REPORT ON THE HYDROGEOLGY OF

PROPOSED SOUTHERN NEVADA WATER AUTHORITY

GROUNDWATER DEVELOPMENT

Prepared for Office of the Nevada State Engineer
on behalf of
Great Basin Water Network

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INTRODUCTION

After having reviewed SNWA’s July 1 evidentiary submissions, I have the following observations:

DATA

In my June Report, I included a Table from Myers (2011) that lists recharge estimates to a number of the valleys under consideration. I indicated that the estimates of recharge varied widely and reflect a level of uncertainty. I include the Table here in order to make a further point:

Table 1. Estimates of pre-development recharge, from Myers, 2011 (ac-ft/yr).

	Recon Report or Water for Nevada	**Flint et al (2004) (mean year)**	**Flint et al (2004) (time series)**	**Flint and Flint (2007)**	**LVVWD (2001)**	**Kirk and Campana (1990)[2]**
Cave Valley	14000	10264	9380	11000	19500	11999
Dry Lake Valley	5000	10627	11298		13300	6664
Delamar Valley	1000	7764	6404		4600	1926
White River Valley	38000	34925	30759	35000		35001
Pahroc Valley	2200	4432	4832			1994
Pahranagat Valley	1800	7043	7186			1508
Coyote Spring Valley[1]	1900	5184	5951			5344
Kane Springs[1]	500	5421	6328			997
Garden/Coal Valley	12000	21813	18669			10994
1 - The recon report estimated 2600 af/y for Coyote Spring and Kane Springs Valleys together. The estimates here are from Water for Nevada.						
2 - Values adjusted from m^3/s						

	Snake Valley	**Spring Valley**	**Steptoe Valley**	**Tippett Valley**	**Deep Creek**
Reconnaissance Reports (Hood and Rush, 1965; Rush and Kazmi, 1965; Eakin et al, 1967; NV Div of Water Resources, 1971)	103000	75000	85000	7000	17000
Watson et al (1976)		63000	75000	5000	
		33000	45000	6000	
Nichols (2000)		104000	132000	13000	

Epstein (2004), as referenced in Welch et al (2008)		93000	101000	9000	
Dettinger (1989)		62000			
Flint and others (2004)	93000	67000	111000	10000	12300
	82000	56000	94000	8000	11400
Brothers et al (1993 and 1994), as referenced in Welch et al (2008)	110000	72000			
Flint and Flint (2007); Welch et al (2008)	111000	93000	154000	12000	

Myers, in Table 1, lists nine estimates of recharge for Spring Valley. One can treat these estimates as independent and normally distributed. Figure 1 is a plot of the estimates—assuming they are normally distributed:

