SOUTHERN NEVADA WATER AUTHORITY
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July 27, 2007

VIA FACSIMILE
(Original Via Federal Express)

Mr. Kimball Goddard
State Representative
U.S. Geological Survey
2730 North Deer Run Road
Carson City, Nevada 89701

Re: Southern Nevada Water Authority's Comments regarding the BARCAS Study

Dear Mr. Goddard:

Enclosed please find the Southern Nevada Water Authority's (SNWA) comments on the *Water Resources of the Basin and Range Carbonate-Rock Aquifer System, White Pine County, Nevada, and Adjacent Areas in Nevada and Utah--Draft Report* (BARCAS). The SNWA requests that the enclosed comments be considered and included in the administrative record for BARCAS.

The SNWA appreciates the opportunity to provide these comments. If you have any questions regarding these comments please contact me directly at (702) 258-3107.

Sincerely,

Kay Brothers

Kay Brothers
Deputy General Manager
Engineering and Operations

KB:JJE:td
Enclosure

cc: Diana Weigmann, Southern Nevada Project Manager - U.S. Department of Interior, Office of the Secretary
Rick Felling, Chief Hydrologist - Nevada Division of Water Resources

<u>Southern Nevada Water Authority Comments on the</u>
<u>*Water Resources of the Basin and Range Carbonate-Rock Aquifer System, White Pine County, Nevada, and Adjacent Areas in Nevada and Utah--Draft Report*</u>

The components of the Basin and Range Carbonate Aquifer System (BARCAS) study made available for public review as of the date of these comments and that are the subject of these comments are listed below:

- *Water Resources of the Basin and Range Carbonate-Rock Aquifer System, White Pine County, Nevada, and Adjacent Areas in Nevada and Utah--Draft Report.* U.S. Geological Survey Open-File Report 2007-1156. ("Summary Report")

- *Irrigated Acreage Within the Basin and Range Carbonate-Rock Aquifer System, White Pine County, Nevada, and Adjacent Areas in Nevada and Utah.* U.S. Geological Survey Data Series 273.

- *Evapotranspiration Rate Measurements of Vegetation Typical of Ground-Water Discharge Areas in the Basin and Range Carbonate-Rock Aquifer System, White Pine County, Nevada, and Adjacent Areas in Nevada and Utah, September 2005–August 2006.* U.S. Geological Survey Scientific Investigations Report 2007-5078.

- *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. ("SIR 2007-5089")

- *Mapping Evapotranspiration Units 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 2007-5087.

- *Spring Database for the Basin and Range Carbonate-Rock Aquifer System, White Pine County, Nevada, and Adjacent Areas in Nevada and Utah.* U.S. Geological Survey Data Series 272.

- *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. ("Recharge Report")

- *A Methodology for Mapping Shrub Canopy Cover in the Great Basin Desert using High Spatial Resolution Satellite Imagery.* Desert Research Institute, Division of Hydrologic Sciences Publication Number 41236.

- *A Steady-State Water Budget Accounting Model for the Carbonate Aquifer System in White Pine County, Nevada, and Adjacent Areas in Nevada and Utah.* Desert

Research Institute, Division of Hydrologic Sciences Publication Number 41235. ("Lundmark et al., 2007")

- *Ground-water Chemistry Interpretations Supporting the Basin and Range Regional Carbonate-rock Aquifer System (BARCAS) Study, Eastern Nevada and Western Utah.* Desert Research Institute, Division of Hydrologic Sciences Publication Number 41230. ("Hershey et al., 2007")

- *Reconnaissance Estimation of Groundwater Recharge to Selected Hydrographic Basins of Eastern Nevada and Western Utah using the Chloride Mass-balance Method.* Desert Research Institute, Division of Hydrologic Sciences Publication Number 41232.

- *Regional Water Budget Accounting and Uncertainty Analysis Using a Deuterium-Calibrated Discrete State Compartment Model: White Pine County, Nevada, and Adjacent Areas in Nevada and Utah.* A Master's Thesis prepared by Kevin William Lundmark. ("Lundmark, 2007, Master's Thesis)

- *Uncertainty Analysis of Estimates of Ground-Water Discharge by Evapotranspiration for the BARCAS Study Area.* Desert Research Institute, Division of Hydrologic Sciences Publication Number 41234. ("Zhu et al., 2007")

SNWA has completed reviews of the reports and provides the following comments related to (1) the availability of the reports for public comment, (2) qualification and uncertainty of BARCAS results, and (3) interpretations of regional flow. Additional comments related to specific subject matter presented in the BARCAS reports are also provided.

