PROJECT PROPOSAL

EVALUATION OF THE BASIN-FILL AQUIFERS, THEIR CONNECTION WITH SURFACE-WATER RESOURCES AND CARBONATE-ROCK AQUIFERS IN SOUTHERN SNAKE VALLEY, NEVADA

NV08-03

By

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EXECUTIVE SUMMARY

PROBLEM: Supplementary water supplies are needed for a rapidly growing population in southern Nevada. Ground-water resources from basin-fill and consolidated rock aquifers in southern Spring and Snake valleys in eastern Nevada have been identified as a potential water supply source. These aquifers provide water to springs, streams, wetlands, limestone caves, and other biologically sensitive areas on Federal lands in eastern Nevada, which provide habitat for numerous species of plants and animals, including one species of Federally listed endangered fish. The USDOI National Park Service (NPS), Bureau of Land Management (BLM), Fish and Wildlife Service (FWS), and USDA Forest Service (USFS) need additional geologic, hydrologic, and chemical information to assess the hydraulic connection of basin-fill and carbonate-rock aquifers with surface-water resources and water-dependent ecological features. Understanding these connections is important because pumping of ground water in Spring Valley or Snake Valley may result in unintended capture of surface streams and/or ground-water discharge to springs in ecologically sensitive areas of southern Snake Valley.

OBJECTIVES: The objectives of this research are to gain a better understanding of the distributions of aquifers, connection of aquifers with surface water because of the importance of ecologically sensitive areas along streams and at springs, and ground-water flow on Federal lands in and near the southern part of Snake Valley in White Pine County, Nevada. Specifically, the objectives are to: (1) characterize the distribution, geometry, and hydraulic properties of the Cenozoic sedimentary rocks and deposits; (2) characterize streambed hydraulic conductivity and quantify the volume of water exchanged between ground water and surface water along Lehman, Baker, and Snake Creeks; (3) determine the source of water to Rowland Spring, near Lehman Caves and Big Springs, the largest spring discharge in southern Snake Valley; and (4) delineate the ground-water divide between southern Spring Valley and southern Snake Valley and estimate the quantity of ground-water flow across the topographic divide known as the Limestone Hills.

RELEVANCE AND BENEFITS: Results of this study will benefit the Federal bureaus, as well as Nevada and Utah State agencies, by providing relevant hydrologic data to better quantify the current hydrologic condition such that knowledgeable assessments can be determined on potential effects of ground-water withdrawals on surface streams and springs. This study is aligned with the USGS science strategy goal for developing a water census of the United States to inform the public and decision makers about the status of freshwater resources by quantifying, forecasting, and securing freshwater for America's future (USGS, 2007). This study also is aligned with issue 1, refined water budgets and issue 3, ecological health, of the 2004 Nevada District Science Center Plan.

APPROACH: The distribution, geometry, and hydraulic properties of the Cenozoic sedimentary rocks and deposits will be evaluated by drilling new test wells, compiling data from existing wells and oil test holes, using geologic maps correlated to geophysical surveys, and visual inspection of geologic outcrops. Streambed hydraulic conductivity will be quantified along selected reaches of the Lehman, Baker, and Snake Creeks using a combination of surface (on the streambed) and subsurface (0.5 and 1 m below the streambed) temperature measurements, stage at temporary surface-water gages, synoptic streamflow measurements (seepage runs), temperature and water-level measurements in shallow piezometers installed in the streambed, and from multiple-well aquifer tests. The source of water to Rowland Spring and Big Springs will be determined by drilling test wells upstream of each spring, collecting water chemistry of water in the wells, creeks, and springs, and analyzing the results using geochemical mixing models. The ground-water divide between southern Spring Valley and southern Snake Valley will be determined by measuring water levels in several new wells drilled in southern Spring Valley, and the flow across Limestone Hills estimated from new test wells drilled along or near the divide.

PROBLEM

Currently, southern Nevada relies on the Colorado River for most of its water supply. Supplementary water supplies are needed to offset a persistent drought in the Colorado River Basin and a rapidly growing population in southern Nevada. Ground-water resources from basin-fill and consolidated-rock aquifers in eastern Nevada are a potential water supply source. These aquifers provide water to springs, streams, wetlands, limestone caves, and other biologically sensitive areas on Federal lands in eastern Nevada, which provide habitat for numerous species of plants and animals, including one species of Federally listed endangered fish. These water-dependent features also are visited and enjoyed by anglers, hunters, and tourists, including numerous visitors to the Great Basin National Park. A dearth of hydrologic data precludes a definitive evaluation of the potential effects of ground-water development on these water-dependent natural resource features.

The USDOI National Park Service (NPS), Bureau of Land Management (BLM), Fish and Wildlife Service (FWS), and USDA Forest Service (USFS), hereafter referred to as the "Federal bureaus", need additional geologic, hydrologic, and chemical information to assess the hydraulic connection of basin-fill aquifers with surface-water resources and water-dependent ecological features, and connection with the regional carbonate-rock aquifer, the known source of many high-discharge springs in the region. Understanding these connections is important because pumping of ground water in Spring Valley or Snake Valley may result in unintended capture of surface streams and/or ground-water discharge to springs in ecologically sensitive areas of southern Snake Valley.

Several sections of surface streams and spring discharge areas in-and-adjacent-to Great Basin National Park in Spring and Snake valleys were identified as susceptible to ground-water withdrawals (Elliott and others, 2006). Additionally, ground-water pumping in southern Spring Valley potentially could capture streamflow and ground-water discharge to springs and Big Springs Creek in southern Snake Valley because previous studies have indicated ground-water flow from southern Spring Valley into southern Snake Valley through carbonate rocks that outcrop along a low topographic divide (Rush and Kazmi, 1965; Harrill and others, 1988; Nichols, 2000; Welch and others, 2007). Estimates of annual flow across the divide range from 4,000 to about 30,000 acre-ft, which is between half to 3 times more than the discharge of Big Springs at the southwestern end of Snake Valley (fig. 1). This study is designed to aid in the assessment of the hydrologic effects of water-supply development in southern Spring and Snake valleys on the water resources in southern Snake Valley.

