TOM MYERS PRESENTATION ON BEHALF OF WHITE PINE COUNTY, GREAT BASIN WATER NETWORK, ET AL.

PRESENTATION TO THE OFFICE OF THE NEVADA STATE ENGINEER

SOUTHERN NEVADA WATER AUTHORITY

SPRING, CAVE, DRY LAKE AND DELAMAR VALLEYS

REMAND HEARING

SNWA submitted a suite of evidence reports in support of its applications for the remand hearing. SNWA identified four issues that the court declared needed further proceedings, and described them as follows (Drici et al 2017, p 1-3):

[redacted]

2. Recalculated water available for appropriation from Spring Valley ensuring that the basin will reach equilibrium between discharge and recharge in a reasonable time
3. Define standards, thresholds, or triggers so that mitigation of unreasonable effects from pumping of water is neither arbitrary nor capricious in Spring Valley, Cave Valley, Dry Lake Valley, and Delamar Valley
4. Recalculate the appropriations from Cave Valley, Dry Lake Valley, and Delamar Valley to avoid over appropriations or conflicts with down-gradient, existing water rights

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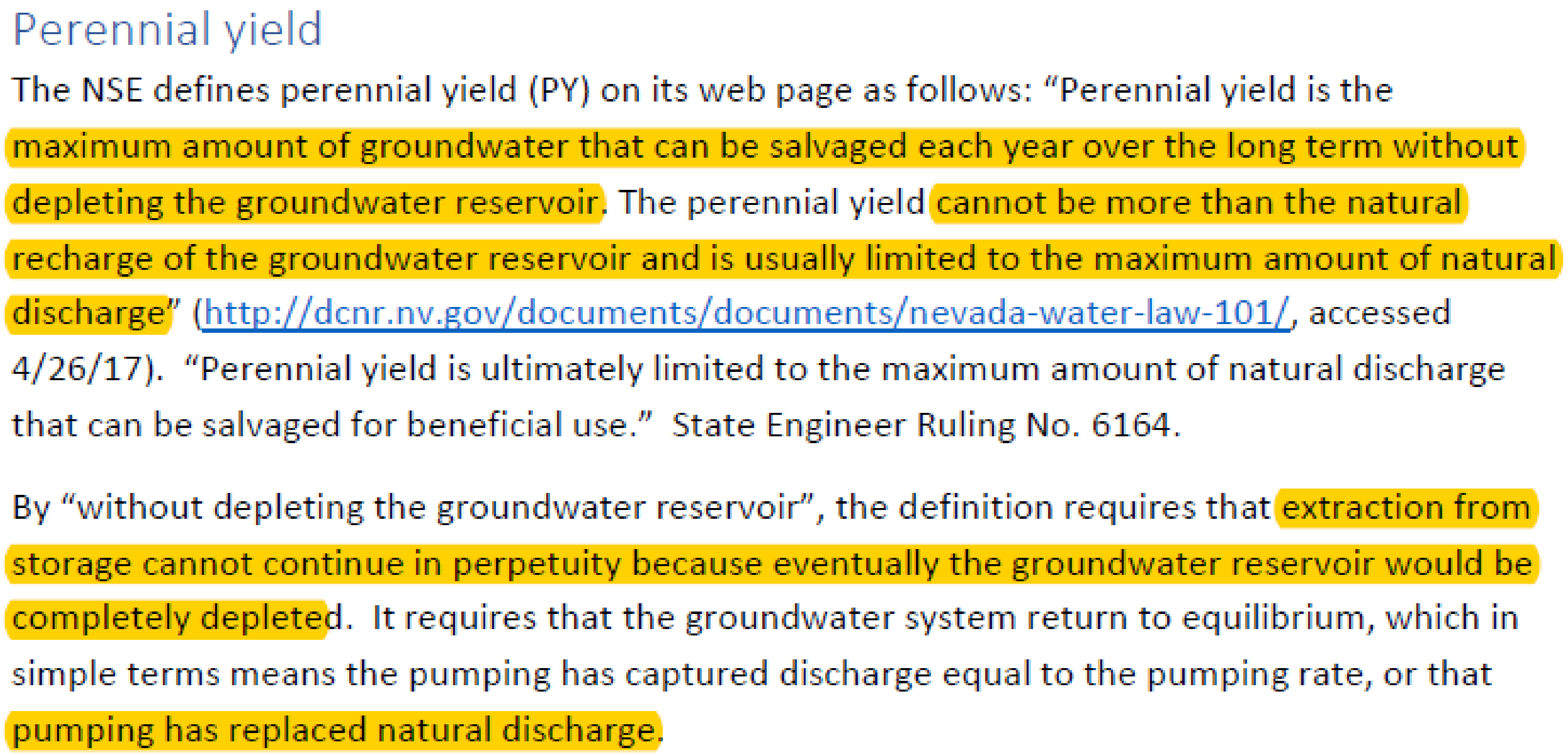
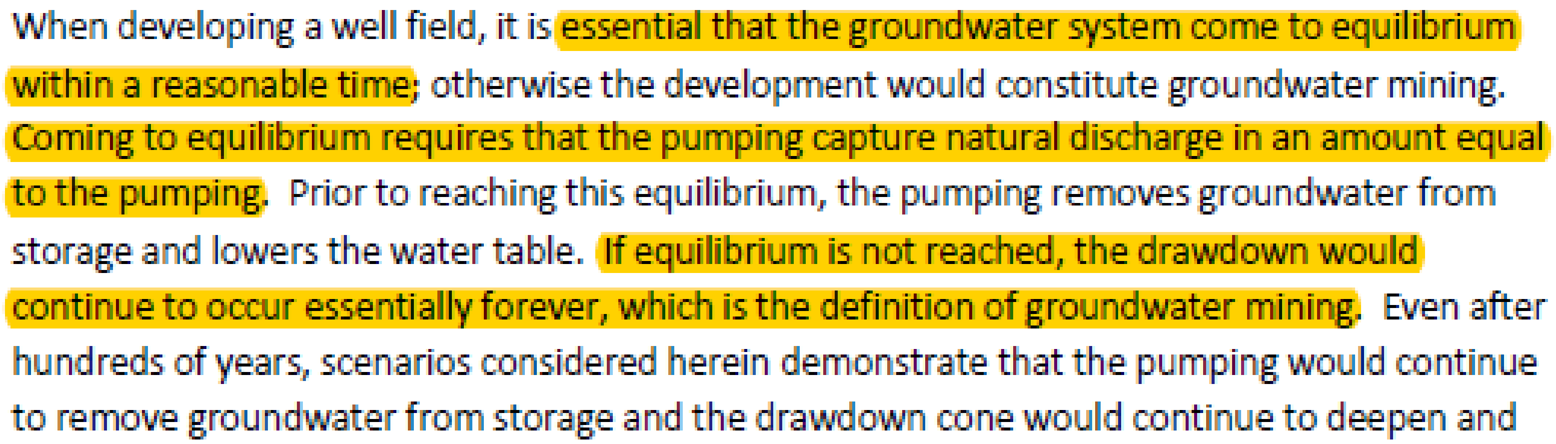


Perennial yield

The NSE defines perennial yield (PY) on its web page as follows: "Perennial yield is the maximum amount of groundwater that can be salvaged each year over the long term without depleting the groundwater reservoir. The perennial yield cannot be more than the natural recharge of the groundwater reservoir and is usually limited to the maximum amount of natural discharge" (http://dcnr.nv.gov/documents/documents/nevada-water-law-101/, accessed 4/26/17). "Perennial yield is ultimately limited to the maximum amount of natural discharge that can be salvaged for beneficial use." State Engineer Ruling No. 6164.

By "without depleting the groundwater reservoir", the definition requires that extraction from storage cannot continue in perpetuity because eventually the groundwater reservoir would be completely depleted. It requires that the groundwater system return to equilibrium, which in simple terms means the pumping has captured discharge equal to the pumping rate, or that pumping has replaced natural discharge.



When developing a well field, it is essential that the groundwater system come to equilibrium within a reasonable time; otherwise the development would constitute groundwater mining. Coming to equilibrium requires that the pumping capture natural discharge in an amount equal to the pumping. Prior to reaching this equilibrium, the pumping removes groundwater from storage and lowers the water table. If equilibrium is not reached, the drawdown would continue to occur essentially forever, which is the definition of groundwater mining. Even after hundreds of years, scenarios considered herein demonstrate that the pumping would continue to remove groundwater from storage and the drawdown cone would continue to deepen and

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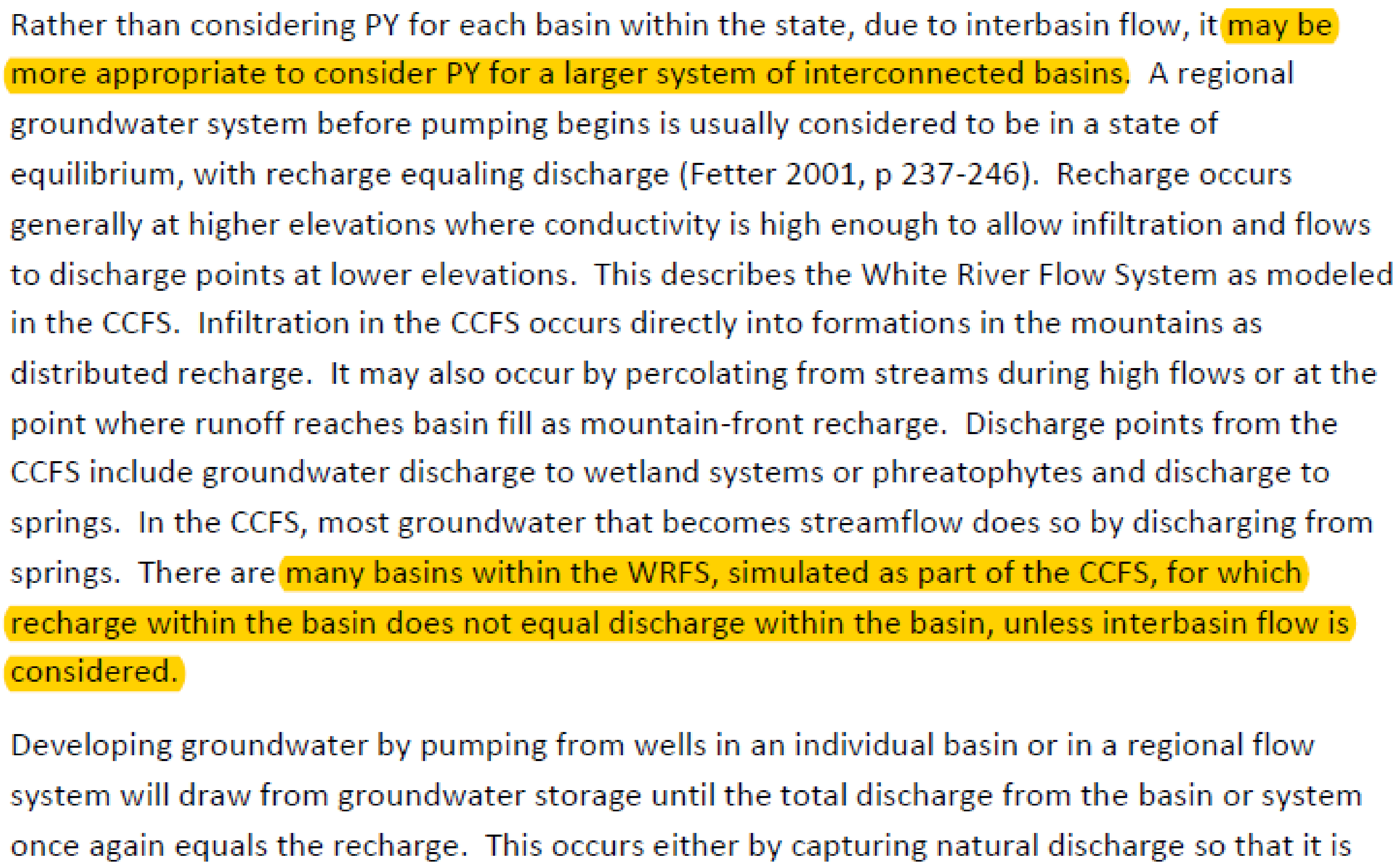

Rather than considering PY for each basin within the state, due to interbasin flow, it may be more appropriate to consider PY for a larger system of interconnected basins. A regional groundwater system before pumping begins is usually considered to be in a state of equilibrium, with recharge equaling discharge (Fetter 2001, p 237-246). Recharge occurs generally at higher elevations where conductivity is high enough to allow infiltration and flows to discharge points at lower elevations. This describes the White River Flow System as modeled in the CCFS. Infiltration in the CCFS occurs directly into formations in the mountains as distributed recharge. It may also occur by percolating from streams during high flows or at the point where runoff reaches basin fill as mountain-front recharge. Discharge points from the CCFS include groundwater discharge to wetland systems or phreatophytes and discharge to springs. In the CCFS, most groundwater that becomes streamflow does so by discharging from springs. There are many basins within the WRFS, simulated as part of the CCFS, for which recharge within the basin does not equal discharge within the basin, unless interbasin flow is considered.

Developing groundwater by pumping from wells in an individual basin or in a regional flow system will draw from groundwater storage until the total discharge from the basin or system once again equals the recharge. This occurs either by capturing natural discharge so that it is

GBWN Exh_281, p 33

less than it was under predevelopment conditions or by inducing additional recharge. The CCFS is generally not conducive to inducing recharge because of the lack of connection between rivers or streams in the basins with groundwater. Pumping draws from groundwater storage until the water table or potentiometric surface expands to capture natural discharge equal to the amount of pumping (Fetter 2001, p 247). At that point, the groundwater system will come to equilibrium with total discharge from the flow system equaling the recharge. In many basins, as will be seen below, the capture will affect adjoining basins by either preventing flow into those basins or by drawing flow from those basins.

The CCFS is a combination of unconfined and leaky confined aquifers, with the basin fill being unconfined and the carbonate and other bedrock aquifers being confined. The confined aquifers are leaky because they receive recharge from overlying basin fill aquifers and from the surrounding mountains. A confined aquifer comes to equilibrium with pumping when all the water being pumped comes from leakage across the confining layer and none comes from elastic storage in the confined aquifer (Fetter 2001, p 160). An unconfined aquifer mathematically approaches equilibrium as the water table is drawn further below the bottom of the depth at which ET occurs (Fetter 2001, p 165, 168). Once captured ET equals the pumping rate, the net storage will not change although the water table shape may continue to change.