AVAILABILITY OF REPORTS AND DELIVERY TO CONGRESS

<u>Availability of Draft Report for Public Comment</u>: The manner in which USGS made the draft BARCAS reports available for public comment did not meet the requirements of the Lincoln County Conservation, Recreation, and Development Act of 2004 ("Lincoln County Act"). Section 301(e)(2) of the Lincoln County Act provides that:

> The Secretary shall complete a draft of the water resources report required under paragraph (1) not later than 30 months after the date of the enactment of this Act. The Secretary shall then make the draft report available for public comment for a period of not less than 60 days. The final report shall be submitted to the Committee on Resources in the House of Representatives and the Committee on Energy and Natural Resources in the Senate and made available to the public not later than 36 months after the date of the enactment of this Act.

The Summary Report made available to the public on June 1, 2007 does not constitute the entire report required by the Lincoln County Act. Numerous components of the

BARCAS study reports were made available during the review period, including a new Desert Research Institute Discrete State Compartment (DSC) Model Report that was published the week of July 23, 2007, and hence have not been available for public review and comment for the entire 60-day mandated review period. The entire BARCAS study report, regardless of how various components of the overall study are categorized within the USGS, were required by federal law to be available for the entire 60-day review period.

In order to comply with the express requirements of the Lincoln County Act, the USGS must submit the final <u>and complete</u> report to Congress by November 30, 2007. Furthermore, any component of the BARCAS report that has not been made available for public review and comment as of the date of these comments must be made available for such review prior to submission of the final report to Congress on November 30, 2007.

- **All of the BARCAS reports should have been made available for review prior to the start of the 60-day public comment period**. SNWA considers all of the reports prepared as part of the BARCAS study integrated and supporting of the Summary Report, and therefore has included each in our review. This review was affected by the late release of some of these publications, including the report *A Steady-State Water Budget Accounting Model for the Carbonate Aquifer System in White Pine County, Nevada, and Adjacent Areas in Nevada and Utah* (Desert Research Institute, Division of Hydrologic Sciences Publication Number 41235), which was released the week of July 23, 2007.

- **A mechanism for review of all of the BARCAS reports should have been created**. The web page (http://nevada.usgs.gov/barcass/pubs.cfm) created to accept public comment was designed specifically to accept comments on the Summary Report. Review comments for all BARCAS reports should be accepted.

- **The complete set of BARCAS reports should be delivered to Congress**. SNWA believes that the complete set of BARCAS reports should have been available for review and should be updated to reflect any review comments and delivered to Congress as a complete package.

QUALIFICATION AND UNCERTAINTY OF BARCAS RESULTS

It is recognized that all hydrologic analysis/studies contain uncertain elements; this uncertainty can be reduced by calibration to more certain elements such as streamflows and water-level measurements, and most importantly must be qualified. In the BARCAS study interbasin groundwater flow volumes and directions were derived from highly uncertain elements such as the recharge and discharge estimates and representation of potentiometric surfaces and water tables. Despite the significant uncertainties associated with each element, the flow volumes and directions were presented as a single interpretation without adequate qualification of the uncertainty, particularly the non-uniqueness of the solutions.

Recharge Uncertainty

The estimates of recharge from precipitation are highly uncertain, and this uncertainty must be propagated through to the interpretations of interbasin flow. Use of the Basin Characterization Model (BCM) to develop recharge numbers is a valid approach but lacks the necessary calibration to reduce the uncertainty in the estimates. The recharge estimates presented in the BARCAS reports have the following issues:

- **The BCM code is unpublished and has not been reviewed**. The publication and review of this code would add to the credibility of its application in providing reasonable recharge estimates.

- **The recharge model is not calibrated**. No attempts were made to calibrate the model by matching simulated outputs to observed values. For example, INFIL models developed for the Yucca Mountain Project were calibrated to stream flow measurements (BSC, 2004; Flint et al., 2000). Instead of calibration, the recharge model relies heavily on the correctness of inputs, sub-models, and underlying assumptions. Consequently, the validity of the BCM-derived recharge estimates depends solely on the validity of the recharge model inputs.