OBJECTIVES AND SCOPE

The objectives of this research are to gain a better understanding of the distributions of aquifers, connection of aquifers with surface water because of the importance of ecologically sensitive areas along streams and at springs, and ground-water flow on Federal lands in-and-near the southern part of Snake Valley in White Pine County, Nevada (fig. 1). The study area includes two primary areas shown as shaded areas in figure 1. The northern area extends south of U.S. Highway 50 to Big Wash along the eastern side of the southern Snake Range eastward across southern Snake Valley to the Nevada state line. The southern area encompasses the interbasin ground-water monitoring zone of the DOI/SNWA Stipulated Agreement and includes Big Springs in southern Snake Valley, northern Hamlin Valley, and southeastern Spring Valley. The study will be done over a three-year period. The proposed research is divided into four major elements.

Element 1. Characterize the distribution, geometry, and hydraulic properties of the Cenozoic sedimentary rocks and coarse- and fine-grained basin-fill deposits because the Cenozoic sedimentary rocks are critical in understanding ground-water flow from consolidated rocks in the mountains to discharge areas on the valley floors and ground-water/surface-water interactions. This characterization will result in a detailed depiction of the three-dimensional framework along the eastern and southern flank of the southern Snake Range into southern Snake and Hamlin valleys.

Element 2. Characterize streambed hydraulic conductivity and quantify the volume of water exchanged between ground water and surface water along selected reaches of Lehman, Baker, and Snake Creeks. The headwaters of Lehman, Baker, and Snake Creeks originate in areas of low permeability rocks high on the east side of the southern Snake Range. The streams are perennial in the upper reaches and are fed by snowmelt percolating through glacial deposits that mantle the low permeability rocks. Downstream these streams flow across areas underlain by alluvial deposits and carbonate rocks that are generally permeable. Depending on differences between stream stage and ground water-level altitudes, stream reaches can gain or lose flow. Baker Creek loses water where it flows across carbonate rocks, whereas Lehman Creek gains water where it flows across basin-fill deposits that directly overlie carbonate rocks. Snake Creek alternately gains and loses water where it flows across carbonate rocks but then substantially gains water where basin-fill deposits overlap the carbonate rocks. Due to these rather unusual and highly variable conditions and because these conditions occur largely in or in close proximity to the Great Basin National Park, an understanding of the spatial and temporal ground-water/surface-water relations along these three creeks is needed to better understand potential affects of ground-water pumping on ecologically sensitive habits associated with streams.

Element 3. Determine the source of water to Rowland and Big Springs. Rowland Spring discharges near the eastern boundary of Great Basin National Park downstream of Lehman Caves and is the largest perennial spring in Great Basin National Park. Determining the source of water to this spring is important because of its proximity to Lehman Caves. Big Springs has the largest spring discharge in southern Snake Valley and forms the headwaters to Big Springs Creek that flows northeast into Utah. Knowing the source of water to these springs is important to evaluating the potential effects of pumping ground water in southern Spring Valley on water resources in southern Snake Valley. Water chemistry and stable isotopes of discharge at the two springs along with water chemistry of Lehman and Baker Creeks (Rowland Spring) and water from wells up gradient of the springs will be used to provide insight as to the sources of water to springs and consequently their susceptibility to changes in either the surface-water or ground-water regimes.

Element 4. Estimate the quantity of ground-water flow across the topographic divide (Limestone Hills) that separates southern Spring Valley from northern Hamlin Valley. The element requires (1) delineation of the ground-water divide at the southern end of Spring Valley, and (2) reliable estimates of the hydraulic gradient, effective thickness of the permeable carbonate rocks, and effective hydraulic conductivity of the permeable units across the topographic divide. The ground-water divide may not be vertical because of variations in hydraulic properties of the basin fill and carbonate aquifers. Additionally, the ground-water divide may or may not be related to geologic structures; rather the divide may simply be where ground water finds it easier to flow either northwest to the wetlands in southern Spring Valley or northeast to discharge areas (Big Springs or areas of natural evapotranspiration) in southern Snake Valley.

