9. Myers (2011a, p.19, Table 2)
   The author provides a list of published recharge estimates for basins of interest and averages these values by basin. It is not clear until the reader gets to Part B (Myers, 2011b) that the author intends these average values to be part of the conceptual model.

   Table 2 lists literature recharge estimates for Spring Valley and adjacent valleys, but some published estimates were excluded, for example, estimates for Spring Valley reported by Epstein (2004) (66,402; 93,840; 92,965; 53,335; and 139,194 afy). The recharge estimates reported by Flint et al. (2004) for Snake, Spring, and Steptoe valleys (93,000, 67,000, and 62,000 afy) and those reported by Flint and Flint (2007) for the same valleys (111,000; 93,000; and 154,000 afy) are based on the same model, the Basin Characterization Model (BCM). However, Flint and Flint (2007) claimed that the latest numbers are based on updated data and a better spatial resolution. It would, therefore, be more reasonable to use the more recent estimates and not the old ones. By including the old, out-dated estimates, Myers (2011a) incorrectly provides them equal weight in the calculation of the average annual recharge rate.

   Using average basin recharge estimates from the literature, while adopting BARCASS boundary flow estimates (Part B, pg. 25, Table 4) is fundamentally wrong because the BARCASS boundary flow estimates are dependent on the BARCASS recharge estimates. BARCASS estimated both recharge and groundwater ET independently and calculated interbasin flow rates as the difference between the two (residuals). In their approach, ET estimates are the least uncertain and boundary flow estimates are the most uncertain. BARCASS considered their recharge estimates to be less uncertain than the boundary flow estimates because they used a soil mass-balance model whose components were supposedly calibrated to observed data. This means that if one accepts the BARCASS boundary flow estimates they must also accept both the BARCASS recharge and groundwater ET estimates. Therefore, Myers (2011a) should have selected the 93,000 afy recharge estimate from Flint and Flint (2007) rather than an average of selected recharge estimates from previous investigations.

10. Section entitled *"Interbasin Flow to and from the Valleys"* (p. 23-24)

Myers (2011a) does not present any original or independent analysis of the available data (hydrologic or geologic) to assess the potential for interbasin flow, and only describes interbasin flow estimates of BARCASS. Myers (2011a) does not provide any conclusions or opinions as to the validity of the postulated BARCASS flow paths, except to cite excerpts from Welch et al. (2007) that largely invalidate such flow paths. Regarding the BARCASS flow path from Steptoe Valley, to Lake Valley, to Spring Valley, to Hamlin Valley, and ultimately Snake Valley, Myers (2011a) states the following:

"Welch et al. (2008) estimated that recharge substantially exceed GW discharge within Steptoe Valley, so they estimated interbasin flow from Steptoe Valley to many adjacent valleys to balance the flows." Myers (2011a, p. 23)

"*Volcanic portions of the Fortification Range bound southwest Spring Valley and may impede flow between Spring and parts of Lake Valley. Northwest of the Fortification Range along Lake Valley summit, there is carbonate rock (UCU) through which the postulated interbasin flow would occur, but with a "thin Chainman shale" layer which may slow or prevent flow through that region (Welch et al, 2008)."* Myers (2011a, p. 23)

"Volcanic rock bounds the south end of Snake and Spring Valley; although not impermeable, groundwater flow would likely be limited to localized systems." Myers (2011a, p. 23)

"Prior to BARCAS, most studies had identified only small amounts of interbasin flow between these valleys; one estimate was 4,000 afy through the Limestone Hills region (Hood and Rush, 1965)." Myers (2011a, p. 24)

Despite these citations from Welch et al. (2007) regarding the BARCASS, Myers (2011a) apparently adopts the flow path and the extraordinary interbasin flow rate of 33,000 afy, even while recognizing that the sole reason for creating these flow paths was to provide a means to rid excess recharge in Steptoe Valley to resolve the imbalance in the BARCASS water budget. No analysis of the geologic and hydrologic features controlling groundwater flow in this area was performed, including recognition of the Indian Peak Caldera Complex forming the southern Fortification Range, north-south striking normal faults through which groundwater would have to flow under the Myers (2011a) theory, the occurrence of in-place recharge in the Fortification Range, and the groundwater divide in southern Spring Valley. These controls are described in greater detail in Rowley et al. (2011) and Burns and Drici (2011). Myers (2011a) finally concludes the following without performing a single evaluation of the hydrogeologic conditions along the flow path:

"Thus, interbasin flow discharging from Spring Valley totals about 51,000 af/y (Welch et al, 2008), which depends almost totally on inflow from Steptoe Valley (most of the inflow from Lake Valley originates in Steptoe Valley)." Myers (2011a, p. 25)

11. *"In the north, the Kern Mountains have impermeable intrusive rock which likely prevents flow, but just south there is potentially flow through Pleasant Valley from Spring to Snake Valley."* (p. 25, 1st sentence)

    Myers (2011a) is incorrect, Pleasant Valley is on the north side of the Kern Mountains, and flow from Spring Valley to Snake Valley via Pleasant Valley would have to be through the impermeable granitic rocks of the Kern Mountains. As with other conclusions on interbasin flow, Myers (2011a) does not analyze the available data and information (geologic or hydrologic) to assess the potential for interbasin flow based on the geologic conditions or hydraulic gradients to support the stated conclusions.

12. *"The decreased flow from the springs since 2008 may reflect ongoing development in the area, just as pumping near Baker has decreased groundwater levels as documented above. Several new irrigation pivots have developed west of the springs since about 2005 (personal communication, Dean Baker, 2006, and field observations by this author)."* (p. 43, 3rd paragraph)

    As Myers (2011a, p. 25 and 2011b, p. 32) states, Big Springs is located on the upgradient side (i.e., west) of the fault that controls its discharge. However, the groundwater development is located downgradient to the northeast of Big Springs, not to the west. Without assessing all of the hydrologic factors and gage maintenance activities that can influence the discharge record, it is conjecture on the part of Myers (2011a) to conclude that the downgradient development has caused the spring discharge to decrease by 1 cfs (or about 10 percent). While there appears to be minor drawdown approximately one mile east and downgradient from the pumping center (i.e., a total of approximately 2.5 ft at Needle Point Spring during the period of record for the Big Springs gage; Utah Geological Survey, 2011), the same effects are not discernable in the discharge records for the Big Springs or Big Springs Creek above Dearden Ranch (aka Stateline Springs) gages (Figure 2). Any apparent trends in the discharge records could easily be explained by changing hydrologic conditions (i.e. natural variation) or gage maintenance activities (i.e. changes to the control). Furthermore, the potential effects of pumping in this area would first be observed at the Stateline Springs because it is much closer and downgradient from the pumping (within one mile), and any potential effects to Big Springs upgradient from the pumping (which is over 3 miles from the springs) would likely be attenuated by the north-south oriented faults that control the spring flows and separate the springs from the pumping centers. Before concluding that the pumping is the sole cause of the variation observed in the discharge records, more due diligence analyzing all of the factors potentially affecting the gage record should have been presented and discussed in Myers (2011a).