- **Some of the input data are highly uncertain.** As stated by the authors of the draft Recharge Report, the greatest source of recharge model uncertainty is likely the saturated hydraulic conductivity of the bedrock. Few measurements of this parameter exist. In addition, the spatial distribution of this parameter is highly variable and is usually derived during model calibration. Since the recharge model was not calibrated, the hydraulic conductivity distribution used in the model may not be valid.

- **The quantitative uncertainty analysis is limited.** The quantified uncertainty does not incorporate the uncertainties of all input parameters. BCM requires many inputs, and each of the inputs has some amount of uncertainty. However, in the uncertainty analysis, only the uncertainty from the percentage of recharge from runoff was quantified. This simplified uncertainty analysis resulted in large ranges in the estimated recharge.

- **Uncertain recharge estimates result in uncertain estimates of interbasin flow.** For each valley, the estimates of interbasin flow were calculated as residuals between recharge and evapotranspiration. Thus, recharge and evapotranspiration estimates drive the estimates of interbasin flow. For example, whereas the amount of recharge for Steptoe Valley was significantly larger than any previously reported estimate (Summary Report, Table 6, p. 48), the estimate of evapotranspiration was similar to previously reported values (Summary Report, Table 7, p. 49). This resulted in a large residual as an estimate of underflow. This underflow could easily be offset with the uncertainties associated with either the recharge estimates or discharge estimates.

  The authors chose to report a single estimate of underflow and did not propagate the uncertainties of recharge and evapotranspiration to their estimates of underflow. This gives the reader the impression that the conceptual model of flow is more certain than it is. It would be preferable to estimate the recharge and discharge as a range and derive estimates of underflow as ranges as well.

Discharge Uncertainty

The evapotranspiration work conducted for the BARCAS study was technically sound and included a good compilation of the available data, but the resultant estimates are highly uncertain given the data limitations and inherent assumptions made in deriving the estimates (Summary Report, Figure 34, p. 65; Zhu et al., 2007). The uncertainty of the resultant estimates need to be propagated all the way through to the flow path discussions.

Water-Level Uncertainty

The following issues related to the uncertainty of potentiometric water-level contours contribute to the overall uncertainty regarding the groundwater flow directions postulated in USGS publication Scientific Investigations Report (SIR) 2007-5089 and the Summary Report.

- **There was no effort to quantify the uncertainty associated with water levels.** The water levels used to create Plates 1 and 2 were provided in SIR 2007-5089, but an uncertainty analysis of the water-level data was not presented to quantify the accuracy of the measurements. For example, USGS publication WRIR 02-4102 (D'Agnese et al., 2002) illustrated a method to quantify the observation error on hydraulic head measurements.

- **The term "static" should be defined**. Page 3 of SIR 2007-5089 states that the study collected, compiled, and evaluated 418 water-level measurements to determine measurements that represent **static** water-level conditions in each aquifer. Page 5, however, states that historical water-level measurements that represent current ground-water conditions were used to develop the contour maps. It is uncertain what the water-level measurements actually represent. If the assumption is that the current measurements represent static conditions, this should be explicitly stated.

- **There is a lack of water-level data for the carbonate-rock aquifer and yet contour lines depicted on Plate 3 do not signify this uncertainty**. SIR 2007-5089 states that 76 basin-fill wells and 43 carbonate wells were used to create the potentiometric contour map. This means that over 60% of the control points do not penetrate the carbonate-rock aquifer system. As a result, contour lines near these control points are uncertain and should be depicted as such (i.e., dashed lines indicate "Uncertain" status). Also, page 5 of SIR 2007-5089 states that potentiometric surface and water-table maps published in previous reports were used as secondary guides in developing hydraulic head contours. These reports were not documented or discussed nor were the areas documented where these previous reports were used. In addition, contours in these areas should be dashed to indicate "Uncertain" status.

- **Data used for contour construction do not match those used in Plate 1 of the USGS publication by Belcher (2004) for similar regions**. Although the authors state that the approach used to generate the contour map is similar to that published in the Death Valley Regional Flow System (DVRFS) for southern Nevada, the control points appear to be quite different. For example, only two regional springs were used in the entire BARCAS map, whereas the DVRFS map contains many springs for the same area. For example, on Plate 1 of Belcher (2004) there are at least 6 spring locations (Bastian, South Millick, Shoshone, Minerva, Swallow Canyon, and Unnamed spring), in Spring Valley alone, that were used for the construction of water-level contours.