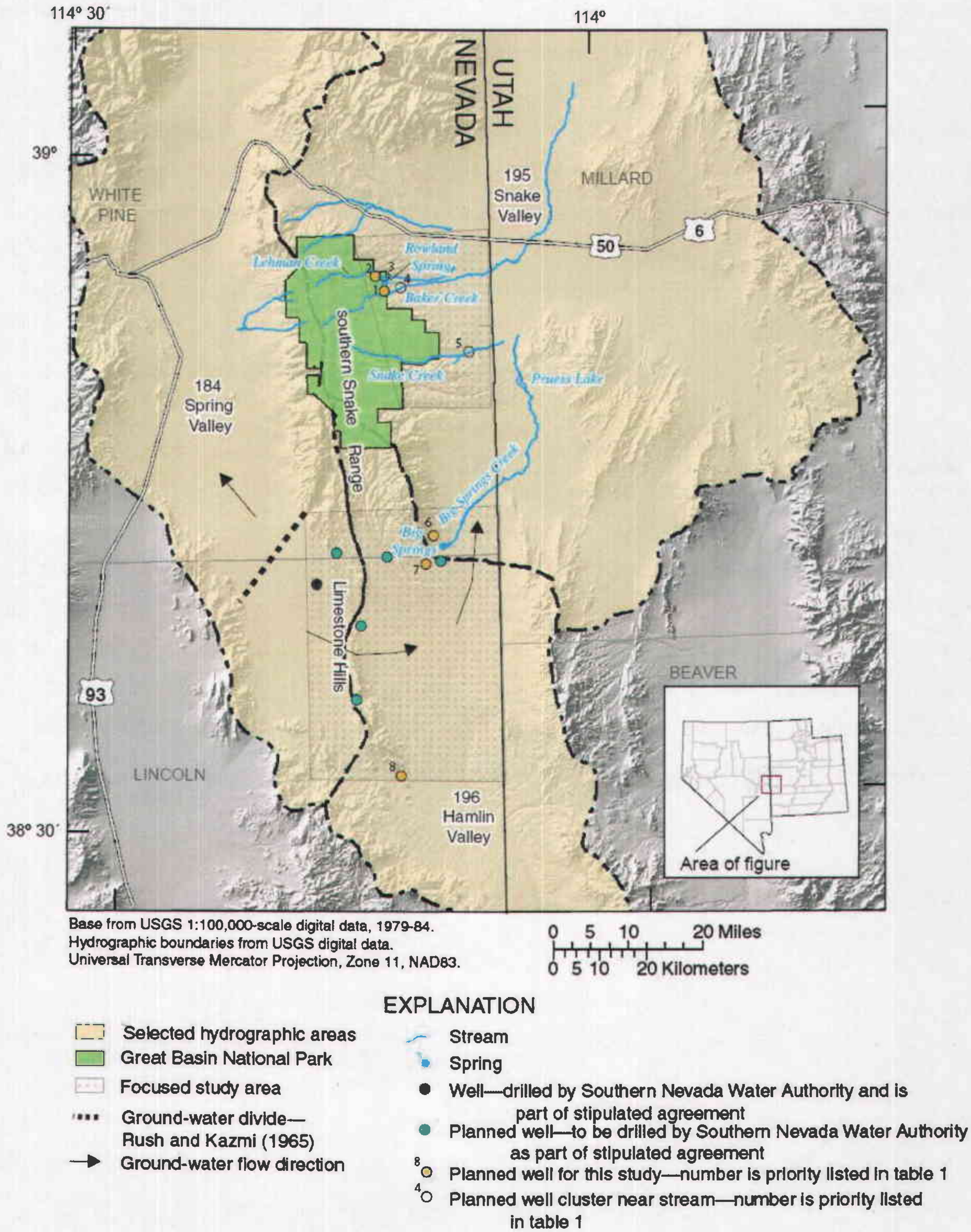

Figure 1—Location of Great Basin National Park, focused study area, and proposed wells in southern Spring Valley, northern Hamlin Valley, and southern Snake Valley, White Pine and Lincoln Counties, Nevada.

RELEVANCE AND BENEFITS

Results of this study will benefit the Federal bureaus, as well as Nevada and Utah State agencies, by providing relevant hydrologic data to better quantify the current hydrologic condition such that the information can be used to assess potential effects to ground-water withdrawals on streams and springs. The analyses also will benefit the Southern Nevada Water Authority and complement their planned ground-water monitoring program by providing additional wells in areas distant from proposed pumping centers, information on the distribution of hydraulic properties in the unconsolidated deposits beneath the valleys and along streams, information on the source areas to high-discharge springs, determination of the ground-water divide between southern Spring and southern Snake valleys, and hydraulic properties of carbonate rocks along the topographic divide between southern Spring and northern Hamlin valleys. The results of the proposed study will provide the additional data needed to develop a clearer understanding of the entire hydrologic system in the study area, potentially resulting in more realistic and reliable numerical flow models.

The study objectives are directly related to the mission and long-term plans of the USGS. Specifically, this study is aligned with the USGS science strategy goal for developing a water census of the United States to inform the public and decision makers about the status of freshwater resources by quantifying, forecasting, and securing freshwater for America's future (USGS, 2007). This study also is aligned with issue 1, refined water budgets and issue 3, ecological health, of the 2004 Nevada District Science Center Plan.

APPROACH

Nine new basin-fill and carbonate-rock test wells are planned or under construction in the southern part of the study area (fig. 1). Five new wells (besides one that has already been drilled) will be drilled by the Southern Nevada Water Authority as part of a stipulated agreement between the Water Authority and the Federal bureaus. The remaining three wells will be drilled as part of this study. Geologic, hydrologic, and chemical data collected from these wells will be used to estimate the annual quantity of ground-water flow across the topographic divide and to evaluate the source of water to Big Springs. The USGS, Utah Water Science Center also is drilling several new test wells on the Utah side in southern Snake Valley. Locations of wells to be drilled by this study and as part of stipulated agreement are shown on figure 1. Six of these wells will be screened in carbonate rocks and three will be screened in basin fill. Two of the basin-fill wells are planned about one mile northwest and southwest of Big Springs and are designed for the purpose of evaluating the source of water to the springs. Table 1 provides general location information and anticipated/completed well construction.

Single-well aquifer tests will be done to estimate the water-transmitting and storage properties of the rocks and deposits encountered in each of the new test wells. Each well will be pumped for a minimum of one day and a maximum of five days. For each aquifer test, the pumping rates, water-level declines, and temperature will be routinely collected in each well during the pumping period. Prior to commencement of the aquifer test, two weeks of water-level and temperature data will be collected. Water levels and temperatures will continue to be collected for one month after pumping ceases.

At most, 17 shallow test wells will be drilled in the northern part of the study area (locations shown on fig. 1). Two wells not more than 250 feet deep are planned west and south of Roland Spring and are designed for the purpose of evaluating the source of water to the spring. Single-well aquifer tests also will be done at these wells. At most, five wells each will be drilled to depths of less than 60 feet near Lehman, Baker, and Snake Creeks. Access along Lehman Creek is extremely limited on Federal land and consequently only the pumping well likely will be drilled 50 ft from the Creek. The test on Lehman Creek may be limited to the pumped well and several shallow piezometers driven into the streambed along the sub-reach adjacent to the pumped well. Multiple well-aquifer tests will be done at these sites to evaluate the connectivity of the streambed to ground water. The details of these wells and aquifer tests are described in the approach to element 3. Table 1 provides the general-location information and anticipated/completed-well construction of each well.