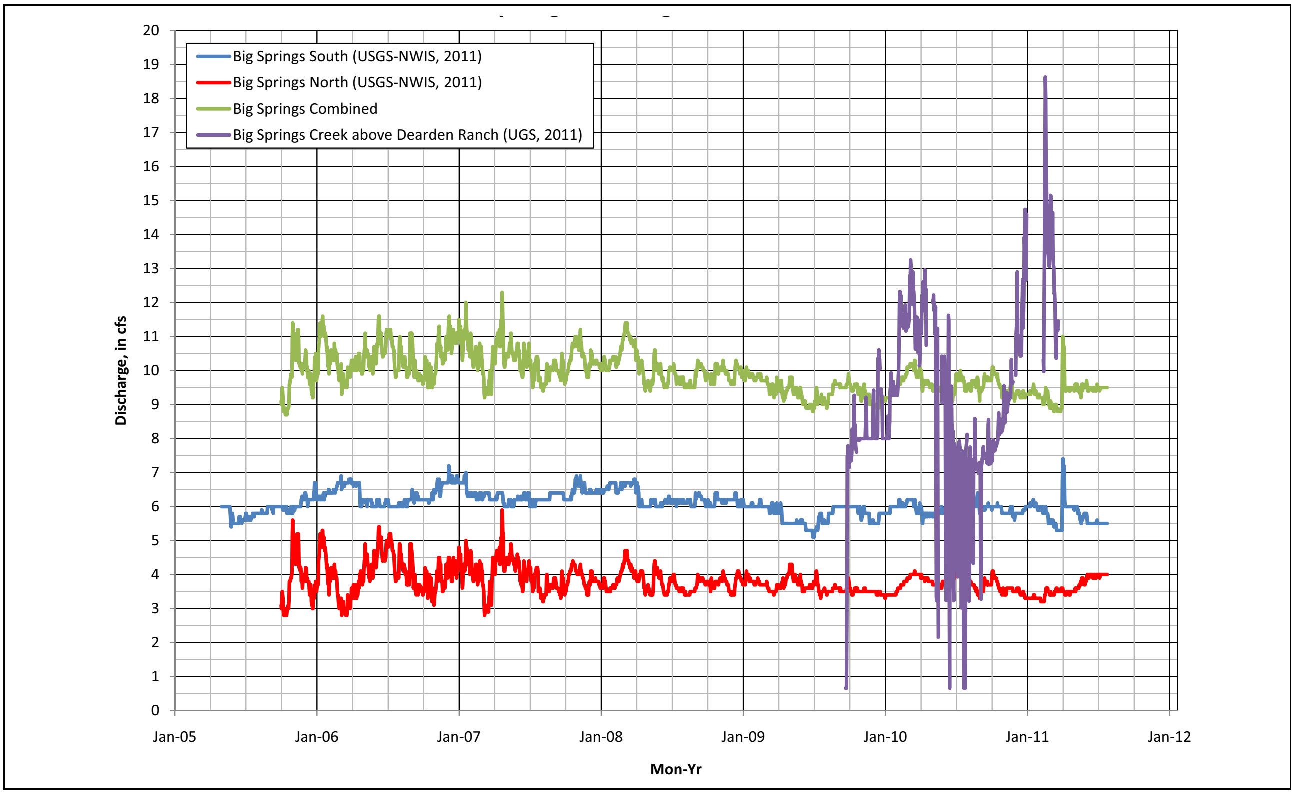

Figure 2
Spring Discharge 2005-2011

13. "*The conceptual groundwater model developed and documented in this report is an accurate description of the hydrogeology, water balance fluxes, springs and streams for Spring, Snake and surrounding valleys. It provides an accurate conceptualization for a numerical model which can be coded and calibrated to simulate the proposed SNWA water rights applications.*" (p. 44, last paragraph)

This conclusion is not supported by the explanation, data, or analysis provided in Myers (2011a), and the conceptual model is never clearly stated or explained. Much of the report recites excerpts from the BARCASS reports, but rarely are conclusions or opinions offered in support or opposition to their results. The reader is left without a description of the conceptual model, let alone an accurate one. Myers (2011a) description of the hydrogeology is lacking, with no maps depicting the extents of hydrogeologic units, cross-sections that present their thicknesses, or fault structures or calderas that control the geometry of the framework. Without this explanation or understanding, it is hard to believe the spatial distribution of hydraulic properties assumed during model construction can be anywhere close to accurate. No evaluation of basin-specific hydraulic-property data from aquifer tests was performed to provide data that could have been used to guide model calibration. The importance of the hydrogeologic framework appears to have been diminished based on the explanation provided, yet it is the primary control on groundwater flow. The water budget was not fully disclosed. Only the recharge was quantified, but in an unorthodox manner by averaging the results of selected previous investigations. Groundwater ET was never quantified, mapped, or used to constrain estimates of recharge. Flow paths and interbasin flow rates were recited from the BARCASS reports, but it is unclear to the reader as to what was adopted for the conceptual model. Presumably the BARCASS interbasin flows were adopted, and these were derived from the excess recharge and water-budget imbalance in Steptoe Valley. Myers (2011a) apparently adopts these interbasin flows, but not the recharge from which they were derived. By adopting elements of the water budget from several different investigations Myers (2011a) assumes the conceptual model is an accurate description of the groundwater systems of Spring, Snake, and surrounding valleys. However, the lack of due diligence in the data compilation and analysis, and the incomplete explanation of the groundwater budget yielded an undefined conceptual model that could hardly be evaluated, let alone used in model development. These deficiencies coupled with the lack of transparency and full disclosure of the conceptual model and its limitations invalidate any conclusions reached using the model; therefore, they should be rejected.