INTERPRETATIONS OF REGIONAL FLOW

Some of the flow paths presented in the BARCAS study are significant departures from those of previous studies including numerous USGS authored publications such as Harrill et al. (1983), Harrill et al. (1988), Harrill and Prudic (1998), and Nichols (2000). This is particularly troubling in light of the lack of new data presented and the highly uncertain results associated with the data analysis. The two most troubling flow paths and volumes are the flows from Steptoe Valley to Snake Valley and from Steptoe Valley to White River Valley.

Steptoe to Snake

The Summary Report purports significant groundwater flow (Plate 3) from southern Steptoe Valley through Lake, Spring, and Hamlin valleys to Snake Valley. This interpretation appears to be the result of the residual between natural recharge and discharge estimates, the largest residual being in Steptoe Valley (Summary Report, p. 48-49), and represents a major departure from the commonly accepted delineations of groundwater flow systems in the Great Basin region. For example, numerous reports from the USGS, including Harrill et al. (1983), Harrill et al. (1988), Harrill and Prudic (1998), and Nichols (2000), all consider Steptoe Valley to be part of the Goshute Valley flow system not the Great Salt Lake Desert flow system. Specifically, USGS publications HA 694-C (Harrill et al., 1988) and Professional Paper 1628 (Nichols, 2000) route groundwater from Steptoe Valley to Goshute Valley not to Lake, Spring, Hamlin, and Snake valleys. There were no new data presented to substantiate this quite different interpretation of regional flow systems.

- **The geologic evidence does not support large groundwater flow volumes along this path**. The recent work performed by SNWA analyzed previous investigations conducted by the Nevada Bureau of Mines and Geology, University of Utah, Stanford University, and USGS (Hose and Blake, 1976; Tschanz and Pampeyan, 1970; Loucks et al., 1989; Best et al., 1989; Best et al., 1993; Gans et al., 1989; Lumsden et al., 2002; Mankinen et al., 2007; McPhee, et al., 2005; McPhee, et al., 2006; Scheirer, 2005; Dixon et al, in prep.; Poole and Sandberg,1977; Willis et al., 1987; Drewes, 1967) and concluded that the northern portion of the Fortification Range is complexly faulted and contains repeated sections of the Chainman Shale, an aquitard, beneath the surface and water table. The southern portion of the Fortification Range contains volcanic rocks that SNWA interprets to be intracaldera rocks of the Indian Peak caldera complex. SNWA believes that the combination of Chainman Shale and intracaldera rocks most likely restricts groundwater flow through the range.

- **Flow arrows are not consistent with water-level contours.** The potentiometric surface map (Plate 3) includes flow arrows that depict flow going from southern Steptoe Valley to Lake Valley. However, the potentiometric contours indicate a groundwater gradient that is steeper in the direction of southern Steptoe Valley to Cave Valley. The permissibility of flow characterization (Plate 3) also indicates a preferential flow path in the direction of Cave Valley. This information is contradictory to the postulated flow from Steptoe Valley and to the commonly accepted delineations of groundwater flow systems in the Great Basin (e.g., Harrill et al., 1983; Harrill et al., 1988; Harrill and Prudic, 1998; Nichols, 2000). Furthermore, in USGS publication HA 694-B (Thomas et al., 1986) the potentiometric contours for the rocks of the carbonate-rock province clearly indicate groundwater flow from southern Steptoe Valley to northern Steptoe Valley not Lake Valley.

- **Geochemical modeling does not support the flow path directions and/or volumes**. The deuterium-calibrated discrete state compartment (DSC) model, developed by the Desert Research Institute (Lundmark, 2007, Master's Thesis; Lundmark et al., 2007), is based on the same series of water samples used for the geochemical modeling described in Hershey et al. (2007). The DSC model is based on a single geochemical parameter (deuterium), whereas the geochemical modeling is a more rigorous process using multiple chemical parameters including deuterium. Flow paths developed using the DSC model should therefore be supported by the geochemical modeling in order to be considered viable. This is not the case for the Steptoe Valley to Snake Valley flow path. The relatively high flow rates from Steptoe Valley to Lake Valley and from Lake Valley to Spring Valley (Summary Report, Plate 3) are inconsistent with the geochemical modeling results. Although geochemical modeling does not support flow from Steptoe Valley into Lake Valley (Hershey et al., 2007, p. 74), flow of 20,000 acre-feet per year is shown in Plate 3. Although only 0 to 5 percent of the groundwater in southern Spring Valley was determined to be from Lake Valley (Hershey et al., 2007, p. 69), flow of 29,000 acre-feet per year is shown in Plate 3.