Table 1—Location, elevation, total depth, hole diameter, well diameter, screened interval, lithology, and geophysical logs proposed test wells

UTM coordinates 11S (NAD83)[1]	Elevation (feet above mean sea level)	Total depth (feet)	Hole diameter (inches)	Well diameter (inches)	Screened interval (feet)	Lithology	Geophysical logs [2]	Priority[3]
741549E 4320644N	6,790	250	10	6	50	Pole Canyon Limestone	Yes	1
740821E 4321301N	6,770	250	10	6	50	Pole Canyon Limestone	Yes	2
741625E 4321631N	6,590	<60	10	6	25	Basin fill	Yes	3[4]
743839E 4320744N	6,210	<60	10	6	25	Basin fill	Yes	4[4]
752906E 4312117N	5,620	<60	10	6	25	Basin fill	Yes	5[4]
747688E 4287827N	5,800	400	10-12	6-8	200	Basin fill	Yes	6
744915E 4258052N	6,200	750	10-12	6-8	200	Carbonate	Yes	7
747617E 4285855N	6,000	600	10-12	6-8	200	Carbonate	Yes	8

[1]Wells are shown on figures 1, 2, and 3 by priority number.
[2]Geophysical logs include caliper, temperature, short- and long-normal resistivity, spontaneous potential, natural gamma, and flow-meter logs.
[3]Wells listed in order of priority. Uncertainty of actual drilling may require additional funds to complete all desired wells.
[4]Wells to include two 35-foot deep wells and two 15-foot deep wells next to stream (see figure 4). These shallow wells will be 2-inch diameter PVC with 5-foot screened intervals.

The approach proposed for each element is described below:

Element 1. Characterize the distribution and geometry and hydraulic properties of the Cenozoic sedimentary rocks and coarse- and fine-grained basin-fill deposits.

- The distribution and geometry of the sedimentary rocks and basin-fill deposits will be delineated using geologic maps correlated with magnetotelluric, aeromagnetic, seismic, and audio-magnetotelluric geophysical surveys. Analysis of lithologic and geophysical logs from existing wells (including oil and gas and MX wells) and planned or newly completed wells (stipulated agreement, USGS, Utah Water Science Center, and proposed wells) will constrain (complement) a three-dimensional depiction of the hydrogeologic framework.

- The percent of coarse-grained deposits (gravel) within the basin-fill deposits will be estimated from geologic sections (outcrop) measured in the field and lithologic data provided on drillers' logs and correlated with hydraulic tests (specific capacity and aquifer tests) to construct lithofacies maps of the basin-fill aquifer in a manner similar to that described by Bredehoeft and Farvolden (1962).

- The spatial and vertical distribution of hydraulic properties will be determined from aquifer tests performed at the planned or newly constructed wells and compiled from available hydraulic data from existing wells.

- Geologic maps, cross-sections, and three-dimensional interpretations of unit thickness, lithology, grain-size distribution, location and importance of faulting based on outcrop, geophysical, and well data in Lehman, Baker, and Snake Creeks drainage basins and in the vicinity of Big Springs will be constructed. Rockworks software will be used to construct these products.

Element 2. Characterize streambed hydraulic conductivity and quantify the volume of water exchanged between the ground-water and surface-water along selected reaches of Lehman, Baker, and Snake Creeks.

- Streambed hydraulic conductivity will be quantified along selected reaches of the Lehman, Baker, and Snake Creeks using a combination of surface (on the streambed) and subsurface (0.5 and 1 m below the streambed) temperature measurements, river stage at temporary surface-water gages, synoptic streamflow measurements (seepage runs), temperature and water-level measurements in shallow piezometers installed in the streambed, and from multiple-well aquifer tests. The extent of the reaches of interest in this study begin where streams flow across carbonate-rock units and terminate where the streams are either diverted into lined canals or at the Nevada state line.

- Temperature profiling and seepage runs will be done twice during the study along the selected stream reaches shown in figures 2 and 3, once during June-July when flows tend to be high during snowmelt runoff and once during October-November when streamflow is at a minimum. A 1,000-meter-long optical-temperature cable will be placed on the streambed of each creek. The streambed temperature data from the optical cable will be collected every five minutes for 48 hours at 1-meter increments in conjunction with subsurface temperature data from shallow piezometers installed 0.5 and 1-meter below the streambed every 100-meters. The data will be used to determine gaining and losing sub-reaches (Selker and others, 2006) and to determine the streambed hydraulic conductivity along each creek (Niswonger and Prudic, 2003). Additionally, pressure transducers will be placed in each piezometer and in the stream and record data at 5-minute increments over a 48-hour period and streamflow at the upstream and downstream end of the optical cable will be measured every two hours during daylight. The procedure will be repeated until the entire reach of each stream has been surveyed. Expected results from this phase of the study will be mapped areas of gaining and losing reaches at a finer scale then what can be determined from simply computing the difference between stream discharge measurements along the stream. This approach also should provide an independent estimate of hydraulic conductivity of the streambed that can be compared to basin-fill hydraulic conductivity estimated in element 1.

- Three groups of three relatively shallow wells (less than 60 feet deep) will be drilled, one group of wells each on Lehman, Baker, and Snake Creeks (location of proposed sites also are shown on figure 2 and 3). A 50-to-60-foot-deep 6-inch diameter monitoring well will be drilled about 50 feet away from the stream and screened over the saturated interval. Two test wells will be drilled adjacent to the stream approximately 25 feet upstream and downstream of the pumped well (fig. 4). Each of the two test wells next to the stream will have a dual completion using nominal 2-inch diameter PVC monitoring wells with five-foot screens completed at depths of between 10 and 15 feet and 30 and 40 feet. Access to Lehman Creek is limited and thus only the 60-ft deep well likely will be drilled. Shallow piezometers will be placed beneath the streambed for the aquifer test (fig. 4). A 48-hour aquifer test will be completed along the selected sub-reach of each creek. The six-inch well will be pumped at a constant rate of 200 to 400 gallons per minute provided the materials are sufficiently permeable. Water-level and temperature data will be recorded in the pumped and observation wells and in shallow piezometers temporarily installed in the streambed. The optical temperature cable will be placed along the reach and two pressure transducers at the upstream and downstream end of the cable measured every five minutes and compared with stream discharge measured every two hours during daylight. Analysis of the data will provide estimates of the vertical and horizontal hydraulic conductivities of the upper 50 feet of alluvium next to the stream and within the streambed. These estimates will be compared to estimates from the streambed temperature survey and seepage runs and to estimates using the methodology described in element 1.