References

Acheampong, S.Y., Farnham, I.M., and Watrus, J.M., 2009, Geochemical characterization of ground water and surface water of Snake Valley and the surrounding areas in Utah, *in* Tripp, B.T., Krahulec, K., and Jordan, F.L., Geology and geologic resources and issues of Western Utah: Utah Geological Association Publication 38, p. 325-344.

Burns, A.G., and Drici, W., 2011, Hydrology and water resources of Spring, Cave, Dry Lake, and Delamar valleys, Nevada and vicinity: Presentation to the Office of the Nevada State Engineer: Southern Nevada Water Authority, Las Vegas, Nevada.

D'Agnese, F.A., 2011, A summary of the development of the Central Carbonate-Rock Province Groundwater Flow Model: Presentation to the Office of the Nevada State Engineer: EarthKnowledge, Tucson, Arizona.

Dixon, G.L., Rowley, P.D., Burns, A.G., Watrus, J.M., Donovan, D.J., and Ekren, E.B., 2007, Geology of White Pine counties and adjacent areas, Nevada and Utah: The geologic framework of regional groundwater flow systems: Southern Nevada Water Authority, Las Vegas, Nevada, Doc. No. HAM-ED-0001, 157 p.

Durbin, T., 2006, Development and Use of a Groundwater Model for the Spring Valley Area. Prepared for the Southern Nevada Water Authority: Presented to the Nevada State Engineer, Spring Valley Hearing, 2006.

Elliot, P.E., Beck, D.A., and Prudic, D.E., 2006, Characterization of surface-water resources in the Great Basin National Park area and their susceptibility to ground-water withdrawals in adjacent valleys, White Pine County, Nevada: U.S. Geological Survey Scientific Investigations Report 2006-5099, 156 p.

Epstein, B.J., 2004, Development and uncertainty analysis of empirical recharge prediction models for Nevada's desert basins [M.S. thesis]: University of Nevada, Reno, 202 p.

Flint, A.L., and Flint, L.E., 2007, Application of the basin characterization model to estimate in-place recharge and runoff potential in the Basin and Range carbonate-rock aquifer system, White Pine County, Nevada, and adjacent areas in Nevada and Utah: U.S. Geological Survey Scientific Investigations Report 2007–5099, 20 p.

Flint, A.L., Flint, L.E., Hevesi, J.A., and Blainey, J.M., 2004, Fundamental concepts of recharge in the desert southwest: A regional modeling perspective, *in* Hogan, J.F., Phillips, F.M., and Scanlon, B.R., eds., Groundwater recharge in a desert environment: The southwestern United States: American Geophysical Union Water Science and Applications Series, Vol. 9, p. 159–184.

Kistinger, G.M., Prieur, J.P., Rowley, P.D., and Dixon, G.L., 2009, Characterization of streams and springs in the Snake Valley area, Utah and Nevada, *in* Tripp, B.T., Krahulec, K., and Jordan, F.L., Geology and geologic resources and issues of Western Utah: Utah Geological Association Publication 38, p. 299-324.

Mankinen, E.A., and McKee, E.H., 2009, Geophysical setting of western Utah and eastern Nevada between Latitudes 37o 45' and 40o N, *in* Tripp, B.T., Krahulec, K., and Jordan, F.L., Geology and geologic resources and issues of Western Utah: Utah Geological Association Publication 38, p. 271-286.