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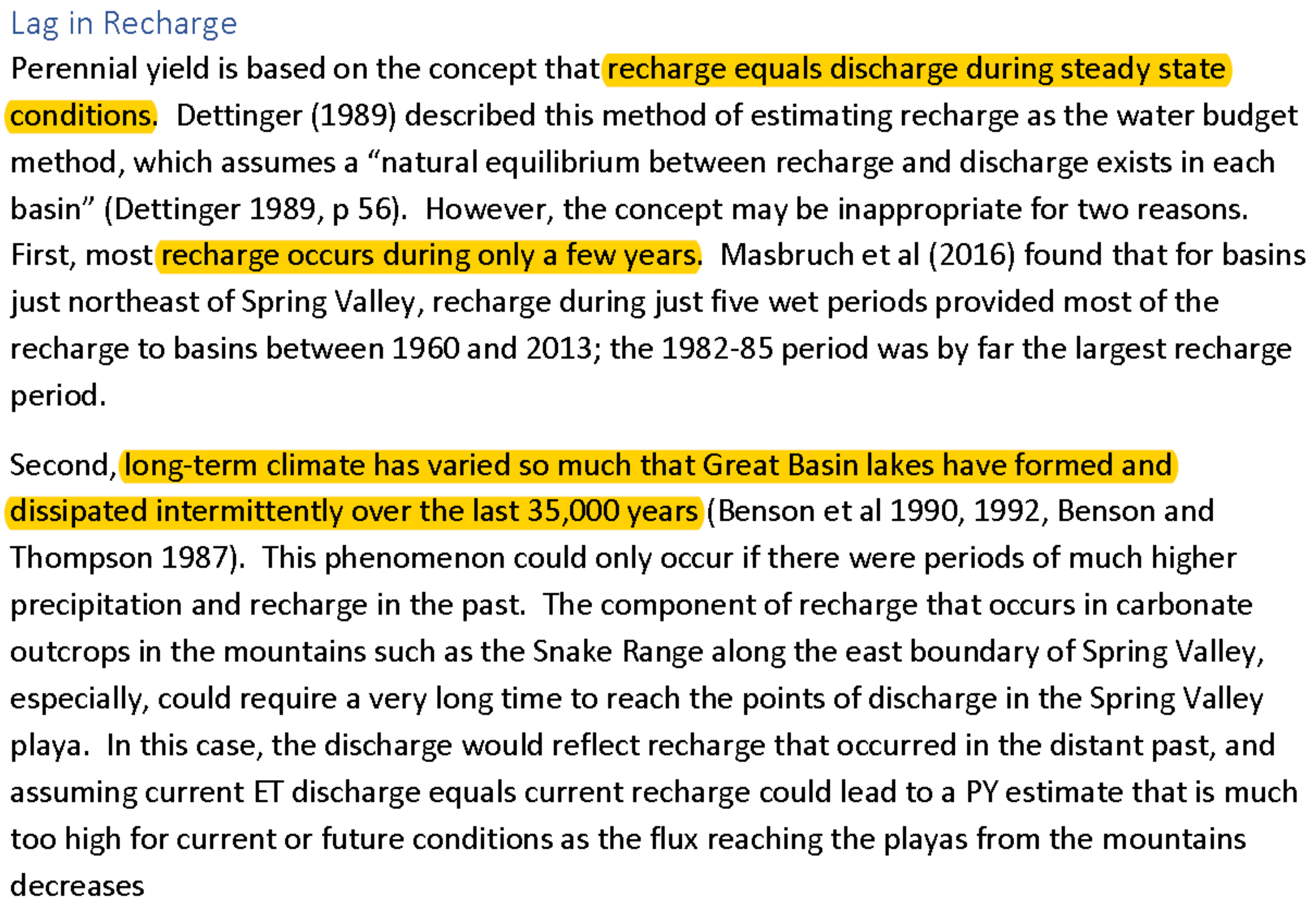

Lag in Recharge

Perennial yield is based on the concept that recharge equals discharge during steady state conditions. Dettinger (1989) described this method of estimating recharge as the water budget method, which assumes a "natural equilibrium between recharge and discharge exists in each basin" (Dettinger 1989, p 56). However, the concept may be inappropriate for two reasons. First, most recharge occurs during only a few years. Masbruch et al (2016) found that for basins just northeast of Spring Valley, recharge during just five wet periods provided most of the recharge to basins between 1960 and 2013; the 1982-85 period was by far the largest recharge period.

Second, long-term climate has varied so much that Great Basin lakes have formed and dissipated intermittently over the last 35,000 years (Benson et al 1990, 1992, Benson and Thompson 1987). This phenomenon could only occur if there were periods of much higher precipitation and recharge in the past. The component of recharge that occurs in carbonate outcrops in the mountains such as the Snake Range along the east boundary of Spring Valley, especially, could require a very long time to reach the points of discharge in the Spring Valley playa. In this case, the discharge would reflect recharge that occurred in the distant past, and assuming current ET discharge equals current recharge could lead to a PY estimate that is much too high for current or future conditions as the flux reaching the playas from the mountains decreases

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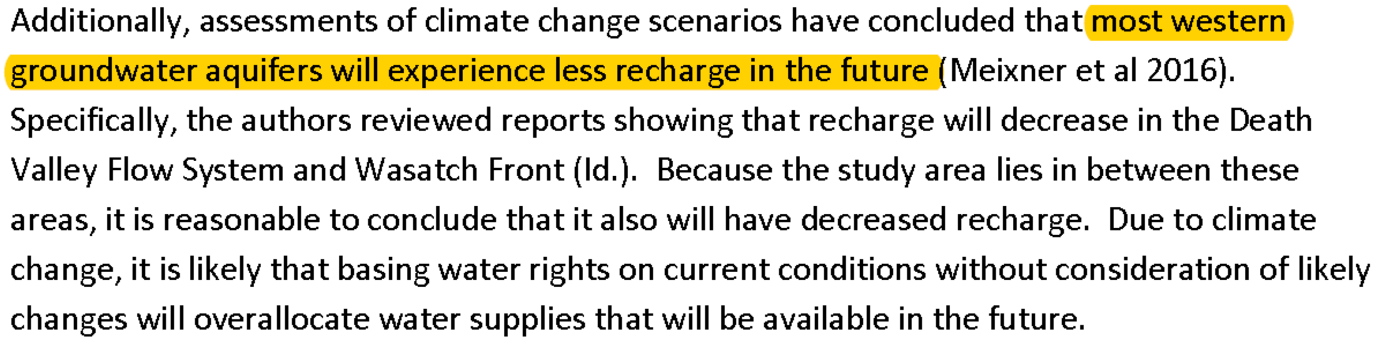
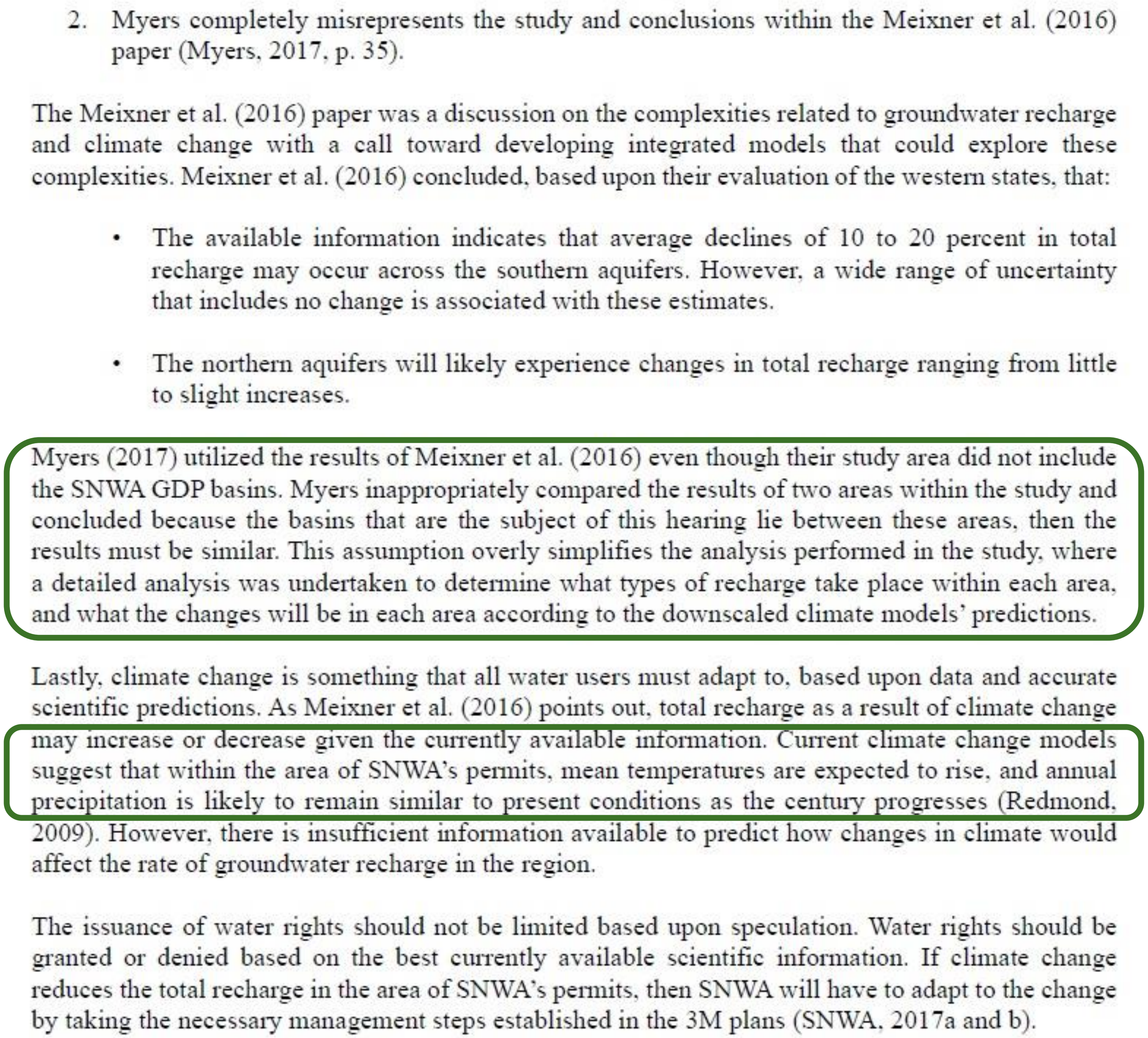


Additionally, assessments of climate change scenarios have concluded that most western groundwater aquifers will experience less recharge in the future (Meixner et al 2016). Specifically, the authors reviewed reports showing that recharge will decrease in the Death Valley Flow System and Wasatch Front (Id.). Because the study area lies in between these areas, it is reasonable to conclude that it also will have decreased recharge. Due to climate change, it is likely that basing water rights on current conditions without consideration of likely changes will overallocate water supplies that will be available in the future.

GBWN Exh_281, p 35



2. Myers completely misrepresents the study and conclusions within the Meixner et al. (2016) paper (Myers, 2017, p. 35).

The Meixner et al. (2016) paper was a discussion on the complexities related to groundwater recharge and climate change with a call toward developing integrated models that could explore these complexities. Meixner et al. (2016) concluded, based upon their evaluation of the western states, that:

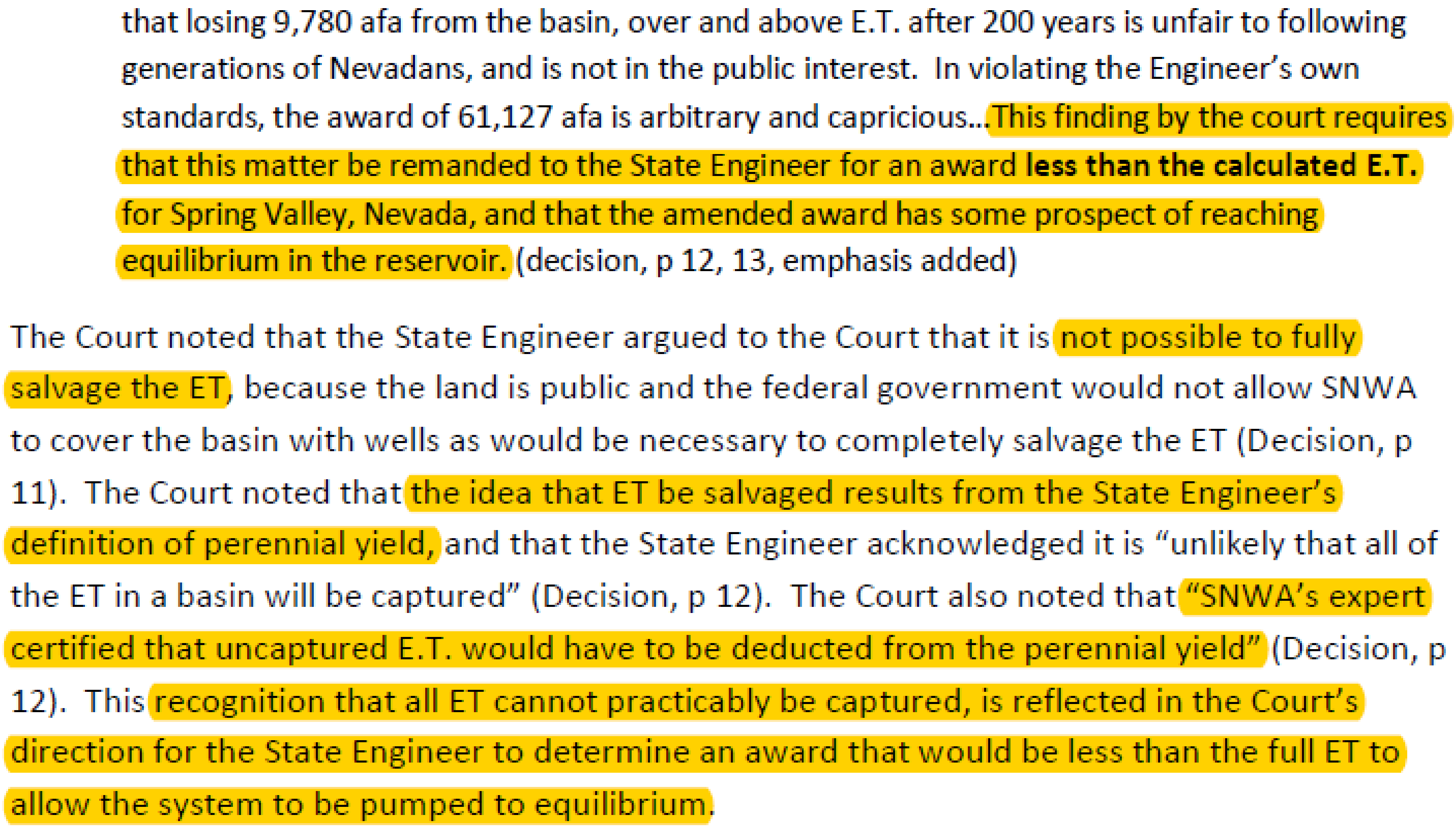
- The available information indicates that average declines of 10 to 20 percent in total recharge may occur across the southern aquifers. However, a wide range of uncertainty that includes no change is associated with these estimates.
- The northern aquifers will likely experience changes in total recharge ranging from little to slight increases.

Myers (2017) utilized the results of Meixner et al. (2016) even though their study area did not include the SNWA GDP basins. Myers inappropriately compared the results of two areas within the study and concluded because the basins that are the subject of this hearing lie between these areas, then the results must be similar. This assumption overly simplifies the analysis performed in the study, where a detailed analysis was undertaken to determine what types of recharge take place within each area, and what the changes will be in each area according to the downscaled climate models' predictions.