- **The waters representing the initial and the recharge components in Table 8 (Summary Report, p. 79) are not defined in either the BARCAS Summary Report or Hershey et al. (2007)**. Without knowing the locations of the initial (or mixing) waters, their chemical compositions, and their relative contribution as a mixing end-member, the validity of the model in supporting interbasin flow cannot be verified. In addition, in Table 8 of the Summary Report the ratio of initial and recharge components for the Lake Valley to Spring Valley flow path is misleading because the initial water (95 to 100 percent) is from Spring Valley and not Lake Valley as suggested in the table.

- **The magnitude of interbasin flow is not always supported by geochemical modeling**. The Summary Report states that the magnitude of interbasin flow for selected HA boundaries was supported by geochemical modeling (p. 73, last sentence). The *selected* HA boundaries should be specified and the reason for this selection presented. Only a limited number of the flow paths were tested using geochemical modeling (interbasin flow between Spring and Snake, Steptoe, and Lake basins and between Steptoe and Spring, Lake, and Cave basins) (Hershey et al., 2007, pp. 39 and 40). Out of these modeled flow paths, the magnitude of interbasin flow is not always supported by the geochemical modeling results. For instance, geochemical modeling does not support 20,000 acre-feet per year flow from Steptoe Valley into Lake Valley; (1) no valid models were found for this flow path (Hershey et al., 2007, p. 74); (2) nor is 29,000 acre-feet per year flow from Lake Valley into Spring Valley supported; and (3) the contribution of Lake Valley groundwater to Spring Valley was determined to be 0 to 5 percent (Hershey et al., 2007, p. 69). The geochemical modeling results indicated that the contribution of southern Spring Valley groundwater to southern Snake Valley was indeterminate (Hershey et al., 2007, p. 67).

- **DSC model results are not consistent with the previous work of Thomas et al. (2001)**. The results of the DSC model are also inconsistent with those obtained using a similar approach by Thomas et al. (2001) and appear to be quite dependent on the boundaries of the model. For instance, the flow directions in the model by Thomas et al. (2001) are south from Lake Valley to Patterson Valley and southwest from Cave Valley to Pahroc Valley. In the DSC model, the flow is east from Lake Valley to Spring Valley (with no southward flow into Patterson Valley) and southwest from Cave Valley to White River Valley (with no southward flow to Pahroc Valley). Lake Valley is on the northeast boundary of the Thomas et al. (2001) model and is on the southern boundary in the current DSC model. Similarly, Cave Valley is on the northern boundary of the Thomas et al. (2001) model and is on the southern boundary of the current model. Therefore, it seems worthwhile to extend the DSC model boundaries further south to determine the impact on the modeled flow direction and magnitude.

Steptoe to White River

Plate 3 in the Summary Report purports groundwater flow from Steptoe Valley to White River Valley. This interpretation is once again the result of the residual between estimates of natural recharge and discharge and represents another major departure from the conventional understanding of the groundwater flow systems. Numerous reports from the USGS, including Harrill et al. (1983), Harrill et al. (1988), Harrill and Prudic (1998), and Nichols (2000), consider Steptoe Valley to be part of the Goshute Valley flow system not the White River flow system.

- **The geologic evidence does not support large groundwater flow volumes along this path**. The recent work performed by SNWA analyzed previous investigations conducted by the Nevada Bureau of Mines and Geology and USGS (Hose and Blake, 1976; Brokaw and Shawe, 1965; Brokaw and Heidrich, 1966; Brokaw, 1967; Brokaw and Barosh, 1968; Lumsden et al., 2002; Ponce, 1992; Scheirer, 2005; Mankinen et al., 2006; Dixon et al., in prep.; Kleinhampl and Ziony, 1985) and determined that the presence of volcanic, plutonic, and clastic rocks would most likely prohibit flow from Steptoe Valley to White River Valley.

- **This flowpath was not evaluated as part of the BARCAS geochemical modeling work performed by Hershey et al. (2007)**. Given the major departure from conventional thought, this flow path should have been evaluated to help support or refute this new idea or the idea should have been abandoned since there appears to be no new data or evidence to support this interpretation.