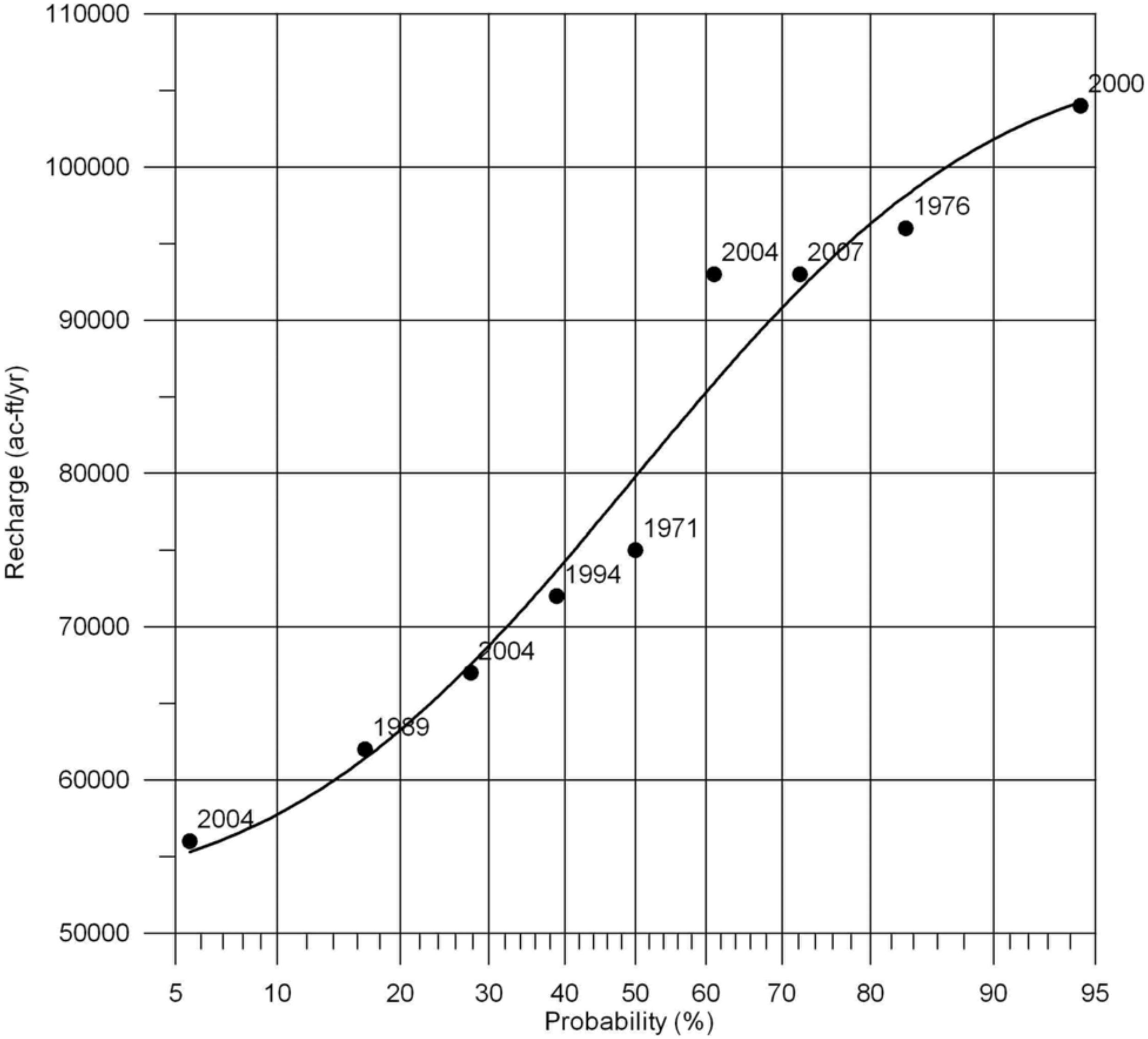

Figure 1. Probability distribution for nine estimates of recharge for Spring Valley. The line is a linear fit through the data.

One sees that the estimates vary from less than 60,000 to more than 100,000 ac-ft/yr, with a mean value of 80,000 ac-ft/yr. Figure 1 indicates the uncertainty in the water budget data, The plot suggests that one standard deviation about the mean is plus or minus 10,000 ac-ft/yr—70,000 to 90,000 ac-ft/yr. There is almost no suggestion that the recent estimates are any better than the older ones.

MODEL PROJECTIONS

I pointed out in June that there are at least three models that have been used to estimate the impact of the SNWA development upon the hydrology of Spring Valley:

1. SNWA (2009,2010)
2. Myers (2011)

3. Durbin and Loy (2010)

For Cave, Dry Lake, and Delamar Valleys there are two recent models:

1. SNWA (2009,1010)
2. Myers (2011)

Myers used the earlier USGS RASA (Prudic et al, 1995) two-layer model for which he refined the Prudic et al grid in the area of interest.

Watrus and Drici (SNWA, 2011) only projected drawdown from full project build out for 75 years. However, in SNWA's earlier Simulation report for the Draft Environmental Impact Statement (SNWA, 2010) a number of scenarios of project development were simulated for 200 years of full operation.

All of the several models give similar projections of drawdown.