Lastly, climate change is something that all water users must adapt to, based upon data and accurate scientific predictions. As Meixner et al. (2016) points out, total recharge as a result of climate change may increase or decrease given the currently available information. Current climate change models suggest that within the area of SNWA's permits, mean temperatures are expected to rise, and annual precipitation is likely to remain similar to present conditions as the century progresses (Redmond, 2009). However, there is insufficient information available to predict how changes in climate would affect the rate of groundwater recharge in the region.

The issuance of water rights should not be limited based upon speculation. Water rights should be granted or denied based on the best currently available scientific information. If climate change reduces the total recharge in the area of SNWA's permits, then SNWA will have to adapt to the change by taking the necessary management steps established in the 3M plans (SNWA, 2017a and b).

SNWA Exh_596, p 5



> that losing 9,780 afa from the basin, over and above E.T. after 200 years is unfair to following generations of Nevadans, and is not in the public interest. In violating the Engineer's own standards, the award of 61,127 afa is arbitrary and capricious...This finding by the court requires that this matter be remanded to the State Engineer for an award **less than the calculated E.T.** for Spring Valley, Nevada, and that the amended award has some prospect of reaching equilibrium in the reservoir. (decision, p 12, 13, emphasis added)

The Court noted that the State Engineer argued to the Court that it is not possible to fully salvage the ET, because the land is public and the federal government would not allow SNWA to cover the basin with wells as would be necessary to completely salvage the ET (Decision, p 11). The Court noted that the idea that ET be salvaged results from the State Engineer's definition of perennial yield, and that the State Engineer acknowledged it is "unlikely that all of the ET in a basin will be captured" (Decision, p 12). The Court also noted that "SNWA's expert certified that uncaptured E.T. would have to be deducted from the perennial yield" (Decision, p 12). This recognition that all ET cannot practicably be captured, is reflected in the Court's direction for the State Engineer to determine an award that would be less than the full ET to allow the system to be pumped to equilibrium.

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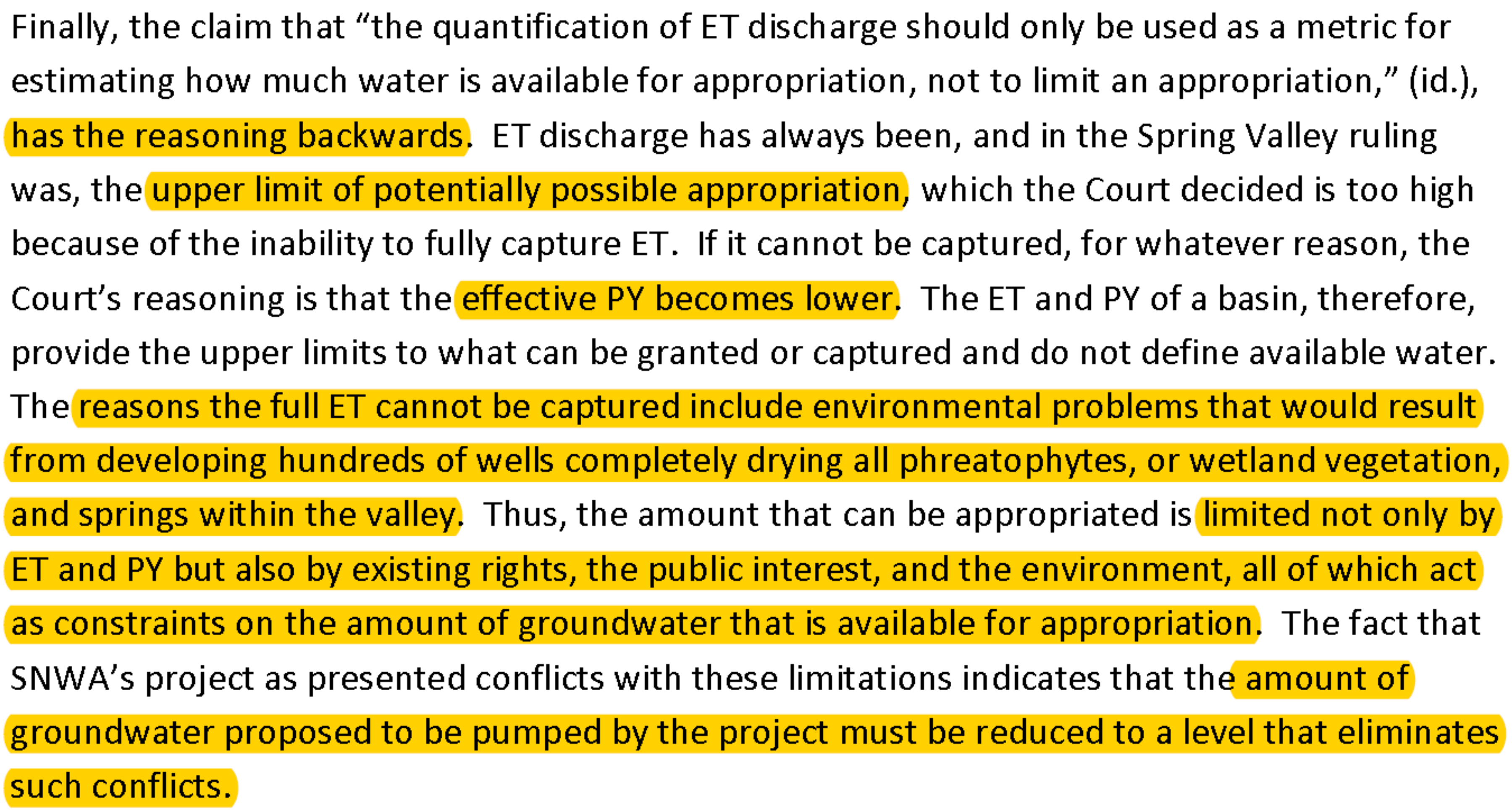

Finally, the claim that “the quantification of ET discharge should only be used as a metric for estimating how much water is available for appropriation, not to limit an appropriation,” (id.), has the reasoning backwards. ET discharge has always been, and in the Spring Valley ruling was, the upper limit of potentially possible appropriation, which the Court decided is too high because of the inability to fully capture ET. If it cannot be captured, for whatever reason, the Court’s reasoning is that the effective PY becomes lower. The ET and PY of a basin, therefore, provide the upper limits to what can be granted or captured and do not define available water. The reasons the full ET cannot be captured include environmental problems that would result from developing hundreds of wells completely drying all phreatophytes, or wetland vegetation, and springs within the valley. Thus, the amount that can be appropriated is limited not only by ET and PY but also by existing rights, the public interest, and the environment, all of which act as constraints on the amount of groundwater that is available for appropriation. The fact that SNWA’s project as presented conflicts with these limitations indicates that the amount of groundwater proposed to be pumped by the project must be reduced to a level that eliminates such conflicts.

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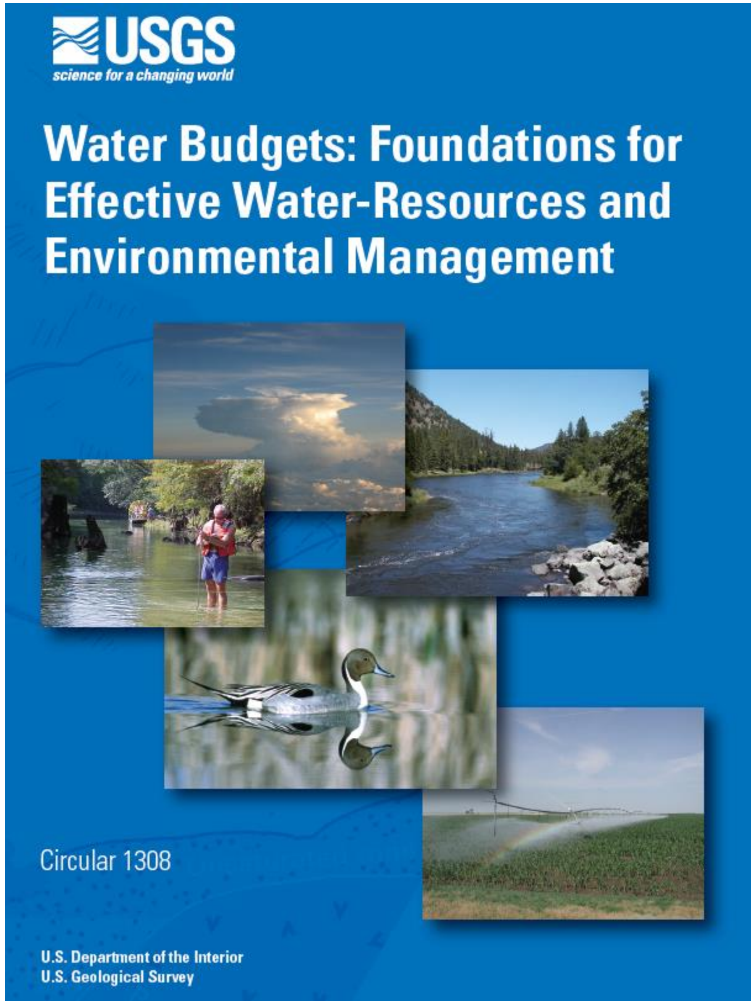


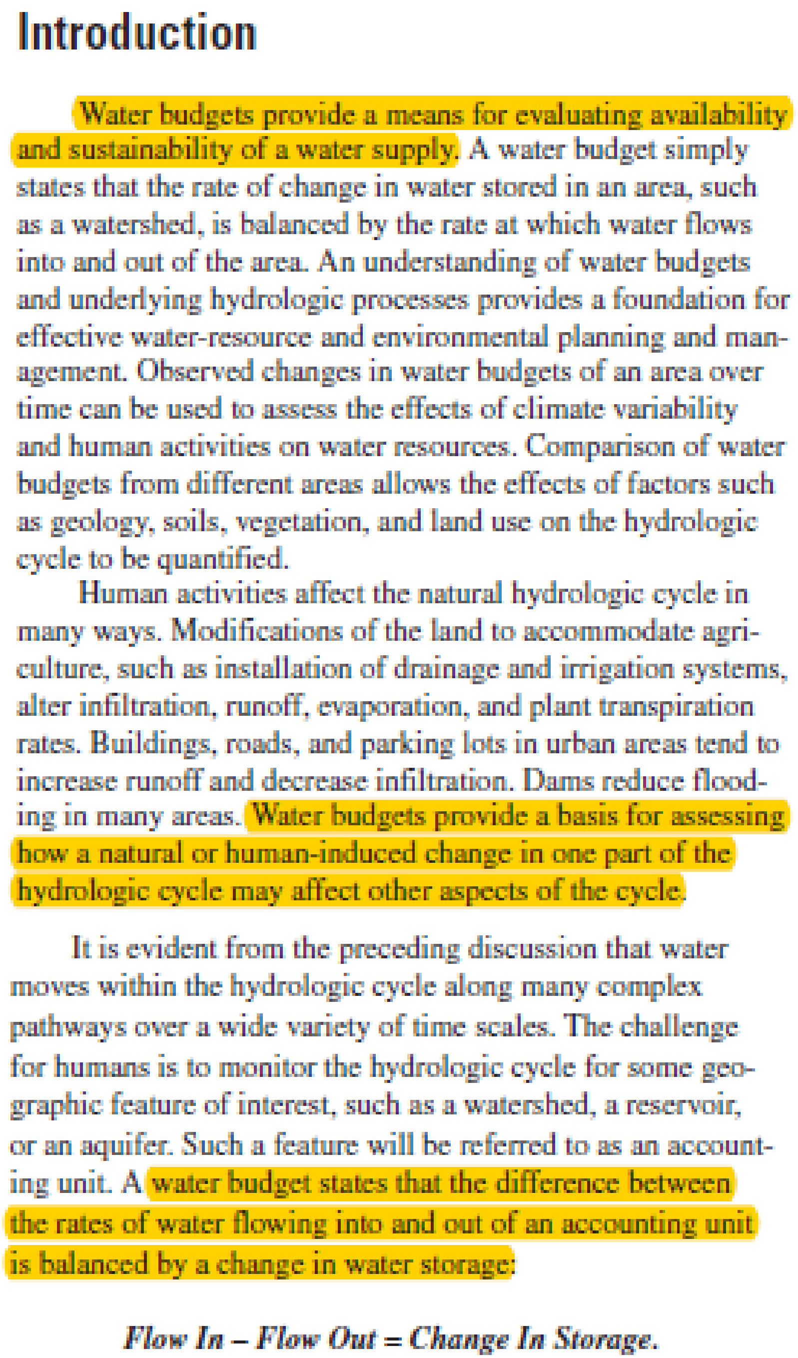
USGS
science for a changing world

Water Budgets: Foundations for Effective Water-Resources and Environmental Management

Circular 1308

U.S. Department of the Interior
U.S. Geological Survey

SNWA Exh 606, cover, p 1, 5, 57



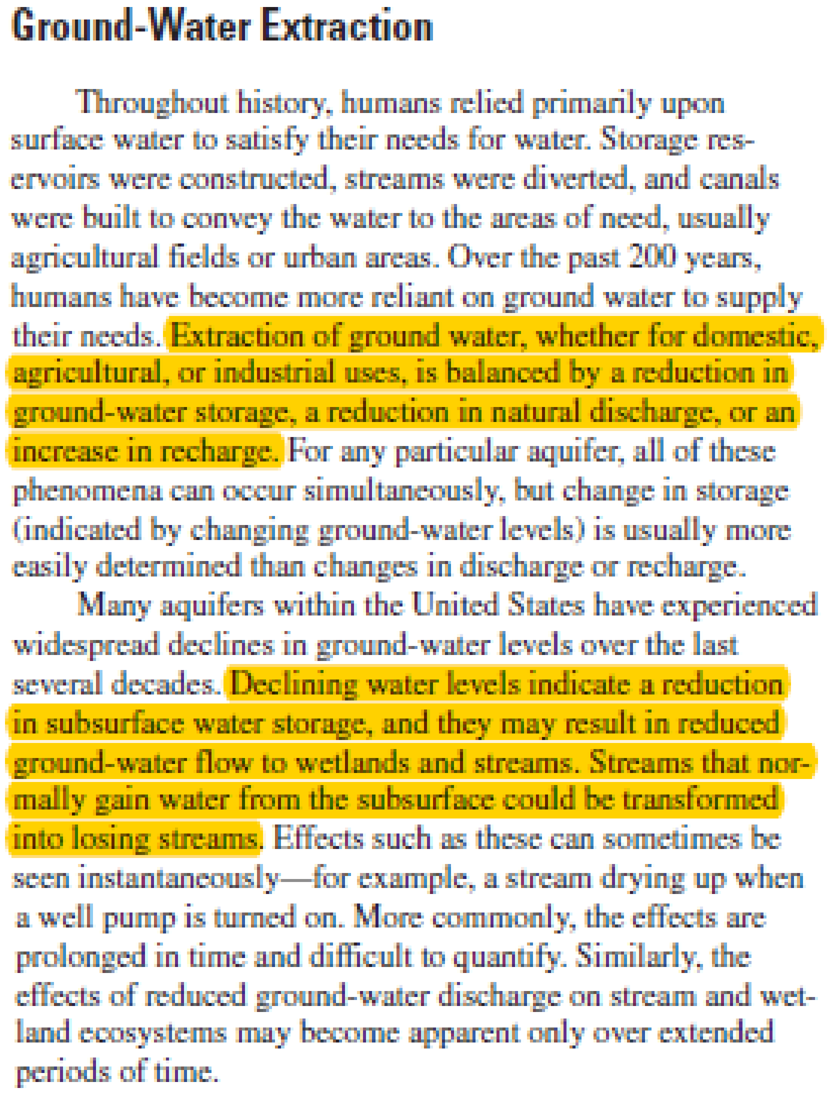
Introduction

Water budgets provide a means for evaluating availability and sustainability of a water supply. A water budget simply states that the rate of change in water stored in an area, such as a watershed, is balanced by the rate at which water flows into and out of the area. An understanding of water budgets and underlying hydrologic processes provides a foundation for effective water-resource and environmental planning and management. Observed changes in water budgets of an area over time can be used to assess the effects of climate variability and human activities on water resources. Comparison of water budgets from different areas allows the effects of factors such as geology, soils, vegetation, and land use on the hydrologic cycle to be quantified.