ADDITIONAL COMMENTS BY TOPIC

Hydrogeologic Framework

- **The sources of information used in the interpretation of the hydrogeology are limited**. For example, Plate 1 (hydrogeologic map) of the Summary Report was compiled only from digital versions of the 1:500,000-scale state geologic maps for Nevada and Utah (Summary Report, p. 13 and Plate 1), with additional sources used for determination of caldera boundaries and boundaries of highly extended terrains. Other more detailed maps were not considered, such as those prepared by the Nevada Bureau of Mines and Geology in cooperation with the USGS (Hose and Blake, 1976; and Tschanz and Pampeyan, 1970; Coats, 1987; Kleinhampl and Ziony, 1985) or those prepared by the Utah Geological Survey in cooperation with the USGS (Hintze and Davis, 2002a and b).

- **The hydrogeologic framework section lacks interpreted cross-sections**. The inclusion of cross-sections, similar to those provided in Sweetkind et al. (2001) for the Death Valley region, could have supported other elements of the study and provided insights into the conceptualization of the hydrogeologic framework. Cross-sections provided on the bottom of Plate 1 of the Summary Report are only diagrammatic and are not referenced to the map. In addition, inconsistencies exist between the map and the cross-sections. For example, fault depiction is not consistent.

- **The BARCAS hydrogeologic framework describes many of the basins as half grabens**. SNWA considers most of the basins in the area to be asymmetrical horsts, bounded on each side by asymmetrical grabens. This is supported by the many geophysical studies completed by the USGS Geophysical Unit of Menlo Park (Scheirer, 2005; Mankinen et al., 2006; Mankinen et al., 2007; McPhee et al., 2006; McPhee et al., 2007). These studies could have been used to explain the structural framework as well as depict the faults on Plate 1.

- **Depiction of the transverse zones shown on Plate 1 of the Summary Report are too general**. Additional work performed by Rowley (1998) and Rowley and Dixon (2001) could be used to improve the transverse zones shown on the hydrogeologic map.

- **Care should be taken in using Hess et al. (2004) to describe basin fill**. In Table 3 of the Summary Report, there are several references to Hess et al. (2004), describing a lack of volcanics in a particular valley. Hess et al. (2004) document oil and gas well data. As the basin fill is generally not a target in drilling oil and gas wells, distinguishing between true valley-fill and volcanics is often not a priority, and therefore the different rock types penetrated while drilling through the basin-fill are typically aggregated into a general basin-fill category. Little Smoky Valley is an example of this type of interpretation error. The valley is surrounded by volcanics, which are described in Table 3 of the Summary Report, and has a caldera underlying the southern subbasin; therefore, it almost certainly contains volcanics that were not described in the borehole data.

Geochemical Modeling

- **Geochemical information used in any analysis should be presented in the report**. Statements made in the Summary Report (p. 78), specifically "some geochemical data were available for the study area" and "additional geochemical information was inferred" leave the reader to question how much data was *real* and how much was *inferred*. This is also not clear from Hershey et al. (2007). Much of the data used for the geochemical models is not presented in any of the BARCAS study reports (only data acquired for the BARCAS study are presented in Appendix A of Hershey et al., 2007). Although the data may be published in databases, *the "best" individual analyses used for water-rock reaction modeling* (Hershey et al., 2007, p. 33) are not known for several of the flow paths evaluated, and thus the validity of these models cannot be verified.

- **Inconsistencies exist in the water-quality tables presented in the Summary Report and in Hershey et al. (2007)**. The tables summarizing exceedances of drinking water standards (Summary Report, Table 5; Hershey et al., 2007, Table 1) are not consistent, and thus it is unclear whether the same data set was used. This information should be consistent between the two reports, especially because the Summary Report is presented as a summary of the work presented in the other BARCAS reports (i.e., Hershey et al., 2007).

- **Flow from north-central Spring Valley to northern Spring Valley is not likely**. A geochemical model was developed and concluded that a flow path from central Spring Valley to northern Spring Valley was possible (Hershey et al., 2007, p. 49 to 53). The Yelland Playa acts as a discharge area for groundwater and streams in north-central Spring Valley. This interpretation is shown in SNWA's (SNWA, in prep.) own work as well as that of the USGS in Thomas et al. (1986).

- **Summary Report Table 8 heading incorrect**. The heading in Table 8 of the Summary Report (p. 79) should read "Inorganic Carbon Groundwater Flow Velocity" rather than "Inorganic Groundwater Flow Velocity".