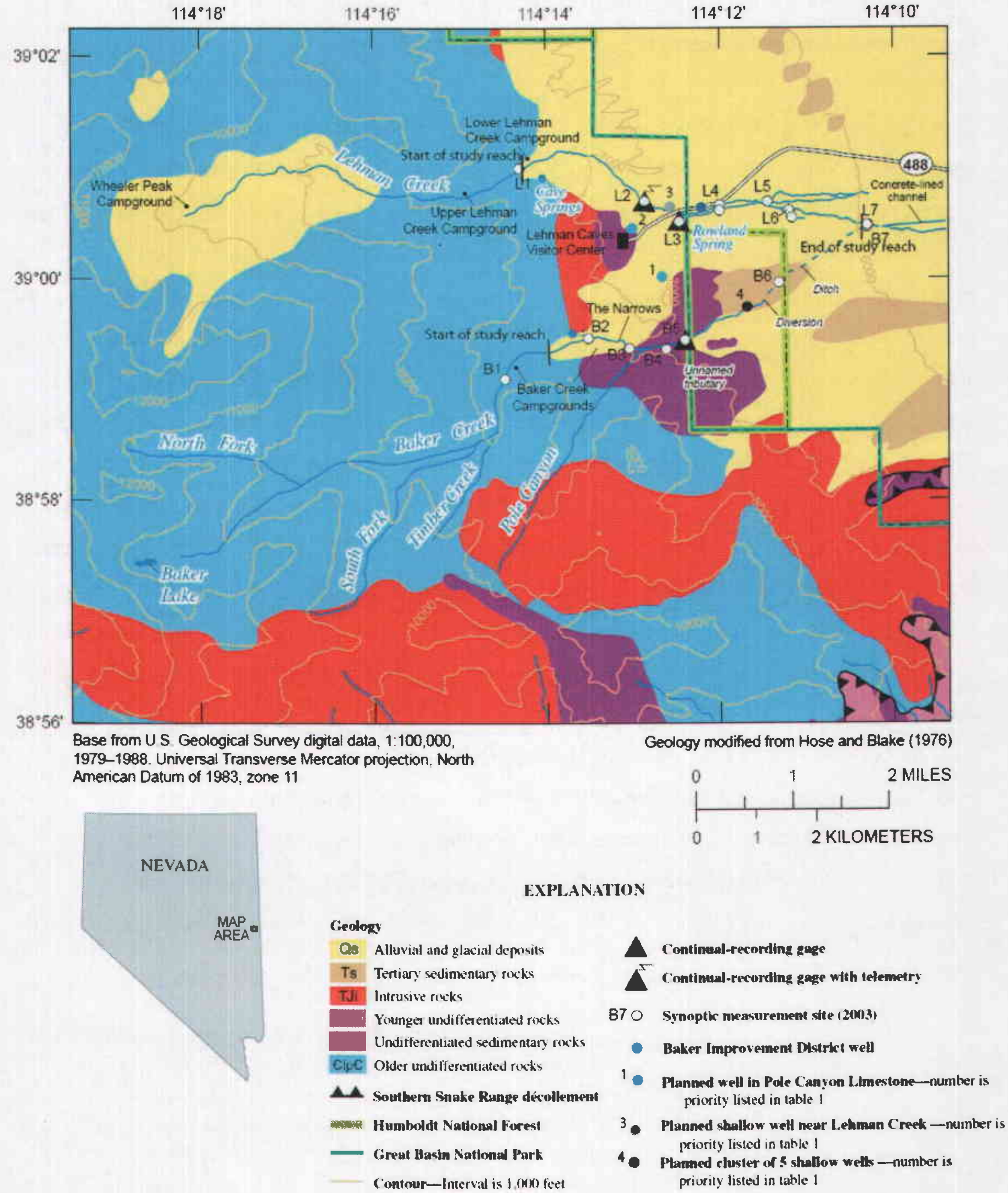

Figure 2—Study reaches along Lehman and Baker Creeks and proposed locations of wells.