Human activities affect the natural hydrologic cycle in many ways. Modifications of the land to accommodate agriculture, such as installation of drainage and irrigation systems, alter infiltration, runoff, evaporation, and plant transpiration rates. Buildings, roads, and parking lots in urban areas tend to increase runoff and decrease infiltration. Dams reduce flooding in many areas. Water budgets provide a basis for assessing how a natural or human-induced change in one part of the hydrologic cycle may affect other aspects of the cycle.

It is evident from the preceding discussion that water moves within the hydrologic cycle along many complex pathways over a wide variety of time scales. The challenge for humans is to monitor the hydrologic cycle for some geographic feature of interest, such as a watershed, a reservoir, or an aquifer. Such a feature will be referred to as an accounting unit. A water budget states that the difference between the rates of water flowing into and out of an accounting unit is balanced by a change in water storage:

Flow In – Flow Out = Change In Storage.



Ground-Water Extraction

Throughout history, humans relied primarily upon surface water to satisfy their needs for water. Storage reservoirs were constructed, streams were diverted, and canals were built to convey the water to the areas of need, usually agricultural fields or urban areas. Over the past 200 years, humans have become more reliant on ground water to supply their needs. Extraction of ground water, whether for domestic, agricultural, or industrial uses, is balanced by a reduction in ground-water storage, a reduction in natural discharge, or an increase in recharge. For any particular aquifer, all of these phenomena can occur simultaneously, but change in storage (indicated by changing ground-water levels) is usually more easily determined than changes in discharge or recharge.

Many aquifers within the United States have experienced widespread declines in ground-water levels over the last several decades. Declining water levels indicate a reduction in subsurface water storage, and they may result in reduced ground-water flow to wetlands and streams. Streams that normally gain water from the subsurface could be transformed into losing streams. Effects such as these can sometimes be seen instantaneously—for example, a stream drying up when a well pump is turned on. More commonly, the effects are prolonged in time and difficult to quantify. Similarly, the effects of reduced ground-water discharge on stream and wetland ecosystems may become apparent only over extended periods of time.

Aquifers in Arizona

The limited amount of surface water in Arizona has led to substantial use of ground water, especially for agriculture. With an arid to semiarid climate and very low rates of recharge, ground-water withdrawals caused water levels in Arizona to decline as early as the 1920s. Declines were more rapid after the 1940s because of the increased availability in rural areas of electricity to power deep-well turbine pumps. Ground-water withdrawals have resulted in reduced discharge to streams and wetlands (Webb and others, 2007) and water-level declines that have caused land subsidence in some areas (Galloway and others, 1999). To help manage ground-water resources, ground-water flow models of aquifers were constructed for many parts of the State. These models, which in effect are water-budget models, were used to predict how ground-water levels would be affected by future aquifer-management practices.

To assess the predictive capabilities of a ground-water flow model of an aquifer in central Arizona (fig. 35), Konikow (1986) compared water levels in 77 wells measured in 1974 with water levels predicted for that year with a model of the Salt River and lower Santa Cruz River basins (Anderson, 1968). The original model was calibrated by using water-level and pumping data collected from 1923 to 1964. Between 1923 and 1964, average ground-water levels declined by an average of about 120 ft. Water levels measured in 1974, 10 years after the ground-water model was completed, differed from those predicted by 50 to 200 ft in large parts of the area (fig. 36).

SNWA Exh 606, p 64, 79

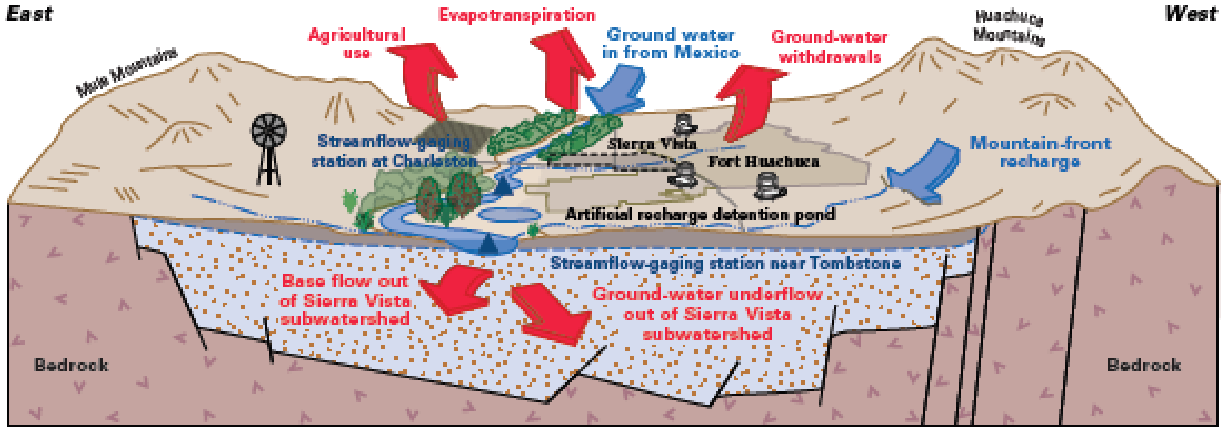


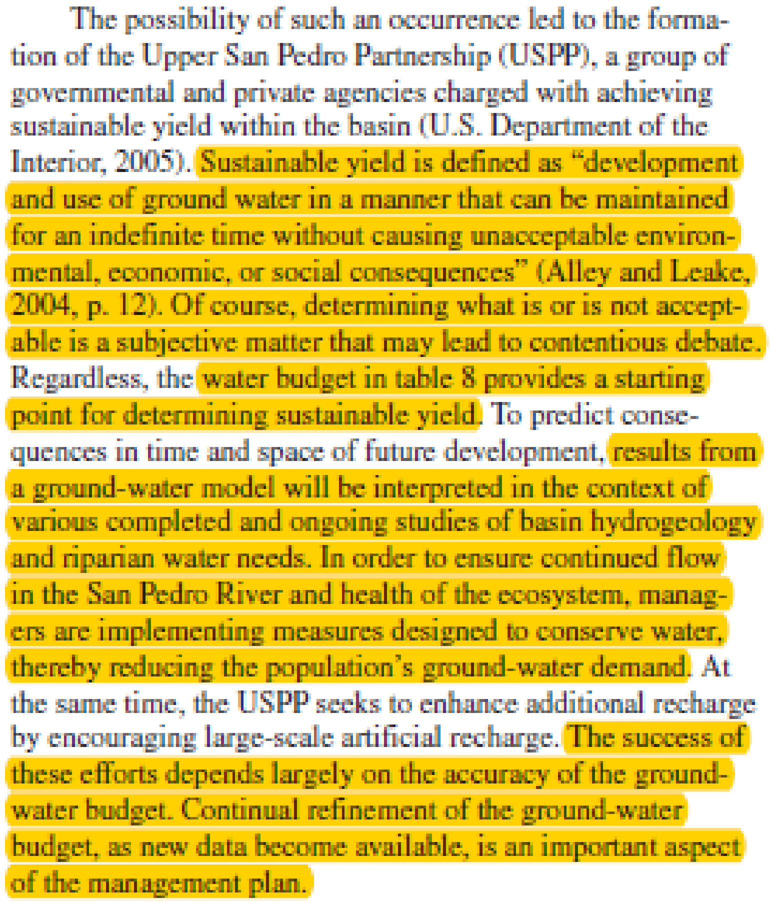
Figure 48. Simulated annual ground-water budget for the upper San Pedro River basin (U.S. Department of the Interior, 2005).

Additional recharge refers to the return of pumped water to the aquifer through drainage of irrigation water, septic tanks, and enhanced recharge from routing of runoff from impervious areas. That routing could be unintentional, as a result of increased impervious areas such as roads, buildings, and sidewalks. It could also be the result of planned urban infiltration galleries that funnel runoff directly to the ground-water system, thus bypassing the soil zone and avoiding uptake by vegetation.

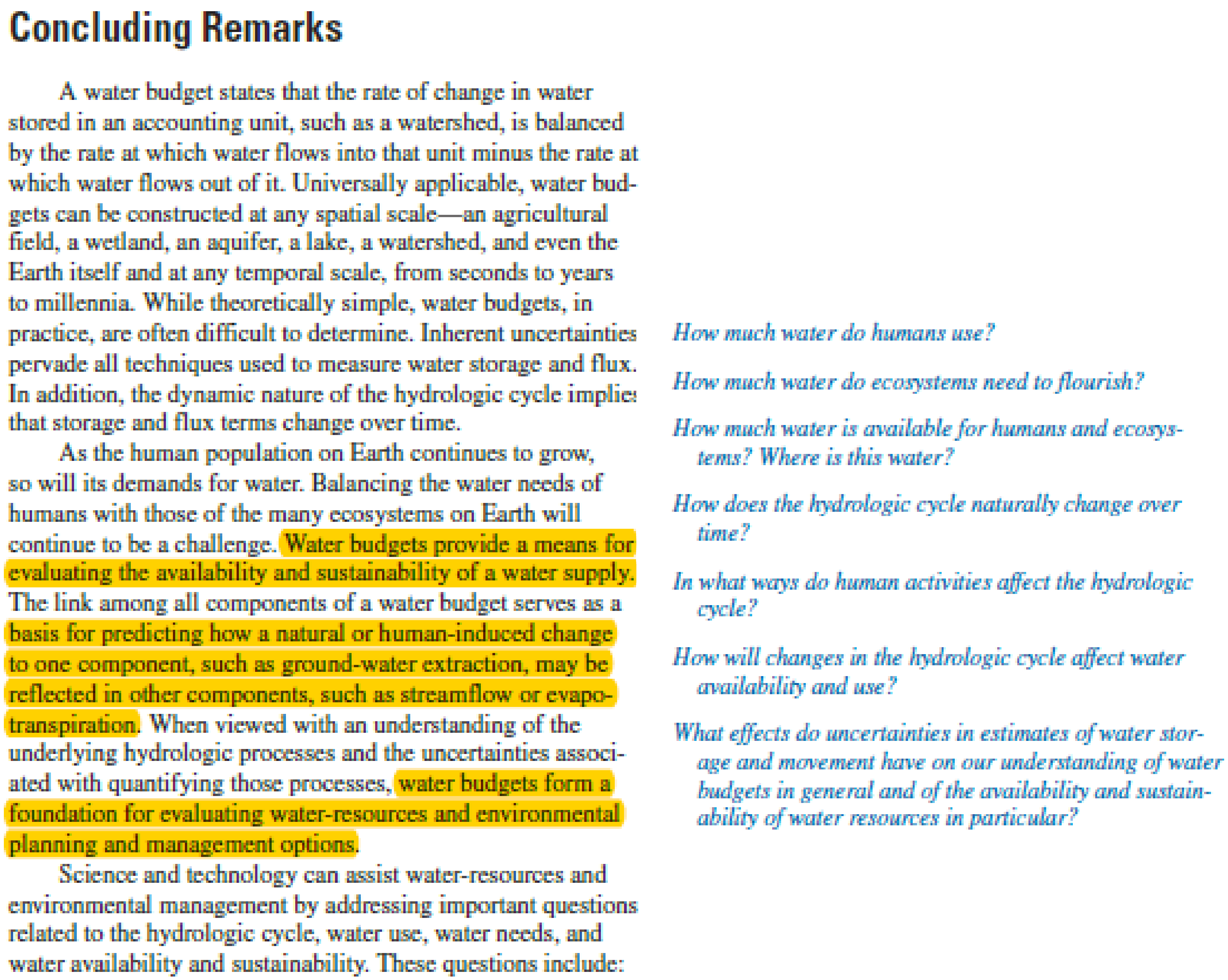
Table 8 shows values for components of the ground-water budget for a time before ground-water development (1940) and after a period of more than 60 years of development (2002). For the water budget to balance, the increase in pumping between 1940 and 2002 must be offset by one or more other water-budget components. Results of computer simulations of ground-water flow indicated that by 2002 there was a 65 percent decrease in annual ground-water discharge (base flow) to the river, 8,400 acre-ft of water was removed from ground-water storage each year, and there was a slight reduction in evapotranspiration rates. Interestingly, recent estimates of evapotranspiration based on field measurements indicate that current rates (about 10,800 acre-ft/yr) are greater than those estimated for the past (Scott and others, 2006). It is not clear if past estimates, which were not based on field estimates, are in error or if, indeed, riparian evapotranspiration rates have increased. In either regard, the ground-water flow simulations indicated that continued pumping at current rates with no additional recharge will eventually dry up the river (U.S. Department of the Interior, 2005). Such a result would have severe implications for the ecosystem.

Table 8. Annual ground-water budget (in acre-feet) for Sierra Vista subwatershed [predevelopment conditions (1940) from Corell and others (1996) and in 2002 (U.S. Department of the Interior, 2005)]. Net pumping is actual pumping minus that amount of pumped water that returned to the aquifer.