- **Summary Report Table 5 heading incorrect**. The heading in Table 5 (Summary Report, pg. 46) should be changed from "With Constituent" to "Constituent Detected." The constituents are naturally occurring and probably present in the groundwater, albeit, at low levels. The "presence" of the constituent is thus dependent on the analytical detection limit.

- **Incorrect Reference given**. Thomas et al. (2001) is listed in the reference section of the Summary Report (p. 94) as "Age Dating Groundwater …", but is probably actually referring to the report "A Deuterium Mass-balance Interpretation of Groundwater Sources and Flows in Southeastern Nevada," (Publication No. 41169).

<u>Water Level Report</u>

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.

- **The process by which water-level contours were created requires additional discussion**. Page 3 states that potentiometric and water-level surfaces are represented by spatially interpolated contours of hydraulic head. A discussion documenting how the contours were created is needed.

- **What is the significance of Figure 4?** Why is it important to highlight that most water-level measurements were collected in 1990 and 2005? The significance of Figure 4 and the 1990 and 2005 years of data collection should be discussed.

- **Incorrect definition of Measurement Altitude in Appendix A**. The definition for Measurement Altitude (feet) states that altitudes are rounded to nearest tenth of a foot. The data in Appendix A are clearly rounded to the nearest 10 feet.

- **Please describe your use of the greater-than or less-than signs in Appendix A.** The circumstances that lead to an altitude being qualified with a '<' or '>' symbol should be described. Do these qualifiers represent dry holes or flowing wells? For example, site 380120114120701 was checked with the National Water Information System Database (http://waterdata.usgs.gov/nwis/) such that the land surface is at 5,770, so why is the value reported as greater than 5,730 ft?

<u>Spring Database Report</u>

Spring Database for the Basin and Range Carbonate-Rock Aquifer System, White Pine County, Nevada, and Adjacent Areas in Nevada and Utah. U.S. Geological Survey Data Series 272.

- **The study would have benefited from field verification**. The spring database is a nice compilation of existing USGS site location databases (such as the National

Hydrography Dataset and National Water Information System, as well as published USGS topographic maps). However, the effort would have benefited from actual field investigations to verify these databases.

Irrigation and Water Use from the Summary Report

- **State that comparisons with NDWR data were only performed for three valleys**. Page 67 of the Summary Report states that delineated acreages were compared to available NDWR crop inventories. The text implies that this was done for the entire study area, when in reality it was done for only Steptoe Valley, Newark Valley, and the northern part of Little Smoky Valley.

- **Additional discussion is needed for the irrigation return flow discussion on page 71 of the Summary Report**. For example, the statement "... if 375 ac-ft is required by the crop, then 425 ac-ft needs to be withdrawn from the well …" is vague and leaves the reader unclear as to the method used to determine the crop requirements. In addition, the text does not mention the supplemental nature of groundwater rights in these basins. Namely, a cursory examination of water rights from the Nevada Division of Water Resources reveals that several of these basins (including Spring, Snake, and Steptoe) contain supplemental groundwater rights. The text also combines spring discharge and groundwater pumped from wells into one category (i.e., groundwater), while the NDWR consider springs to be surface water.

Irrigated Acreage Report

Irrigated Acreage Within the Basin and Range Carbonate-Rock Aquifer System, White Pine County, Nevada, and Adjacent Areas in Nevada and Utah. U.S. Geological Survey Data Series 273.

- **Geodatabase analysis and field verification need to be described**. No discussion was provided in the report to document how the geodatabase that was constructed was analyzed to determine the irrigation water source, irrigation system, and crop type. Was this all determined by field verification? And, if so, additional information should be provided to describe the field verificaiton efforts.

REFERENCES

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Best, M.G., Scott, R.B., Swadley, W.C., Anderson, R.E., Gromme, C.S., Harding, A.E., Deino, A.L., Christiansen, E.H., Tingey, D.G., and Sullivan, K.R., 1993, Oligocene-Miocene caldera compleses, ash-flow sheets, and tectonism in the central and southeastern Great Basin, *in* Lahren, M.M., Texler, J.H., and Spinsosa, C., editors, Crustal evolution of the Great Basin and Sierra Nevada; Field trip guide, Geological Society of America, Cordilleran and Rocky Mountain sections meeting, p. 285-311.

BSC, see Bechtel SAIC Company.

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