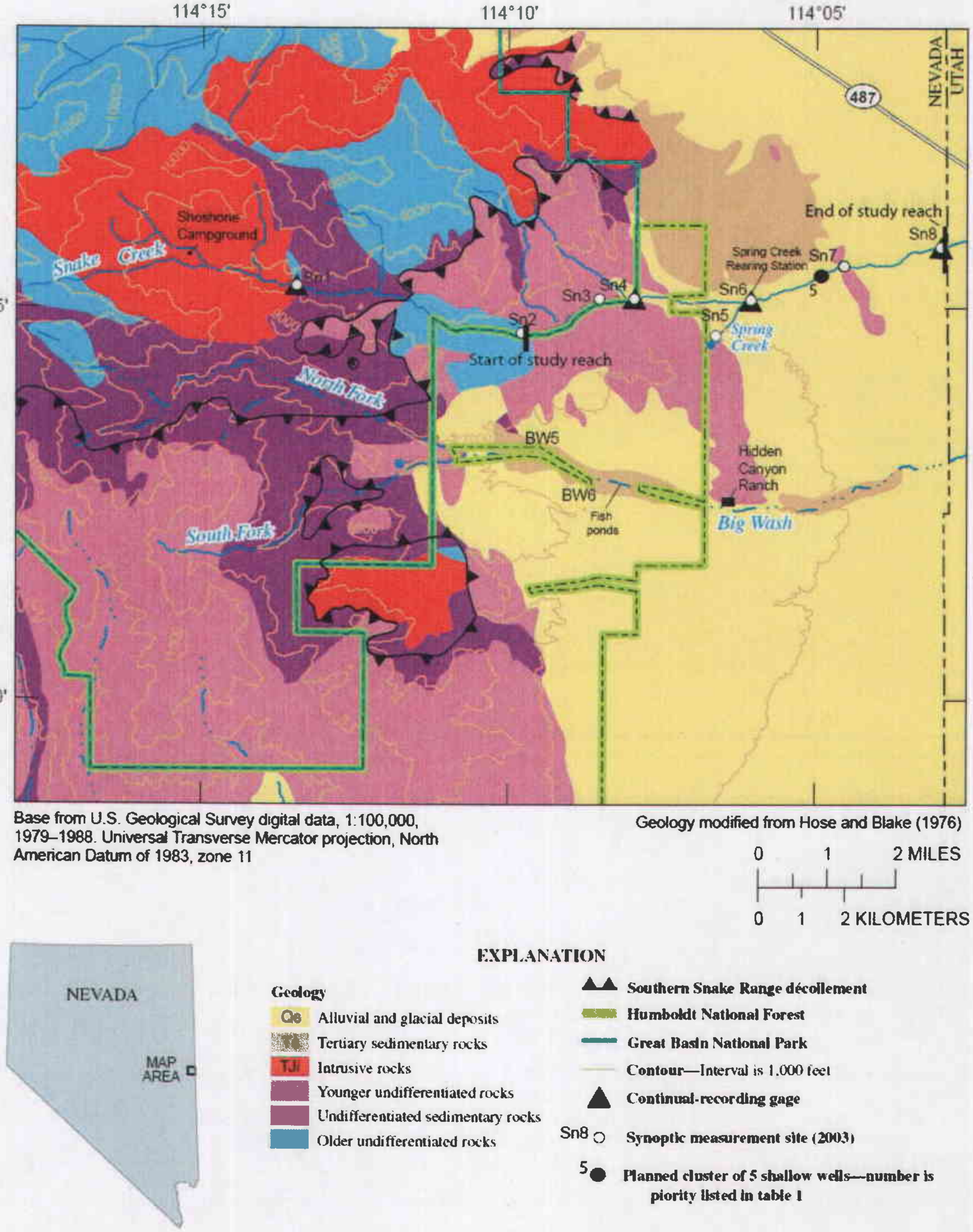

Figure 3—Study reach along Snake Creek and proposed locations of wells.

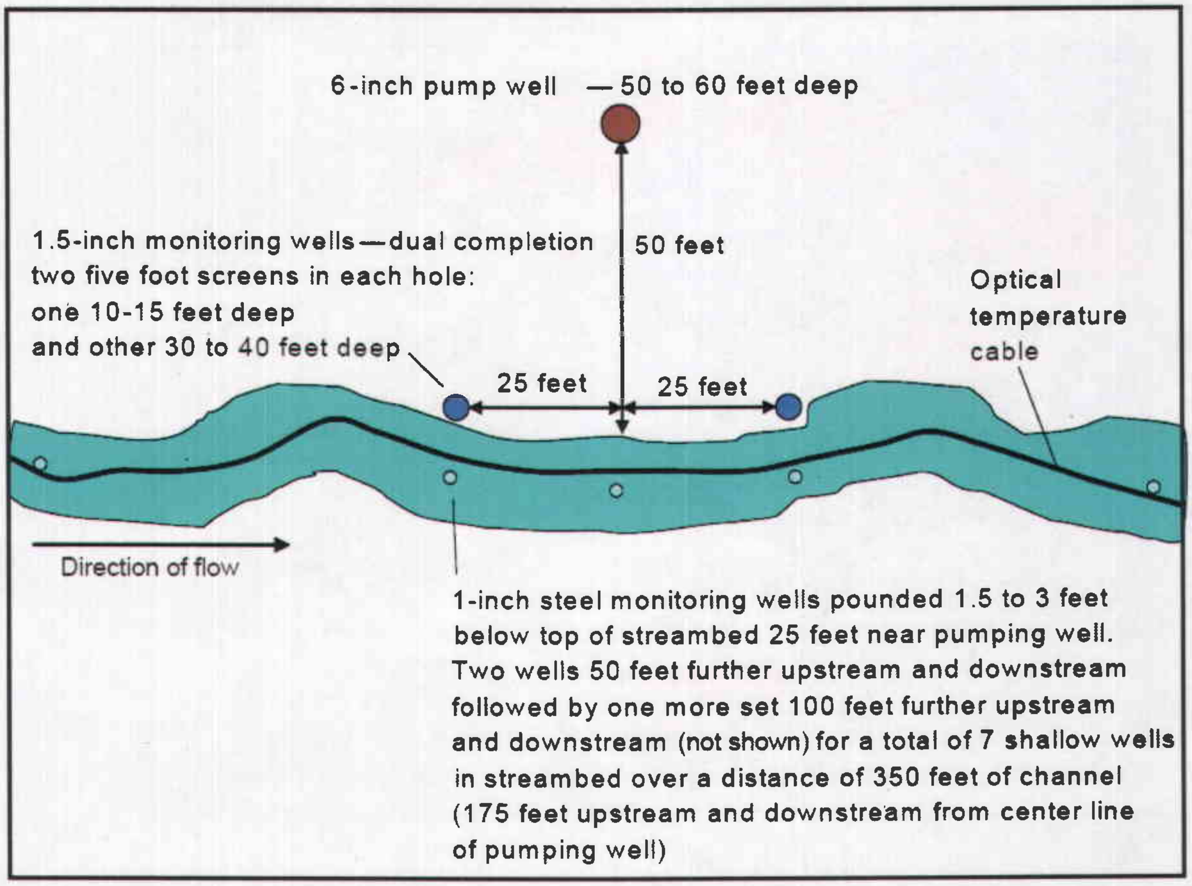

Figure 4—Diagram of multiple-well aquifer test along a stream.

Element 3. Determine the source of water to Rowland and Big Springs.