Year	Natural recharge	Ground-water inflow	Ground-water outflow	Evapotranspiration	San Pedro River base flow	Net pumping	Storage change
1940	16,000	3,000	440	8,020	9,540	1,000	0
2002	15,000	3,000	440	7,700	3,250	15,000	–8,400



The possibility of such an occurrence led to the formation of the Upper San Pedro Partnership (USPP), a group of governmental and private agencies charged with achieving sustainable yield within the basin (U.S. Department of the Interior, 2005). Sustainable yield is defined as "development and use of ground water in a manner that can be maintained for an indefinite time without causing unacceptable environmental, economic, or social consequences" (Alley and Leake, 2004, p. 12). Of course, determining what is or is not acceptable is a subjective matter that may lead to contentious debate. Regardless, the water budget in table 8 provides a starting point for determining sustainable yield. To predict consequences in time and space of future development, results from a ground-water model will be interpreted in the context of various completed and ongoing studies of basin hydrogeology and riparian water needs. In order to ensure continued flow in the San Pedro River and health of the ecosystem, managers are implementing measures designed to conserve water, thereby reducing the population's ground-water demand. At the same time, the USPP seeks to enhance additional recharge by encouraging large-scale artificial recharge. The success of these efforts depends largely on the accuracy of the ground-water budget. Continual refinement of the ground-water budget, as new data become available, is an important aspect of the management plan.



Concluding Remarks

A water budget states that the rate of change in water stored in an accounting unit, such as a watershed, is balanced by the rate at which water flows into that unit minus the rate at which water flows out of it. Universally applicable, water budgets can be constructed at any spatial scale—an agricultural field, a wetland, an aquifer, a lake, a watershed, and even the Earth itself and at any temporal scale, from seconds to years to millennia. While theoretically simple, water budgets, in practice, are often difficult to determine. Inherent uncertainties pervade all techniques used to measure water storage and flux. In addition, the dynamic nature of the hydrologic cycle implies that storage and flux terms change over time.

As the human population on Earth continues to grow, so will its demands for water. Balancing the water needs of humans with those of the many ecosystems on Earth will continue to be a challenge. Water budgets provide a means for evaluating the availability and sustainability of a water supply. The link among all components of a water budget serves as a basis for predicting how a natural or human-induced change to one component, such as ground-water extraction, may be reflected in other components, such as streamflow or evapotranspiration. When viewed with an understanding of the underlying hydrologic processes and the uncertainties associated with quantifying those processes, water budgets form a foundation for evaluating water-resources and environmental planning and management options.

Science and technology can assist water-resources and environmental management by addressing important questions related to the hydrologic cycle, water use, water needs, and water availability and sustainability. These questions include:

How much water do humans use?

How much water do ecosystems need to flourish?

How much water is available for humans and ecosystems? Where is this water?

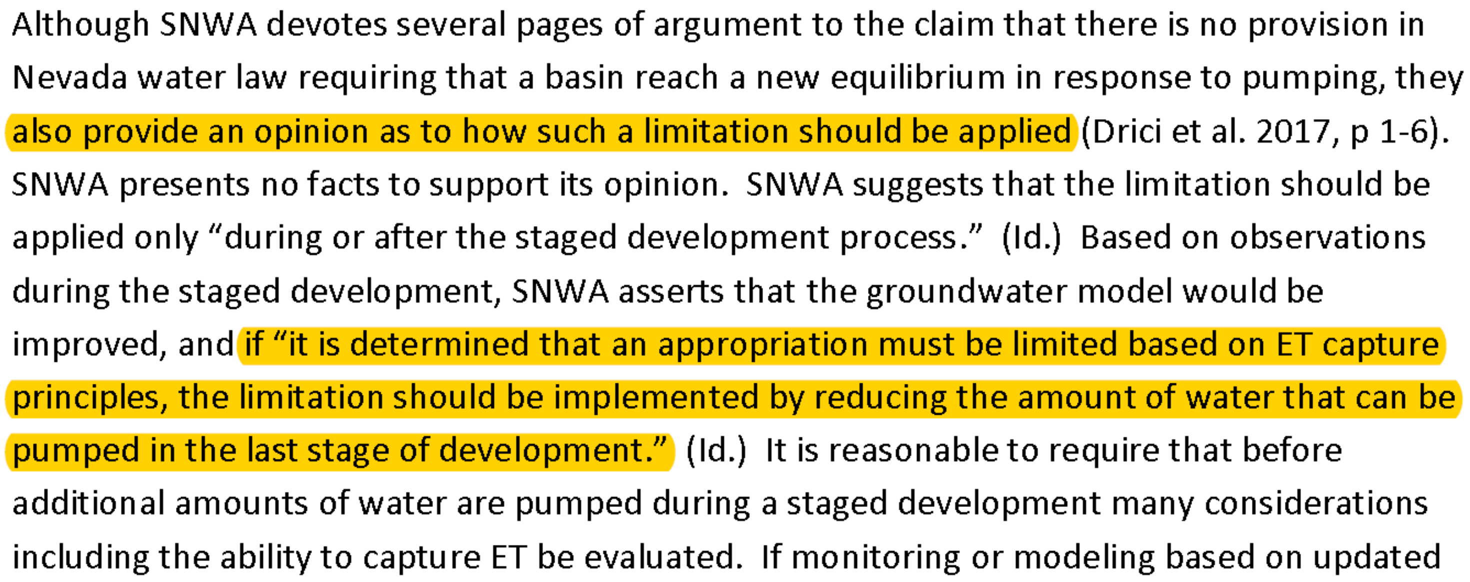
How does the hydrologic cycle naturally change over time?

In what ways do human activities affect the hydrologic cycle?

How will changes in the hydrologic cycle affect water availability and use?

What effects do uncertainties in estimates of water storage and movement have on our understanding of water budgets in general and of the availability and sustainability of water resources in particular?

SNWA Exh 606, p 80, 84



Although SNWA devotes several pages of argument to the claim that there is no provision in Nevada water law requiring that a basin reach a new equilibrium in response to pumping, they also provide an opinion as to how such a limitation should be applied (Drici et al. 2017, p 1-6). SNWA presents no facts to support its opinion. SNWA suggests that the limitation should be applied only "during or after the staged development process." (Id.) Based on observations during the staged development, SNWA asserts that the groundwater model would be improved, and if "it is determined that an appropriation must be limited based on ET capture principles, the limitation should be implemented by reducing the amount of water that can be pumped in the last stage of development." (Id.) It is reasonable to require that before additional amounts of water are pumped during a staged development many considerations including the ability to capture ET be evaluated. If monitoring or modeling based on updated

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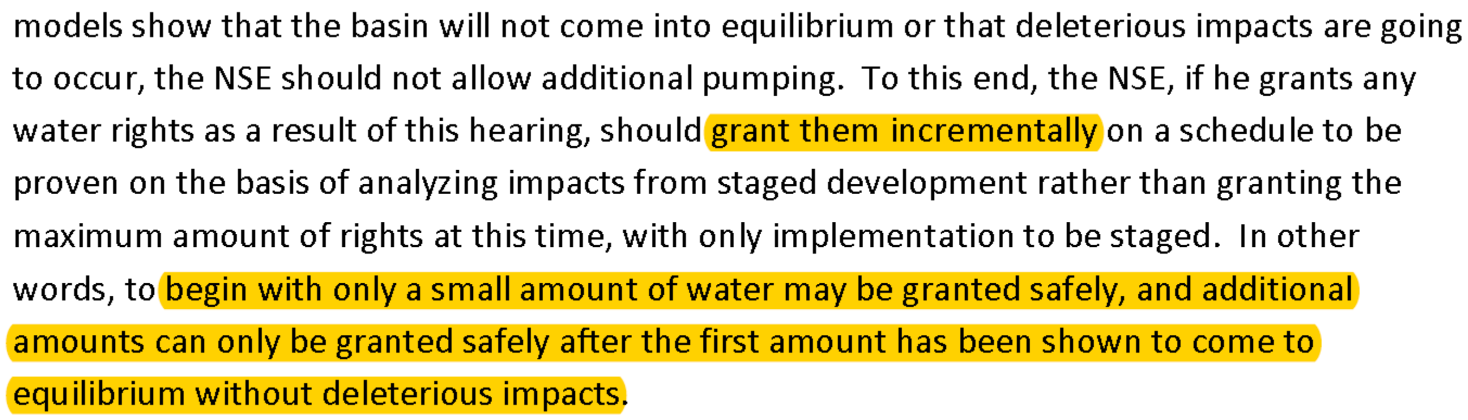


models show that the basin will not come into equilibrium or that deleterious impacts are going to occur, the NSE should not allow additional pumping. To this end, the NSE, if he grants any water rights as a result of this hearing, should grant them incrementally on a schedule to be proven on the basis of analyzing impacts from staged development rather than granting the maximum amount of rights at this time, with only implementation to be staged. In other words, to begin with only a small amount of water may be granted safely, and additional amounts can only be granted safely after the first amount has been shown to come to equilibrium without deleterious impacts.

Conceptual Flow Model

A CFM is a description of the flow sources, sinks, and pathways in a hydrologic system. For a groundwater system, a CFM describes the sources of recharge. Interbasin flow would include

GBWN Exh_281, p 10, 11, 37

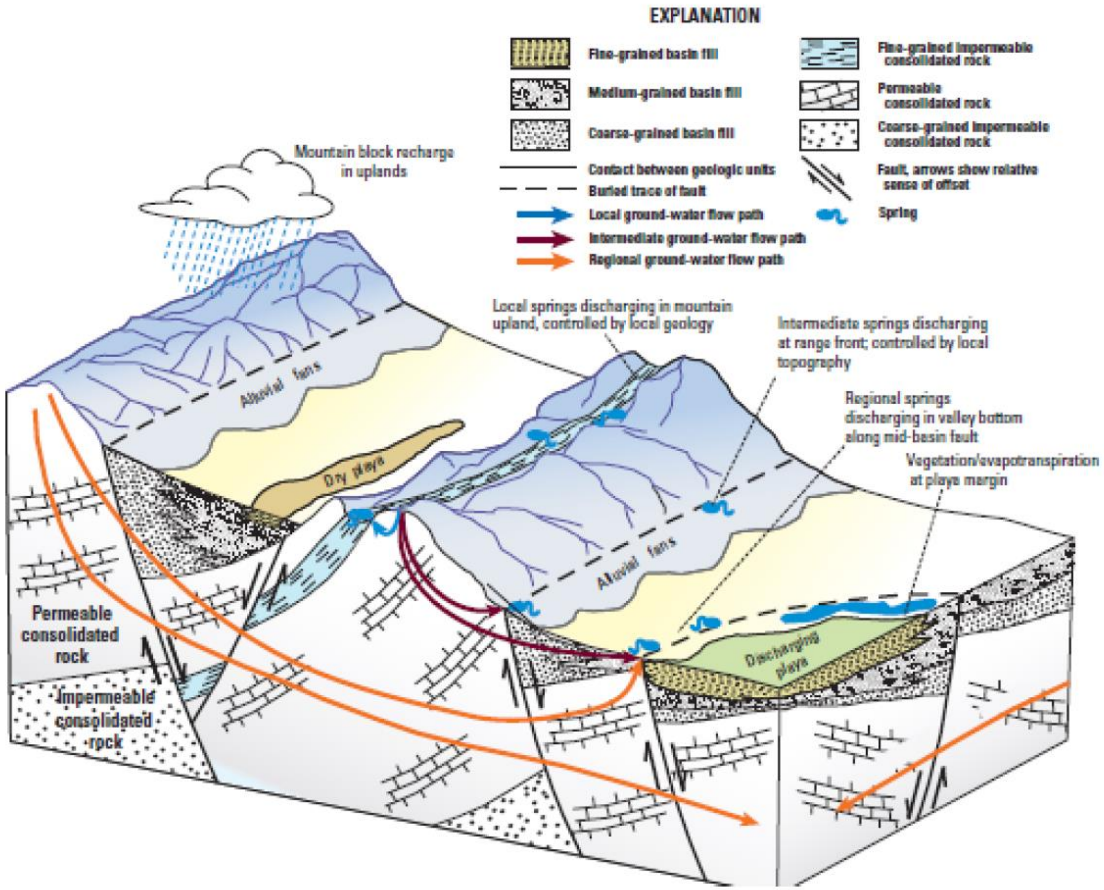
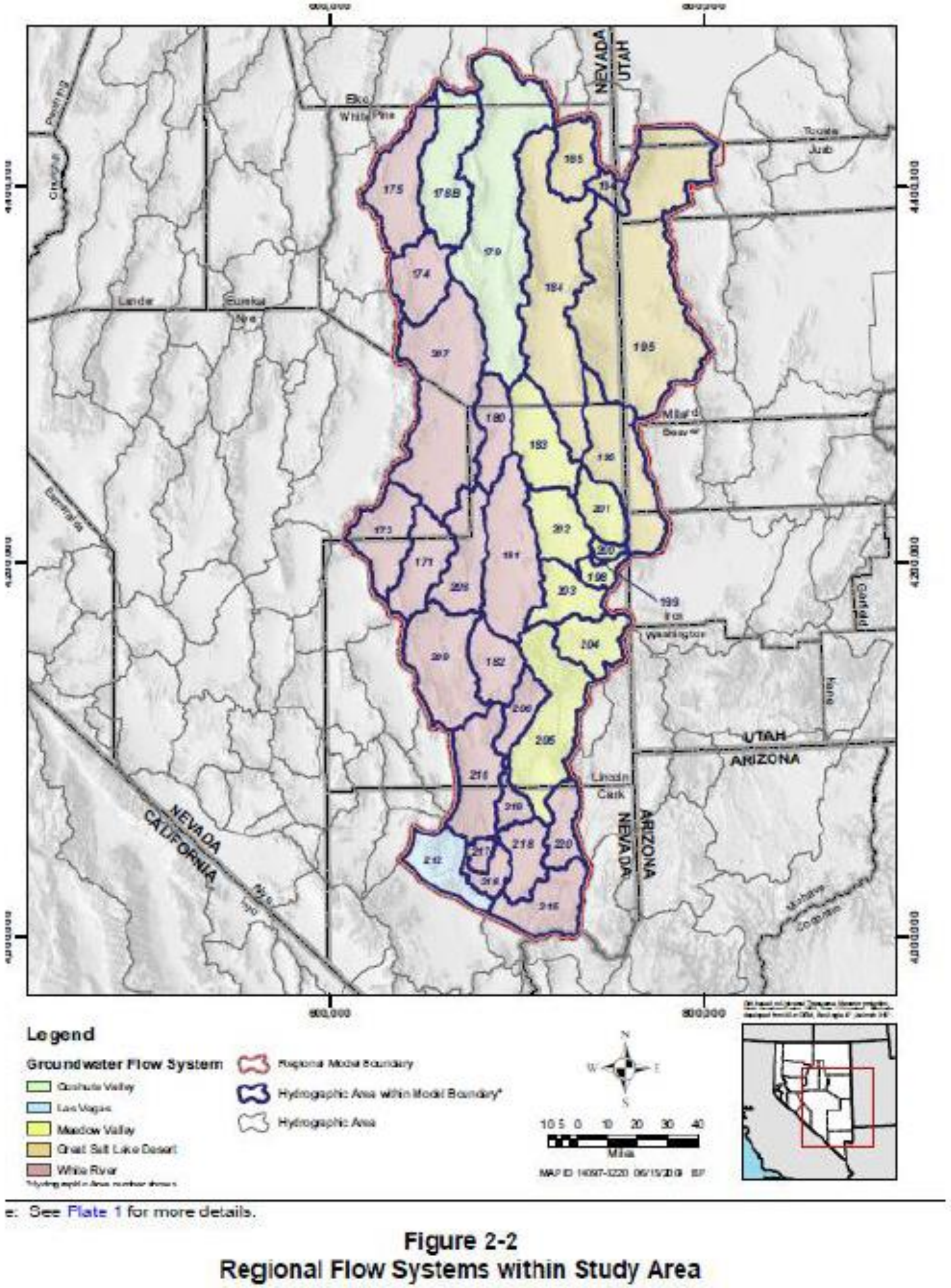


Figure 4: Figure 16 from Welch et al (2008) showing conceptual flow systems for the Great Basin.



e: See Plate 1 for more details.