The three models depicted in Figure 2 show overall similar projected drawdown. Each has a large cone of depression in the central part of the valley. Each model projects drawdown in the southern part of the valley; the projected drawdown is deeper in the SNWA and Durbin and Loy models than in the Myers model. Each model used similar amounts of pumping distributed in approximately the same locations. SNWA's projected drawdown (A) is taken from the SNWA (2010) Simulation report, and represents 200 years of operation after full build out of the project. Full build out entails 91,000 ac-ft/yr of project pumping plus the existing pumping of 6,000 ac-ft/yr at the current points of diversions (Alternative B in the Simulation Report—SNWA, 2010). Myers (2011) projected drawdown (B) results from simulating pumping 91,000 ac-ft/yr at the current points of diversion in addition to the current pumping in the valleys. Durbin and Loy (2011) use the drawdown procedure and simulate the 91,000 ac-ft/yr of pumping at the current points of diversion.

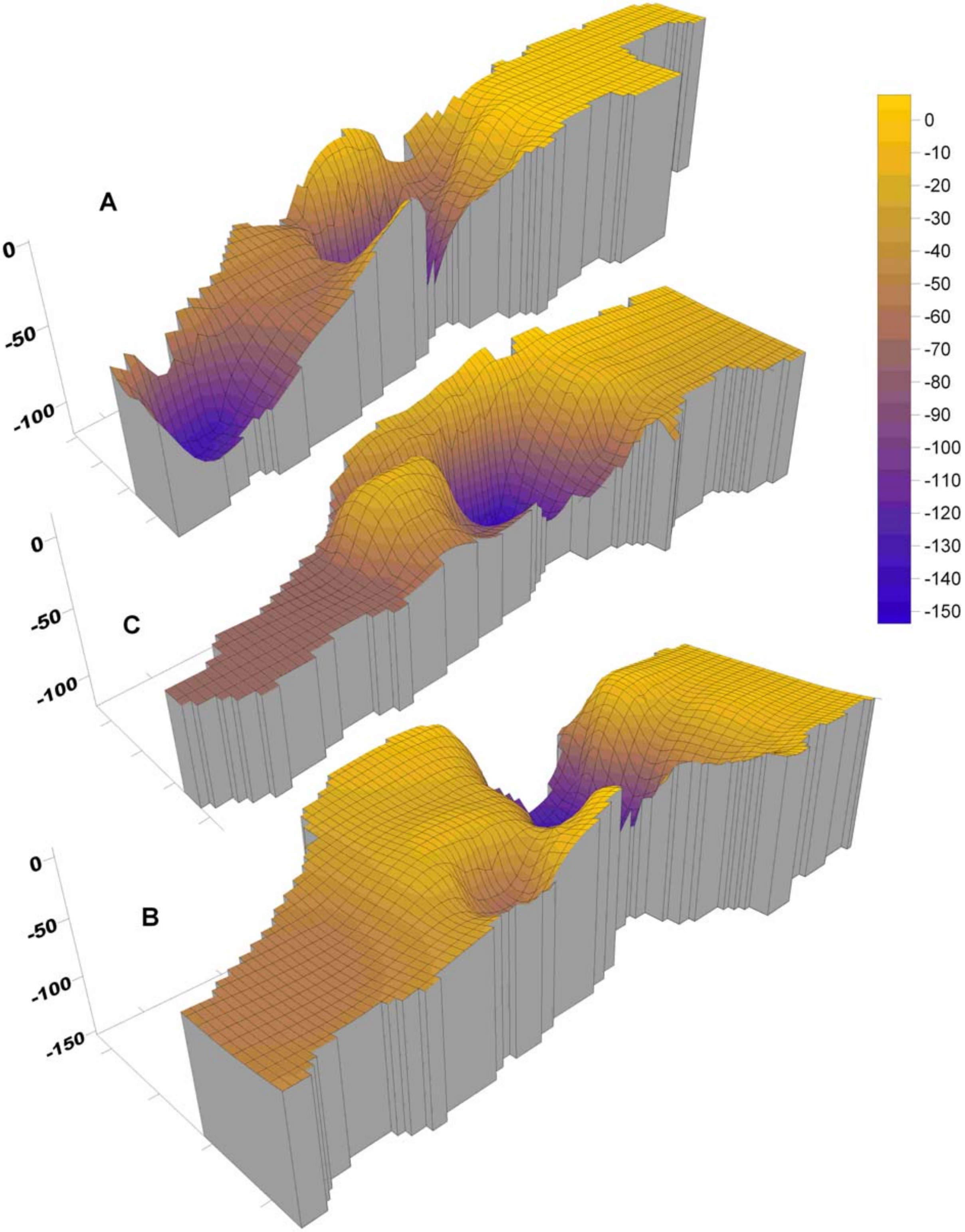

Figure 2. Projected drawdown in the alluvial aquifer for 200 years of full project pumping in Spring Valley from three different models: (A) SNWA, (B) Myers, and (C) Durbin and Loy.

Figure 3 is a comparison of model projections for Cave, Dry Lake, and Delamar Valleys:

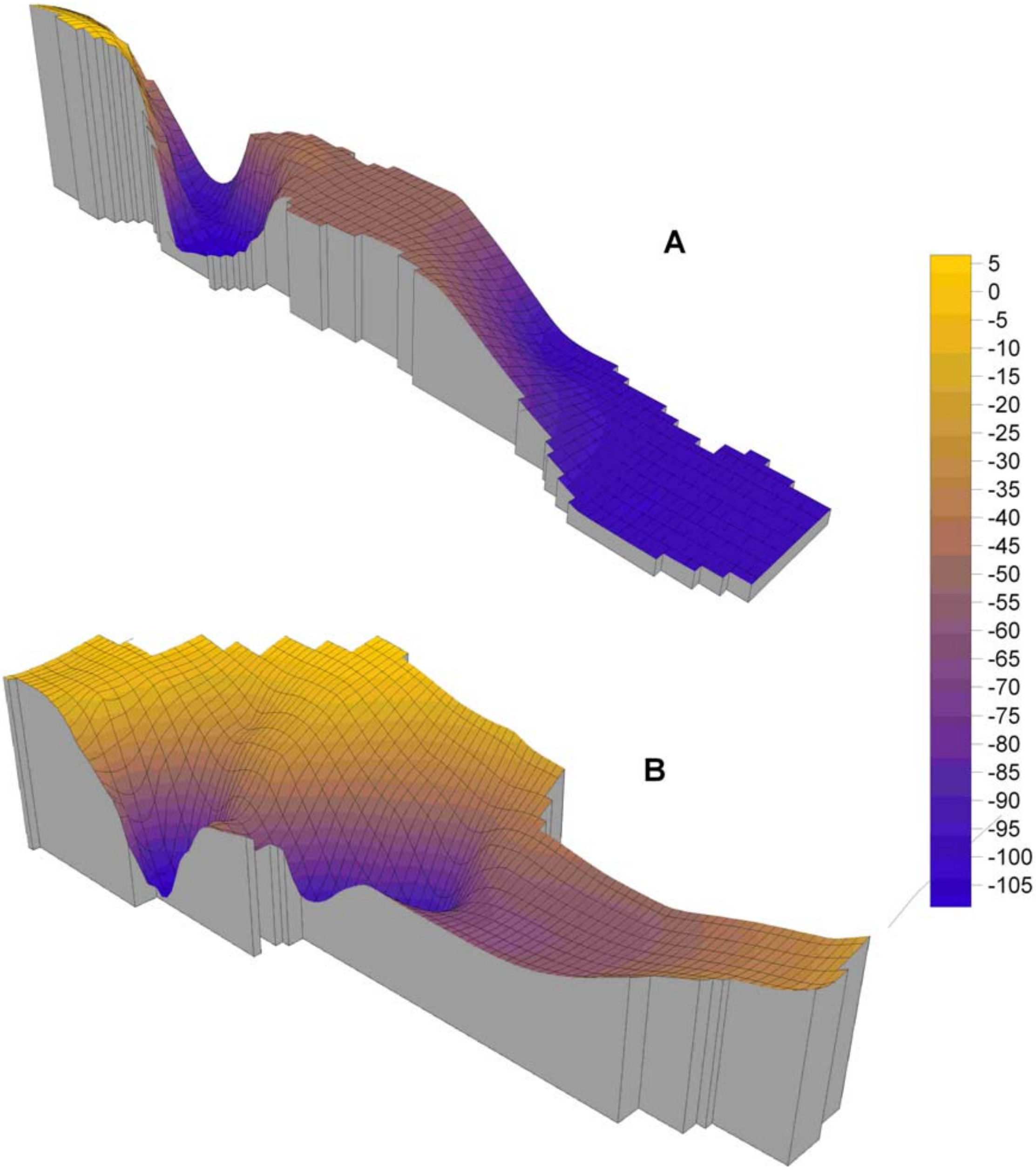

Figure 3. Projected drawdown in the alluvial aquifer for 200 years of pumping in Cave, Dry Lake, and Delamar Valleys from two different models: (A) SNWA, (B) Myers.

SNWA's projected drawdown (Figure 3—A) is taken from the SNWA (2010) Simulation report, and represents 200 years of operation after full build out of the project—35,000 ac-ft/yr at the current points of diversion. Myers (2011) used the USGS RASA two-layer model in which he refined the grid in the vicinity of the subject valleys. Myers simulated the same pumping stresses at approximately the same places.

Both results are projected drawdown for the alluvial aquifer. The RASA model does not emphasize the north-south faults associated with mountain ranges as significant barriers to groundwater flow in the Carbonate Aquifer as the other models do. For this reason using the RASA model tends to project drawdown with a wider extent in an east and west direction. This effect is only hinted at in Figure 3—B, since the plots are shown only for the three valleys—Cave, Dry Lake, and Delamar,

One concludes from all of the model projections that there will be significant hydrologic impacts on the system over a wide area as a result of SNWA's proposed development. The Draft EIS (SNWA, 2010) makes this point explicitly for not only Cave, Dry Lake, and Delamar Valleys, but Spring and Snake Valleys, as well. The question is: can such significant impacts properly be permitted, and if so what can be done about the impacts?

MONITORING

The current conceptual model is that recharge in Cave, Dry Lake and Delamar Valleys creates discharge in other down gradient valleys. The current accepted concept is that the outflow from Delamar Valley passes through Coyote Springs Valley and creates some of the spring discharge to the Muddy River Springs. Delamar Valley is 50 miles, or so, north of the Muddy River Springs, while Dry Lake is approximately 100 miles to the north. The current SNWA modeling suggests that there will be no impact on the Muddy River Springs from the pumping within the simulated 200-year planning horizon. Nevertheless, we know from first principles that sooner or later the springs will be impacted by the pumping—the pumping will ultimately capture the spring flow.

However, it is infeasible to monitor the Muddy River Springs and discriminate a pumping signal created by the pumping in these valleys (Bredehoeft, 2011). I simulated a spring discharging from the lower end of a large valley, as shown in Figure 4:

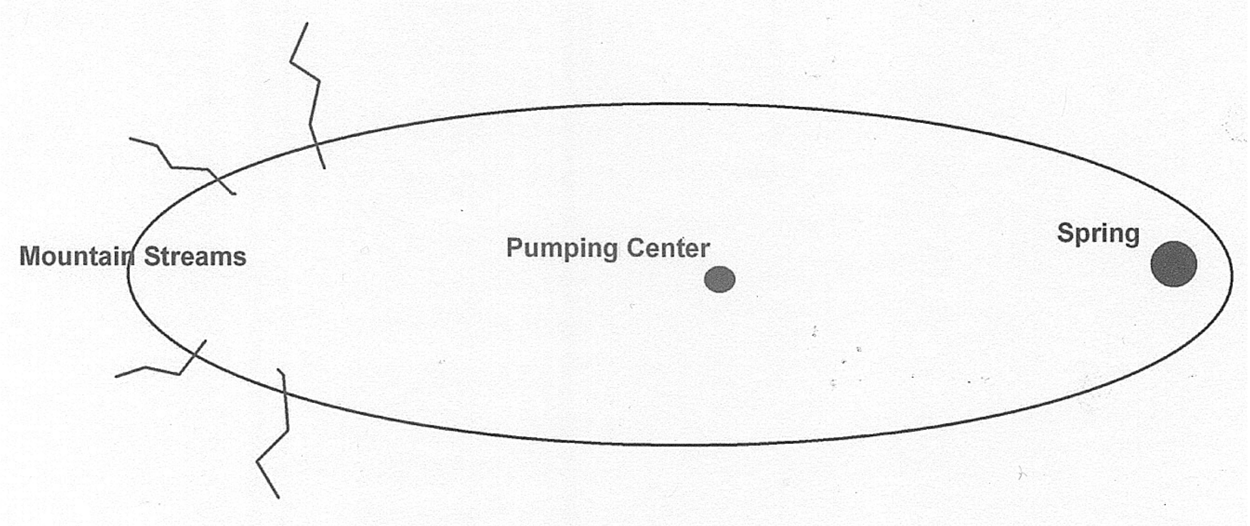

Figure 4. Hypothetical Valley 100 miles long and 25 miles wide, with recharge of 100 cfs from mountain streams to the left, and a spring discharging at a rate of 100 cfs to the right. The pumping is centered in the valley 50 miles from the spring.

In the hypothetical valley pumping is initiated at 100 cfs, equal to the recharge and the initial spring flow. The valley is rather permeable with a transmissivity of 25,000 ft^2/day, and storativity of 0.1 (10% specific yield). The pumping gradually captures flow from the spring. At the point at which the spring flow drops by 10% (90 cfs) pumping is stopped. Figure 5 is a plot of the spring discharge during the period of pumping and after it is stopped:

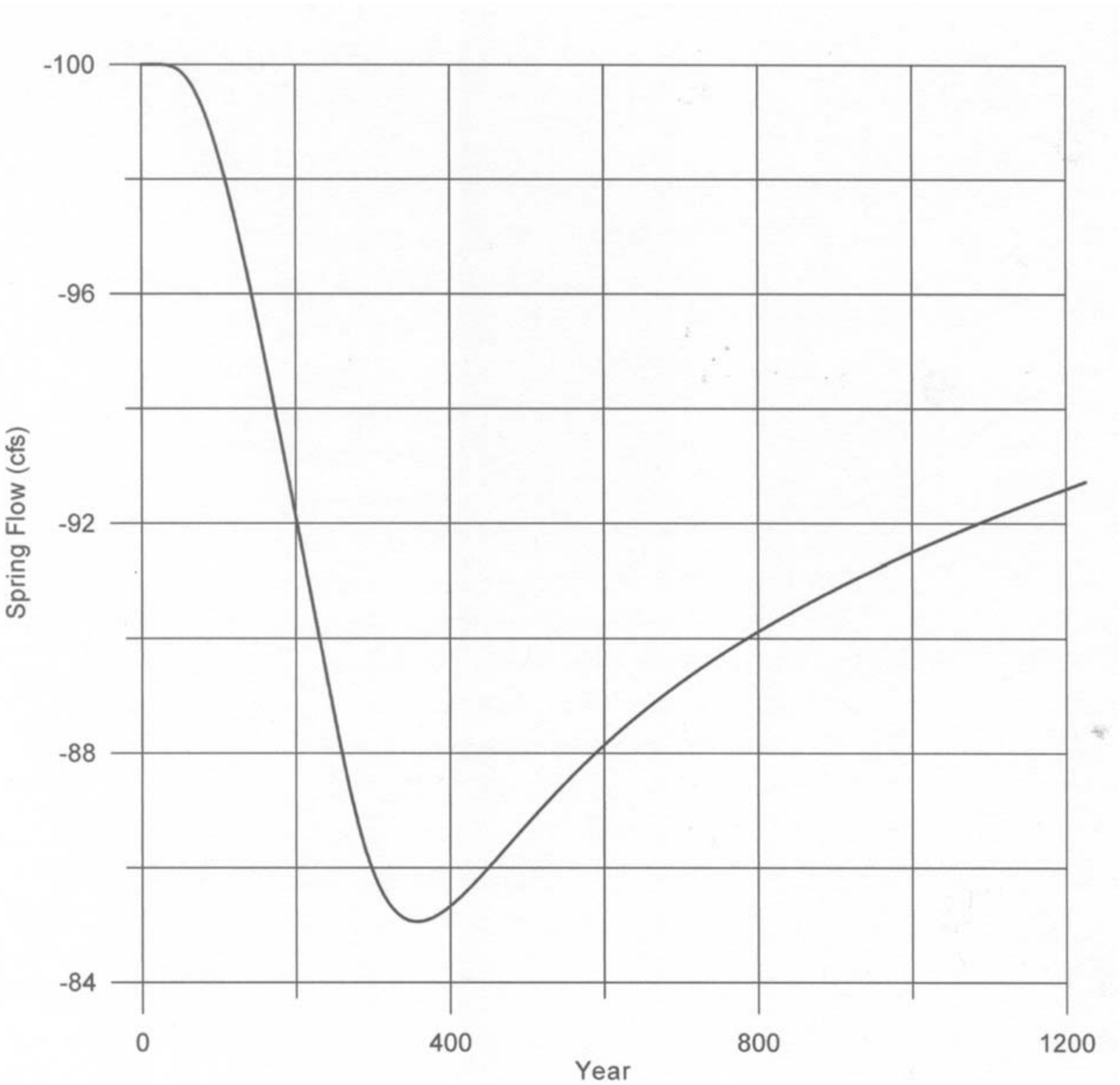

Figure 4. Plot of spring flow versus time. The spring flow reaches 90 cfs after 230 years of pumping, at which time the pumping is stopped.

One sees from the plot of spring discharge that the flow continues to decline at the same rate for approximately another 70 years after the pumping is stopped. The lowest flow rate is reached approximately 350 years, after which the spring flow slowly recovers.

It is instructive to examine a water budget just before pumping ceases (year 230), and just after pumping ceases (year 231):

Table 2. Water budget for the hypothetical valley:

	Year 230	Year 231
Recharge	+100	+100
Pumping	-100	0
Spring flow	-90	-90
Change in storage	-90	+10

One sees that during the last year of pumping storage is being depleted at a rate of 90 cfs. After pumping ceases, storage is be replenished at a rate of 10 cfs. Given this discrepancy in the rate of depletion and replenishment, it takes a much longer period to replace the water taken from storage during the pumping period. This indicates that were one to stop pumping with the idea of returning to pumping again once the system recovered, it would take a very long time for the system to recover, much longer than the initial period of pumping.

The plot of spring flow versus time illustrates the difficulty of monitoring. It takes 70 years after pumping ceases before the spring flow starts to recover even in this hypothetical system in which everything is known. One can only imagine the difficulty in a real system where there are multiple pumpers. The drawdown caused by the SNWA pumping will be superimposed on drawdown from other pumping that impacts the springs, as well as long-term variation in recharge to the system, including the impacts of climate change. It is a virtually impossible signal discrimination problem. It can only lead to arguments among the various interest groups of ***"what/who caused each observed decline in spring flow."***

CONCLUSION:

As indicated in the preceding discussion, nothing in SNWA's evidentiary submission of July 1, 2011, or the BLM Draft EIS published on June 10, 2011, alters the analysis or opinions provided in my initial report. Indeed, both of those sets of materials only serve to reinforce the points I made in June.

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