- The source of water to Rowland Spring and Big Springs will be evaluated from two complete suites of samples collected under low-flow and peak-flow conditions. Source of water to Rowland Spring will be evaluated from samples collected at Rowland Spring, Lehman and Baker creeks, and from two wells to be completed in the carbonate-rock aquifer between Rowland Spring and Baker Creek and Lehman Caves and Rowland Spring. Source of water to Big Springs will be evaluated from samples collected at Big Springs, two 500-foot basin-fill wells located about one mile northwest and 0.75 miles southwest of the spring area, and a 700-foot carbonate-rock well located about two miles southwest of the spring (fig. 1, table 1). Additionally, monthly water samples will be collected for one year from the springs, creeks, wells, and from rain gages and analyzed for major ions as well as the stable isotopes of oxygen and deuterium. Variability in dissolved constituents among the monthly samples will indicate if sources of water to Rowland Spring or Big Springs vary over time. The geochemical mixing model NETPATH (Plummer and others, 1994) will be used to estimate the percentages of water from the two wells discharging at Rowland Spring and Big Springs.

Element 4. Estimate subsurface flow across the topographic divide between southern Spring Valley and northern Hamlin Valley/southern Snake Valley and delineate the ground-water divide in southern Spring Valley.

- Four carbonate-rock wells will be completed along a north-south transect in the Limestone Hills, a topographic feature separating southern Spring Valley and northern Hamlin Valley (fig. 1). One 850-foot deep well will be drilled at the southern end of the Limestone Hills as part of this study (fig. 1). Three other carbonate-rock wells will be completed along the Limestone Hills as part of the stipulated agreement between Southern Nevada Water Authority and the Federal bureaus (fig. 1). Additionally, an exploratory well previously was drilled into carbonate rock west of the Limestone Hills by the Southern Nevada Water Authority prior to the stipulated agreement. Lithologic logs will be prepared by Southern Nevada Water Authority and the USGS. Geophysical logs including caliper, short- and long-normal resistivity, spontaneous potential, natural gamma, pumping temperature and pumping flow logs will be run in the wells during the drilling of each well.

- Flow-log data collected in the wells will be used to identify the water-bearing zones in the screened intervals of the wells. These data will be used to approximate the effective thickness of the carbonate rocks through which subsurface water flows. Estimates of hydraulic conductivity of the water-bearing zones will be estimated for each well by dividing the overall transmissivity estimated from a single-well aquifer test ~~and with~~ the thickness of transmissive zones within the screened interval. The effective thickness to the overall screened interval will then be prorated to the entire thickness of carbonate rocks beneath the limestone hills based on geologic interpretation.

- A water sample will be collected from the new southernmost monitoring well and analyzed for dissolved constituents listed in table 2. Additionally, samples will be collected from the six DOI/SNWA Stipulated Agreement wells drilled on the south end of the southern Snake Range and analyzed for chlorofluorocarbons, dissolved gases, and Helium 3-4. Contemporaneous sampling of these wells will be coordinated with Southern Nevada Water Authority.

- Potentiometric-surface maps in the vicinity of Limestone Hills will be prepared using water levels collected in the new wells and nearby existing wells in southern Spring Valley, northern Hamlin Valley, and southern Snake Valley. Ground-water gradients across the Limestone Hills will be determined using these potentiometric-surface maps. The quantity of subsurface flow from southern Spring Valley to southern Snake Valley will be estimated using Darcy's Law. The hydraulic properties will be estimated from aquifer tests and flow logs. The gradients will be estimated from the potentiometric-surface maps, and the effective cross-sectional area will be estimated from geologic and hydrologic interpretation of test well information. Uncertainty in the volume of subsurface flow across the Limestone Hills will be evaluated.

Table 2—Water chemistry field measurements and analysis of dissolved constituents

Field parameters	Major ions	Trace elements	Isotopes/dissolved gases
Water temperature	Total Dissolved Solids	Arsenic	Deuterium
Air temperature	Calcium	Barium	Oxygen-18
pH	Magnesium	Cadmium	Tritium
Electrical conductivity	Potassium	Chromium	Chlorine-36*
Dissolved Oxygen	Chloride	Lead	Carbon-14*
Alkalinity	Sodium	Mercury	Carbon 12/13
	Fluoride	Selenium	Strontium-86/87
	Bromide	Silver	Uranium-234, 235, 238*
	Sulfate	Manganese	Dissolved gases
	Nitrate	Aluminum	Helium-3/4*
	Phosphate	Iron	Chlorofluorocarbons
	Silica		

*Optional – to be determined at a later date.

Work will begin in the 3rd quarter of FY2008 (table 3). Work in FY2008 and during the first two quarters of FY2009 will focus on project planning and public outreach (meetings with interested parties in Ely and Baker, Nevada), and completing the necessary NEPA forms for drilling wells on BLM and NPS lands and well drilling permits from the Nevada State Engineers Office. One set of optical temperature measurements along the three creeks will be done during September and October 2009. Well drilling is planned for April-June 2009 followed by aquifer tests in wells and water chemistry. Most of the field work will be completed by the end of the first quarter of FY2010 except for the monthly sampling of water chemistry from Roland Spring, two monitoring wells, and Lehman and Baker Creeks (Element 3). This sampling will continue through the third quarter of FY2010 when all fieldwork will be completed. An initial draft of the report will be completed during the second quarter of FY2011 (table 3).

REPORTS

A fact sheet describing the research objectives, anticipated products, and timelines of the proposed project will be published by the end of fiscal year 2008. The purpose for preparing this document is to provide an outreach mechanism that will address issues of public interest by providing information related to new scientific research in east-central Nevada.