Figure 2-2

Regional Flow Systems within Study Area

Figure 2: Figure 2-2 from SNWA (2009a) showing the overall Central Carbonate Rock System, regional flow systems and individual basins.

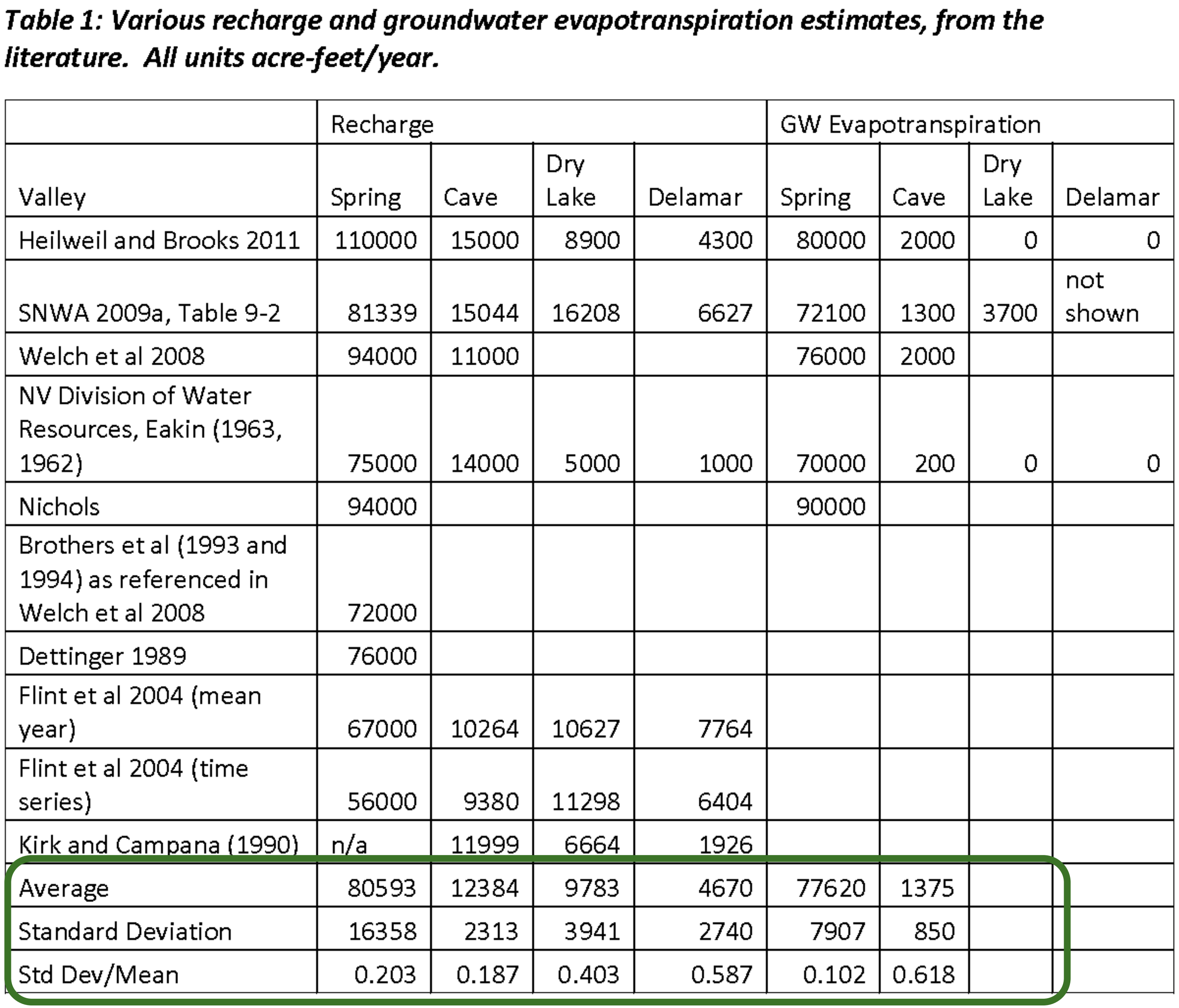


Table 1: Various recharge and groundwater evapotranspiration estimates, from the literature. All units acre-feet/year.

	Recharge				GW Evapotranspiration			
Valley	Spring	Cave	Dry Lake	Delamar	Spring	Cave	Dry Lake	Delamar
Heilweil and Brooks 2011	110000	15000	8900	4300	80000	2000	0	0
SNWA 2009a, Table 9-2	81339	15044	16208	6627	72100	1300	3700	not shown
Welch et al 2008	94000	11000			76000	2000		
NV Division of Water Resources, Eakin (1963, 1962)	75000	14000	5000	1000	70000	200	0	0
Nichols	94000				90000			
Brothers et al (1993 and 1994) as referenced in Welch et al 2008	72000							
Dettinger 1989	76000							
Flint et al 2004 (mean year)	67000	10264	10627	7764				
Flint et al 2004 (time series)	56000	9380	11298	6404				
Kirk and Campana (1990)	n/a	11999	6664	1926				
Average	80593	12384	9783	4670	77620	1375		
Standard Deviation	16358	2313	3941	2740	7907	850		
Std Dev/Mean	0.203	0.187	0.403	0.587	0.102	0.618		

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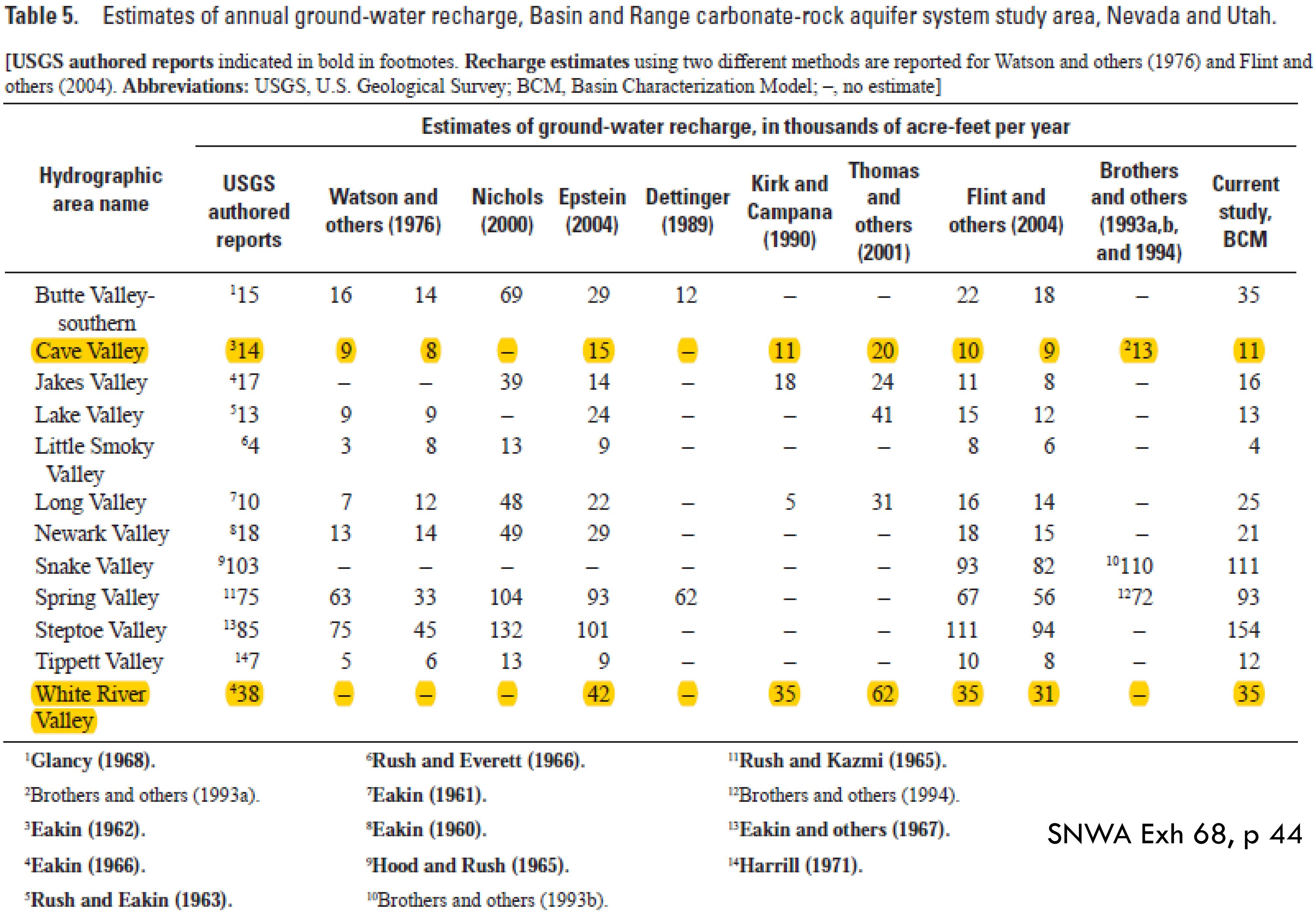

Table 5. Estimates of annual ground-water recharge, Basin and Range carbonate-rock aquifer system study area, Nevada and Utah.

[**USGS authored reports** indicated in bold in footnotes. **Recharge estimates** using two different methods are reported for Watson and others (1976) and Flint and others (2004). **Abbreviations:** USGS, U.S. Geological Survey; BCM, Basin Characterization Model; –, no estimate]

Hydrographic area name	Estimates of ground-water recharge, in thousands of acre-feet per year											
	USGS authored reports	Watson and others (1976)		Nichols (2000)	Epstein (2004)	Dettinger (1989)	Kirk and Campana (1990)	Thomas and others (2001)	Flint and others (2004)		Brothers and others (1993a,b, and 1994)	Current study, BCM
Butte Valley-southern	[1]15	16	14	69	29	12	–	–	22	18	–	35
Cave Valley	[3]14	9	8	–	15	–	11	20	10	9	[2]13	11
Jakes Valley	[4]17	–	–	39	14	–	18	24	11	8	–	16
Lake Valley	[5]13	9	9	–	24	–	–	41	15	12	–	13
Little Smoky Valley	[6]4	3	8	13	9	–	–	–	8	6	–	4
Long Valley	[7]10	7	12	48	22	–	5	31	16	14	–	25
Newark Valley	[8]18	13	14	49	29	–	–	–	18	15	–	21
Snake Valley	[9]103	–	–	–	–	–	–	–	93	82	[10]110	111
Spring Valley	[11]75	63	33	104	93	62	–	–	67	56	[12]72	93
Steptoe Valley	[13]85	75	45	132	101	–	–	–	111	94	–	154
Tippett Valley	[14]7	5	6	13	9	–	–	–	10	8	–	12
White River Valley	[4]38	–	–	–	42	–	35	62	35	31	–	35

[1] **Glancy (1968).**

[2] Brothers and others (1993a).

[3] **Eakin (1962).**

[4] **Eakin (1966).**

[5] **Rush and Eakin (1963).**

[6] **Rush and Everett (1966).**

[7] **Eakin (1961).**

[8] **Eakin (1960).**

[9] **Hood and Rush (1965).**

[10] Brothers and others (1993b).

[11] **Rush and Kazmi (1965).**

[12] Brothers and others (1994).