Mankinen, E.A., and McKee, E.H., 2011, Principle facts for gravity stations collected in 2010 from White Pine and Lincoln Counties, east-central Nevada: U.S. Geological Survey Open-File Report 2011-1084, 24 p.

McPhee, D.K., Pari, K., and Baird, F., 2009, Audiomagnetotelluric investigation of Snake Valley, eastern Nevada and western Utah, *in* Tripp, B.T., Krahulec, K., and Jordan, F.L., Geology and geologic resources and issues of Western Utah: Utah Geological Association Publication 38, p. 287-298.

Myers, T., 2011a, Hydrogeology of Spring Valley and surrounding areas, Part A: Conceptual flow model: Presented to the Office of the Nevada State Engineer: Thomas Myers, Reno, Nevada.

Myers, T., 2011b, Hydrogeology of Spring Valley and surrounding areas, Part B: Groundwater model of Snake and Spring valleys, and surrounding areas: Presented to the Office of the Nevada State Engineer: Thomas Myers, Reno, Nevada.

Myers, T., 2011c, Hydrogeology of Spring Valley and surrounding areas Part C: Impacts of pumping underground water right applications #54003 through 54021: Presentation to the Office of the Nevada State Engineer: Great Basin Water Network, Reno, Nevada, and the Federated Tribes of the Goshute Indians, Ibapah, Utah.

Rowley P.D., Dixon, G.L., Burns, A.G., and Collins C.A., 2009, Geology and hydrogeology of the Snake Valley area, western Utah and eastern Nevada, *in* Tripp, B.T., Krahulec, K., and Jordan, F.L., Geology and geologic resources and issues of Western Utah: Utah Geological Association Publication 38, p. 251-270.

Rowley, P.D., Dixon, G.L., Burns, A.G., Pari, K.T., Watrus, J.M., and Ekren, E.B., 2011, Geology and geophysics of Spring, Cave, Dry Lake, and Delamar valleys, White Pine and Lincoln Counties and adjacent areas, Nevada and Utah: The geologic framework or regional groundwater flow systems: Presentation to the Office of the Nevada State Engineer: Southern Nevada Water Authority, Las Vegas, Nevada.

Rush, F.E., and Kazmi, S.A.T., 1965, Water resources appraisal of Spring Valley, White Pine and Lincoln Counties, Nevada: Nevada Department of Conservation and Natural Resources Ground-Water Resources–Reconnaissance Series Report 33, 36 p.

Sweetkind, D.S., Knochenmus, L.A., Ponce, D.A., Wallace, A.R., Scheirer, D.S., Watt, J.T., and Plume, R.W., 2007, Hydrogeologic framework, *in* Welch, A.H., Bright, D.J., and Knochenmus, L.A., eds., Water resources of the Basin and Range carbonate-rock aquifer system, White Pine County, Nevada, and adjacent areas in Nevada and Utah: U.S. Geological Survey Scientific Investigations Report 2007–5261, p. 11–36.

Tripp, B.T., Krahulec, K., and Jordan, F.L., 2009, Geology and geologic resources and issues of Western Utah: Utah Geological Association Publication 38, 549 p.

U.S. Geological Survey, 2011, National Water Information System (NWIS Web) data [Internet], [accessed August 22, 2011], available from http://waterdata.usgs.gov/nwis/.

UGS, see Utah Geological Survey.

Utah Geological Survey, 2011, Groundwater Database for Site 23: Needle Point Spring [Internet], [accessed on August 1, 2011], available from http://geology.utah.gov/databases/groundwater/site.php?site_id=23.

Welch, A.H., Bright, D.J., and Knochenmus, L.A., eds., 2007, Water resources of the Basin and Range carbonate-rock aquifer system, White Pine County, Nevada, and adjacent areas in Nevada and Utah: U.S. Geological Survey Scientific Investigations Report 2007–5261, 96 p.

Wilson, J.W., 2007, Water-level surface maps of the carbonate-rock and basin-fill aquifers in the Basin and Range carbonate-rock aquifer system, White Pine County, Nevada, and adjacent areas in Nevada and Utah: U.S. Geological Survey Scientific Investigations Report 2007–5089, 2 sheets.