A multi-chapter U.S. Geological Survey Scientific Investigations Report will summarize the results of the project. Chapter 1 will be an executive summary that will provide the principal findings of the study in terms of the connectedness of Lehman, Baker, and Snake creeks to carbonate-rock and basin-fill aquifers, the source of water to Rowland Spring and Big Springs, and an estimation of the subsurface flow from southern Spring Valley into northern Hamlin Valley, and then into southern Snake Valley. Chapter 2 will provide a characterization and delineation of the consolidated sedimentary rock and basin-fill deposits and will include maps and diagrams that delineate the distribution of fine- and coarse-grained basin-fill deposits and associated hydraulic characteristics within each of the two areas. Streambed hydraulic conductivity and quantification of the volume of water exchanged between ground water and surface water will be described in Chapter 3. Sources of water to Rowland Spring and Big Springs will be documented in Chapter 4. An estimate of the volume of subsurface flow between southern Spring and Hamlin Valleys will be documented in Chapter 5. The Scientific Investigations Report will be reviewed by internal USGS reviewers and two independent external reviewers plus formal reviews by the each of the participating Federal Nominating Organizations and the Southern Nevada Water Authority. Anticipated report milestones are listed in table 3.

Table 3— Quarterly schedule of study tasks.

Task	FY08		FY09				FY10				FY11			
	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
Drill planning and well permits	X	X	X											
Well drilling and aquifer testing				X	X									
Element 1			X	X	X	X	X	X	X	X				
Element 2			X	X	X	X	X	X	X	X				
Element 3					X	X	X	X	X	X	X			
Element 4					X	X	X	X	X	X	X			
Letters of quarterly progress	X	X	X	X	X	X	X	X	X	X	X	X		
Draft of final report												X		
Final report review													X	
Final report release														X

PERSONNEL

The project will require coordination between the U.S. Geological Survey, Water Resources and Geologic Disciplines, and the University of Nevada, Reno. The first element will be done largely by Donald Sweetkind (USGS, Geologic Discipline, Denver, CO), Alan Wallace (USGS, Geologic Discipline, Reno, NV), and Russell Plume (USGS, Nevada Water Science Center, Carson City, NV). The well drilling will be done by the California Drill Rig (formerly the Western Drill Rig) supervised by Steven Crawford. A Nevada licensed well driller from the Nevada Water Science Center will be present during the drilling of all wells. The aquifer tests will be done under the supervision of Keith Halford with personnel within the

Nevada Water Science Center. Water quality sampling and analyses of the wells will be done by the Yucca Mountain Environmental Science team with assistance from the Nevada Water Science Center. Element 2 will be done under the supervision of David Prudic and Scott Tyler at the University of Nevada, Reno. Element 3 will be done under the supervision of Michael Lico of the Nevada Water Science Center, and element 4 will be done under the supervision of Russell Plume and Lari Knochenmus. If there is sufficient funding, additional work may be contracted to the Utah Water Science Center for helium-3/4 analysis (Victor Heilweil) and for dye tracing between the new test wells and Roland Spring (Larry Spangler).

BUDGET

The work plan and therefore the budget have been divided among three groups. The three groups are the USGS, Nevada Water Science Center, the USGS, Geologic Discipline, and the University of Nevada, Reno. Funds to each of the three groups will be managed and distributed directly by William Van Liew, Water Rights Branch, National Park Service, Fort Collins, CO. The entire project is funded for $2,000,000 of which $1,460,000 is for the Nevada Water Science Center, $240,000 is for the Geologic Discipline, and $300,000 is for the University of Nevada, Reno. Oversight of the overall project will be the responsibility of William Van Liew (National Park Service) and David Prudic (USGS retired and University of Nevada, Reno). Distributions to the California Drill Rig and the Yucca Mountain Environmental Science team, and possibly to the Utah Science Center will be done by the Nevada Water Science Center. Although every effort will be made to fund the work proposed by the Utah Water Science Center (helium-3/4 sampling and analysis and dye tracing at Roland Spring), uncertainties related to drilling and now increased fuel costs may require the elimination of that work because it has the lowest priority. The drilling along with the primary components to elements 1-4 as outlined in the proposal are of the highest priority. The budget for each of the three groups is itemized by year and cost category (tables 4-6) and has been adjusted for inflation (maybe not sufficient given the rapid rise in cost for fuel).

Table 4.—Total budget of $1,460,000 to Nevada Water Science Center, Water Resources Discipline, itemized by cost categories (gross funds) adjusted for inflation

Cost category	FY08	FY09	FY10	FY11
Labor	35,000	370,000	330,000	52,000
Travel	4,000	25,000	22,500	4,000
Vehicles	2,000	15,000	12,500	2,000
Freight/shipping	250	4,000	3,500	500
Supplies and materials	2,000	25,000	7,500	2,000
Well Drilling (USGS California Drill Rig)	--0--	420,000	--0--	--0--
USGS National Water Quality Laboratory, CFC laboratory, Yucca Mountain Environmental Laboratory	--0--	50,000	50,000	--0--
Report processing (Work Plan—Fact Sheet inFY08; Final SRI report in FY11)	3,750	--0--	--0--	17,500
Totals	$47,000	$909,000	$426,000	$78,000

Table 5.—Total budget of $240,000 to Geologic Discipline, itemized by cost categories (gross funds) adjusted for inflation

Cost category	FY08	FY09	FY10	FY11
Labor	--0--	130,000	80,000	14,000
Travel	--0--	12,000	4,000	--0--
Vehicles	--0--	--0--	--0--	--0--
Freight/shipping	--0--	--0--	--0--	--0--
Supplies and materials	--0--	--0--	--0--	--0--
Totals	--0--	$142,000	$84,000	$14,000

Table 6.—Total budget of $300,000 to Geologic Sciences Department, University of Nevada, Reno, itemized by cost categories (gross funds) adjusted for inflation

Cost category	FY08	FY09	FY10	FY11
Labor	16,700	114,700	86,400	14,700
Travel	3,000	11,700	3,600	500
Vehicles	1,200	5,800	1,800	500
Freight/shipping	100	300	200	150
Supplies and materials	2,200	5,000	4,500	350
Equipment	7,500	12,300	--0--	--0--
Tuition	1,500	3,500	1,800	--0--
Totals	$32,200	$153,300	$98,300	$16,200

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