[13] **Eakin and others (1967).**

[14] **Harrill (1971).**

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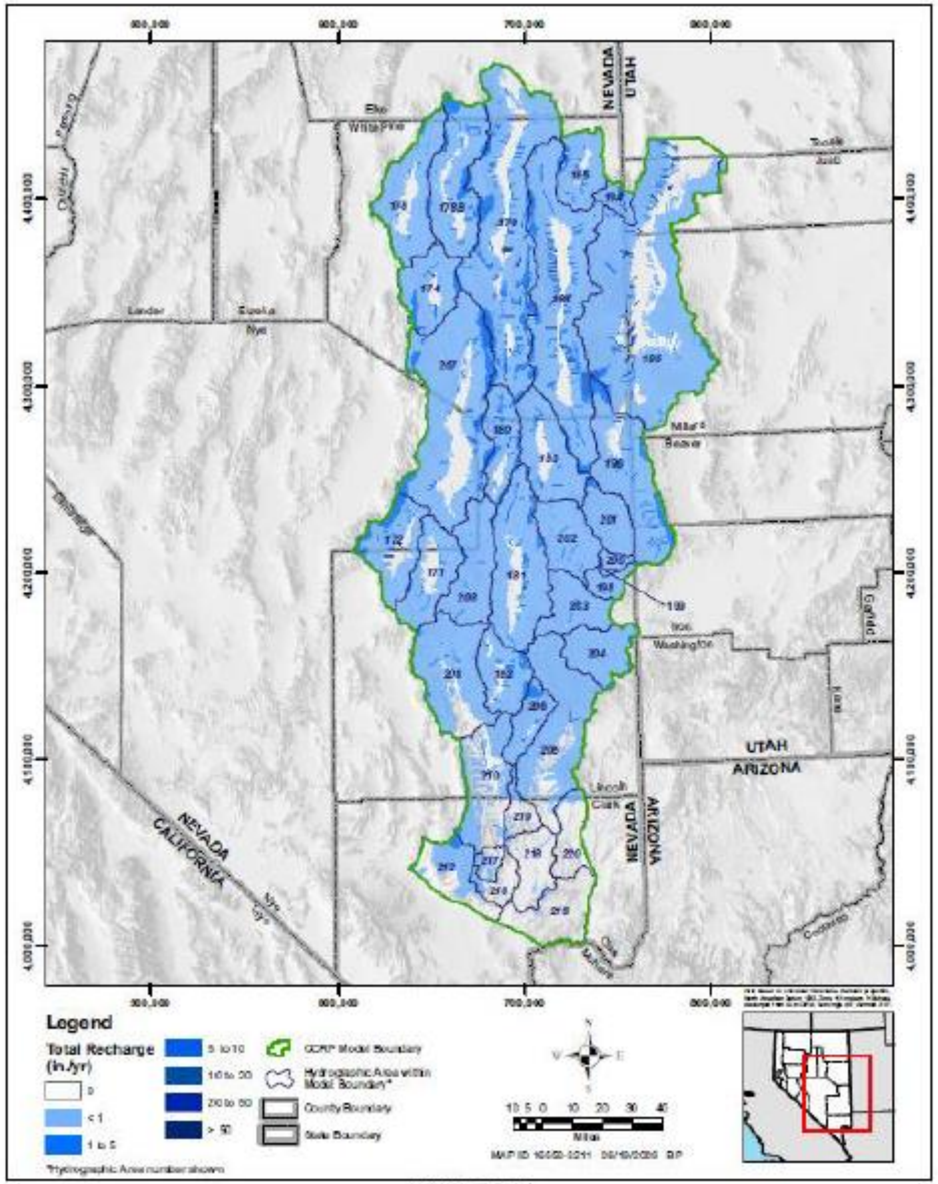
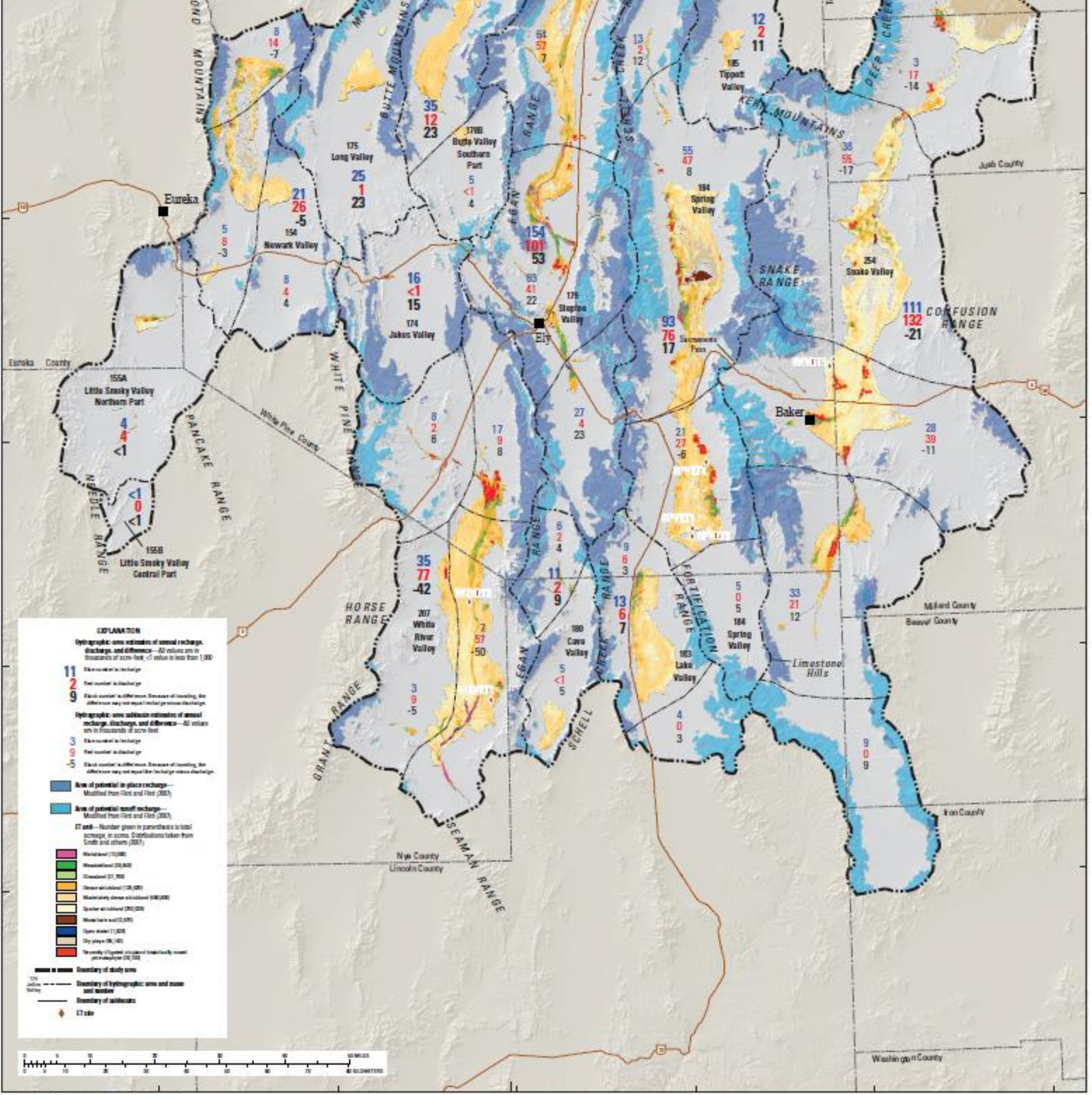


Figure 4-37
Distribution of Total Recharge (Input to MODFLOW-2000)

Figure 19: Snapshot of Figure 4-37 (SNWA 2009d) showing the recharge input to the groundwater model. The light blue is less than 1 in/y.

GBWN Exh_281, p 36



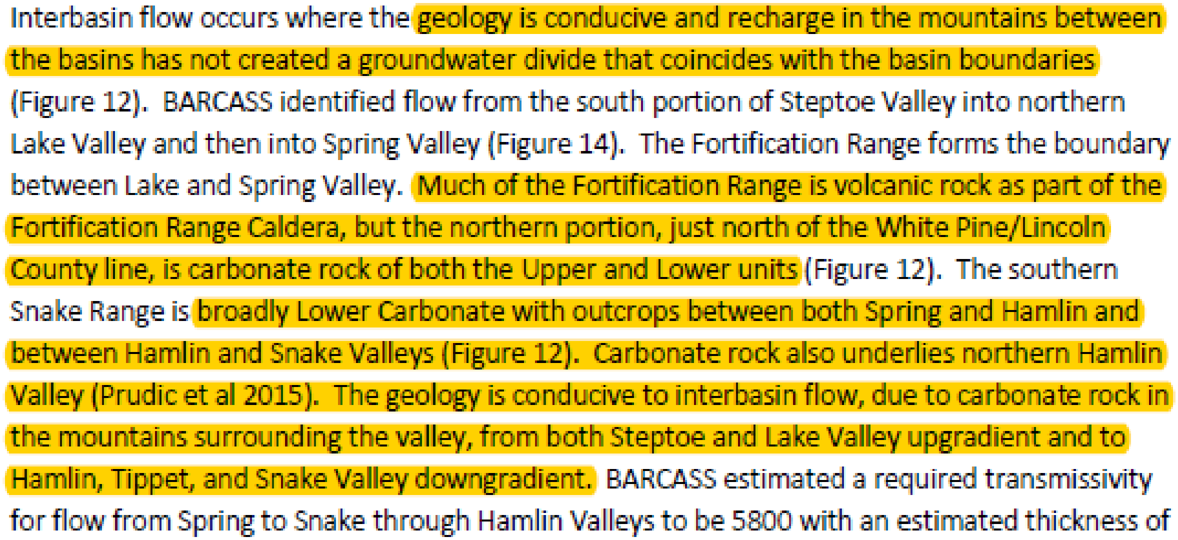
DISTRIBUTION OF GROUND-WATER RECHARGE AND DISCHARGE, AND EVAPOTRANSPIRATION UNITS, WHITE PINE COUNTY, NEVADA, AND ADJACENT AREAS IN NEVADA AND UTAH

By

Randell J. Laczniak, Alan L. Flint, Michael T. Moreo, Lari A. Knochenmus, Kevin W. Lundmark, Greg Pohll, Rosemary W.H. Carroll, J. LaRue Smith, Toby L. Welborn, Victor M. Heilweil, Michael T. Pavelko, Ronald L. Hershey, James M. Thomas, Sam Earman, and Brad F. Lyles

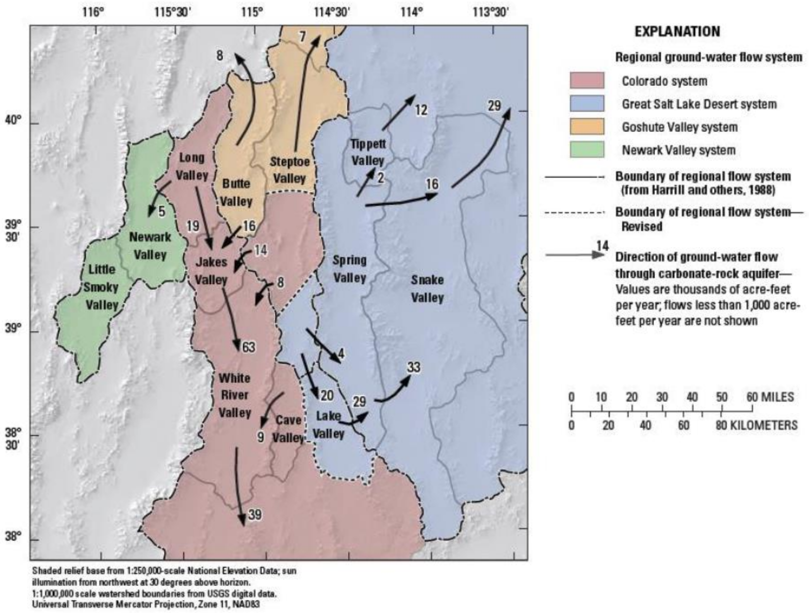
2008

SNWA Exh 68, Plate 4



Interbasin flow occurs where the geology is conducive and recharge in the mountains between the basins has not created a groundwater divide that coincides with the basin boundaries (Figure 12). BARCASS identified flow from the south portion of Steptoe Valley into northern Lake Valley and then into Spring Valley (Figure 14). The Fortification Range forms the boundary between Lake and Spring Valley. Much of the Fortification Range is volcanic rock as part of the Fortification Range Caldera, but the northern portion, just north of the White Pine/Lincoln County line, is carbonate rock of both the Upper and Lower units (Figure 12). The southern Snake Range is broadly Lower Carbonate with outcrops between both Spring and Hamlin and between Hamlin and Snake Valleys (Figure 12). Carbonate rock also underlies northern Hamlin Valley (Prudic et al 2015). The geology is conducive to interbasin flow, due to carbonate rock in the mountains surrounding the valley, from both Steptoe and Lake Valley upgradient and to Hamlin, Tippett, and Snake Valley downgradient. BARCASS estimated a required transmissivity for flow from Spring to Snake through Hamlin Valleys to be 5800 with an estimated thickness of

GBWN Exh_281, p 21

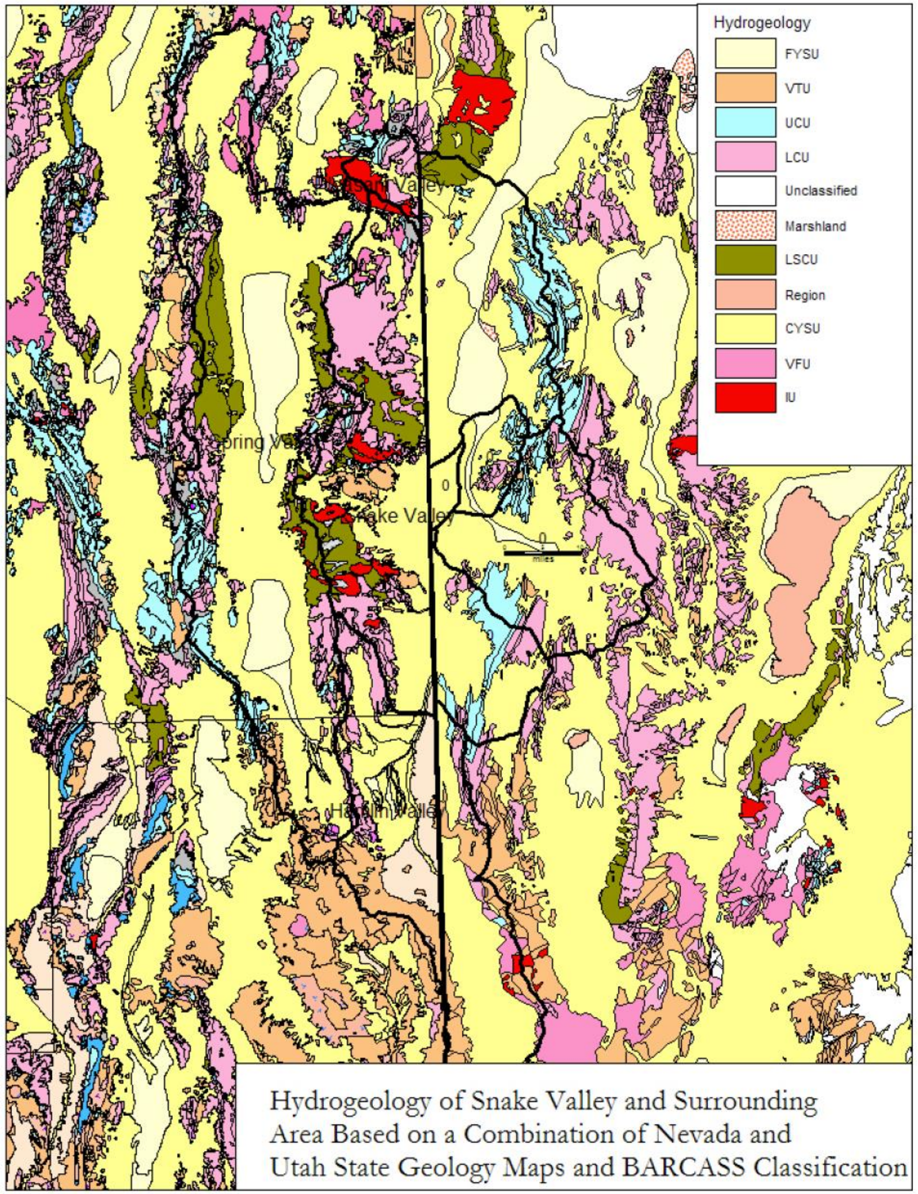


Shaded relief base from 1:250,000-scale National Elevation Data; sun illumination from northwest at 30 degrees above horizon.
1:1,000,000 scale watershed boundaries from USGS digital data.
Universal Transverse Mercator Projection, Zone 11, NAD83

Figure 14: Snapshot of BARCASS Figure 41 showing estimated interbasin flow for basins in the northern portion of the study area (from Welch et al (2008))

GBWN Exh_281, p 24

GBWN Exh_281, p 13



igure 5: Figure 9 from Myers (2011b). Hydrogeology of Spring and Snake Valley study area. ee Table 1 for a description of the hydrogeology. Geology base prepared from Crafford 2007) and Hintze et al (2000).

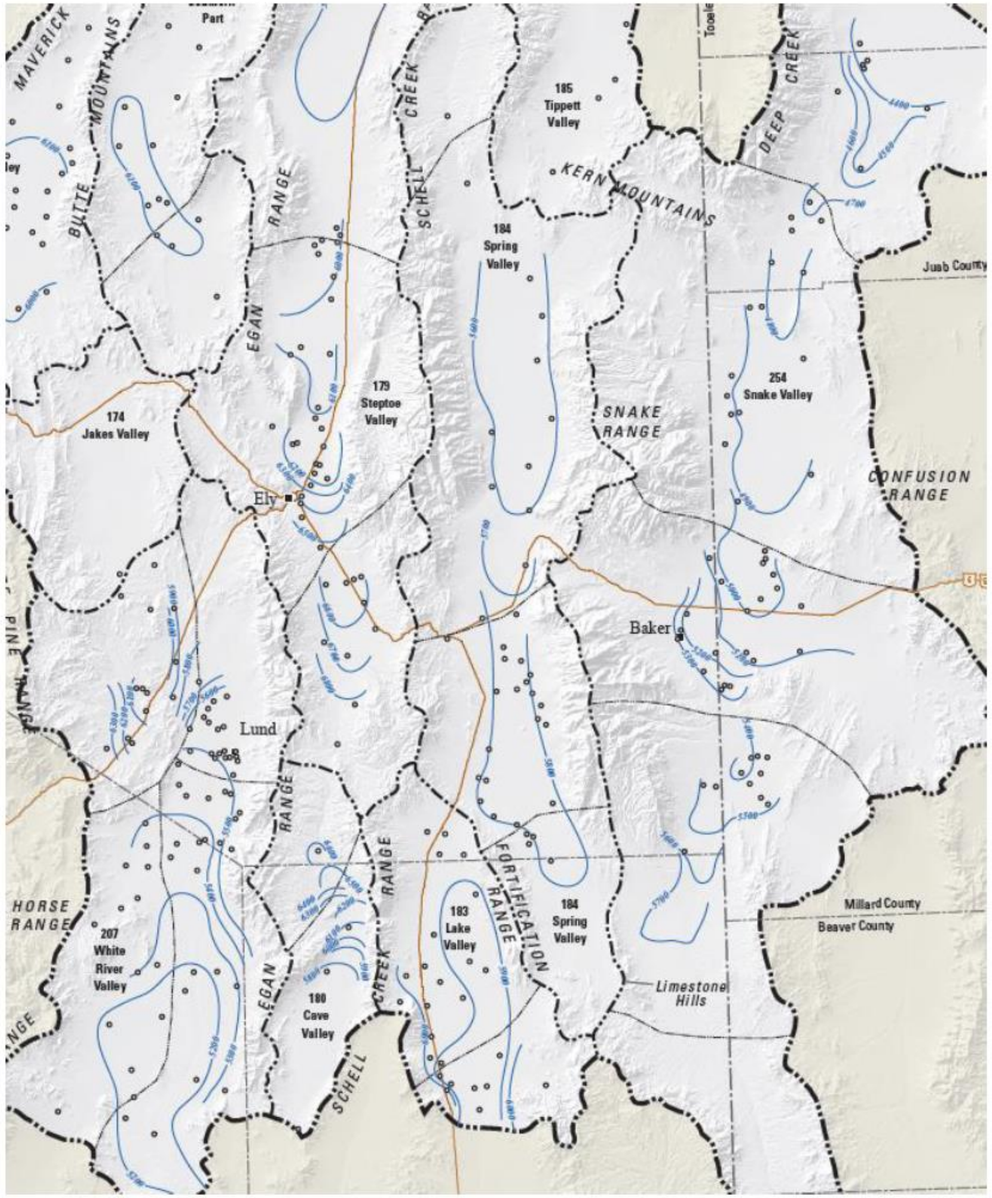


Figure 7: Snapshot of portion of Plate 2 (Welch et al 2008) showing basin fill water levels for Spring and Cave Valleys, and adjoining valleys including Snake Valley and White River Valley.

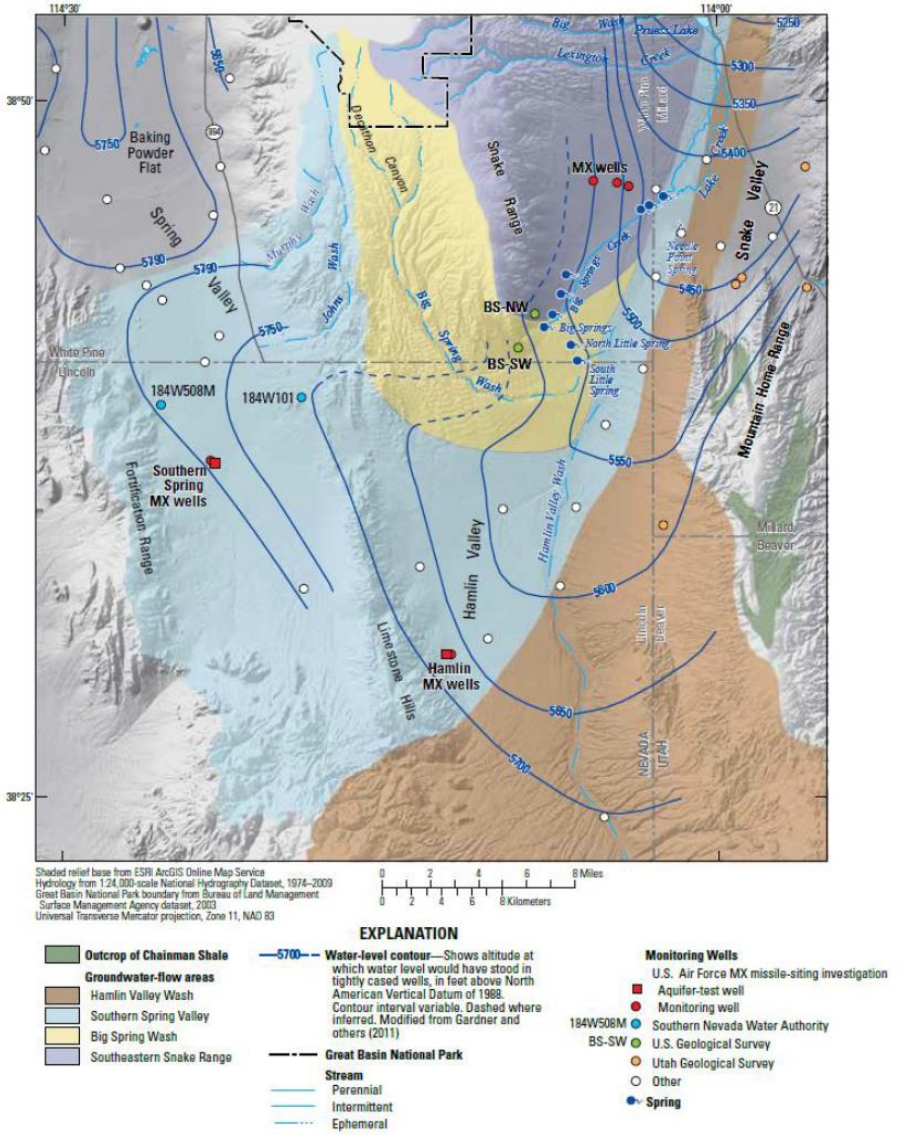


Figure 8: Snapshot of Figure 69 (Prudic et al 2015) showing a groundwater ridge in the southern third of Spring Valley and the conceptualization of groundwater flow from Spring Valley to Snake Valley and from Big Springs.

GBWN Exh_281, p 15, 16

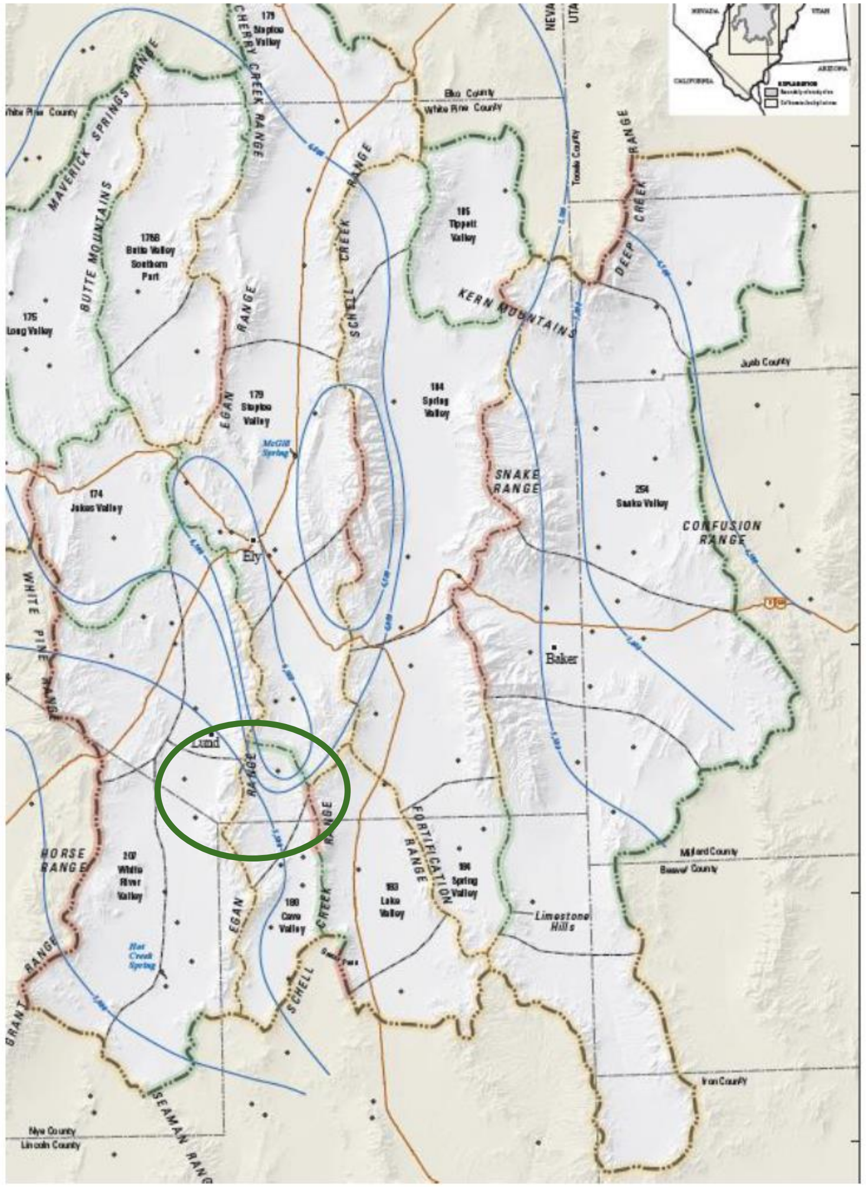


Figure 9: Snapshot of portion of Plate 3 (Welch et al 2008) showing carbonate water levels for Spring and Cave Valleys, and adjoining valleys including Snake Valley and White River Valley.

GBWN Exh_281, p 17

Central Carbonate Flow System Numerical modeling

The CCFS includes all six flow systems simulated by the model (Figure 2). Spring Valley (#184) is part of the Greater Salt Lake Desert Flow System (Figure 2). Spring Valley is the upper portion of the flow system, with recharge originating in Spring Valley flowing into Snake and Hamlin Valleys (Figure 12). Cave, Dry Lake, and Delamar Valleys (#180, 181, and 182 in Figure 2) are part of the White River Flow System (Figure 14). Cave Valley is generally at the headwaters of the WRFS, generating interbasin flow to the White River Valley and possibly to Dry Lake Valley (Figure 14). There is flow from White River Valley to Pahranagat through Pahroc Valley. Dry Lake Valley discharges to Delamar Valley which discharges to Pahranagat and Coyote Spring Valleys (Figure 14). Coyote Spring Valley discharges to the Muddy River Springs area and from the Muddy River Springs (Figure 20), which are a terminal discharge point of the WRFS.

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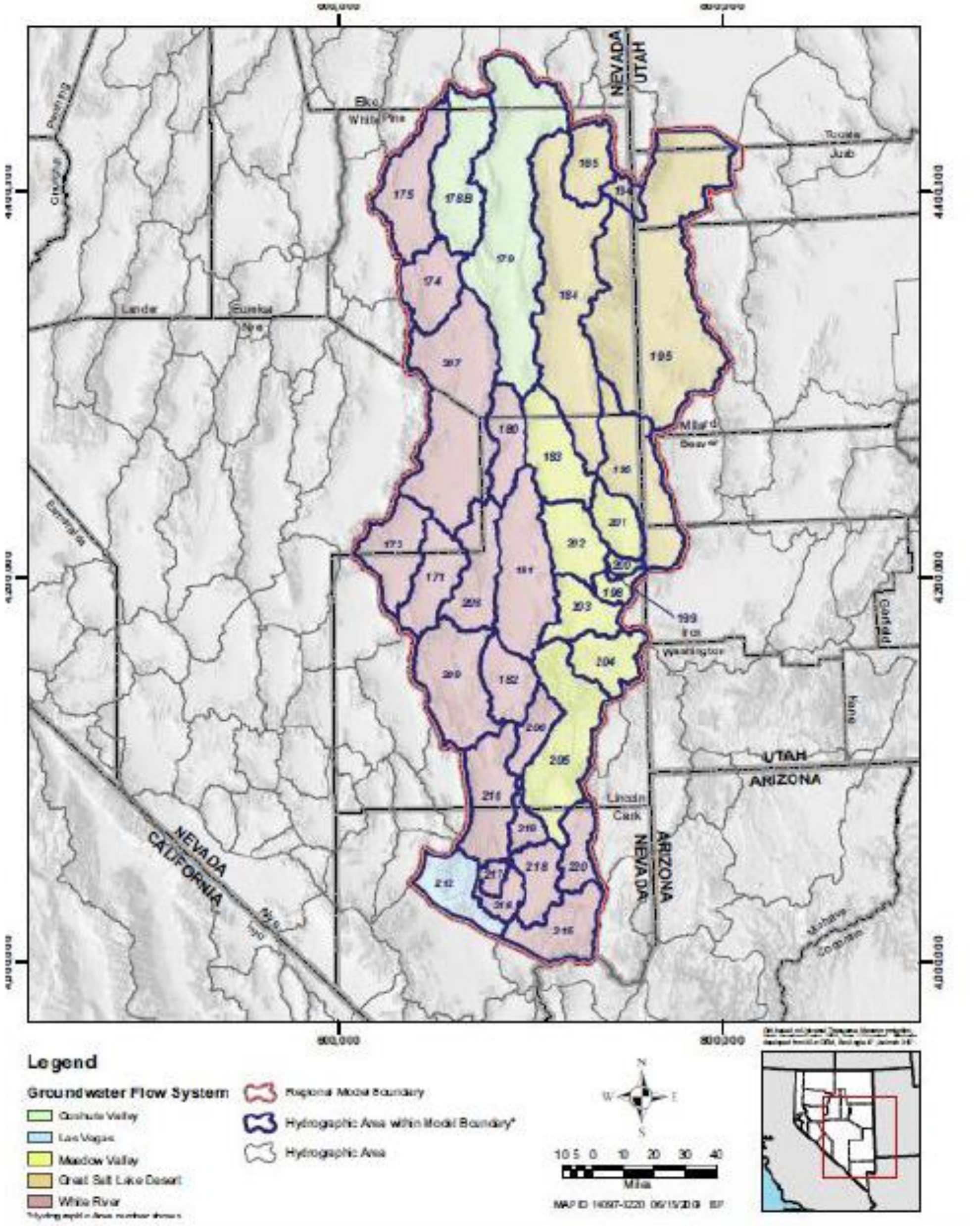
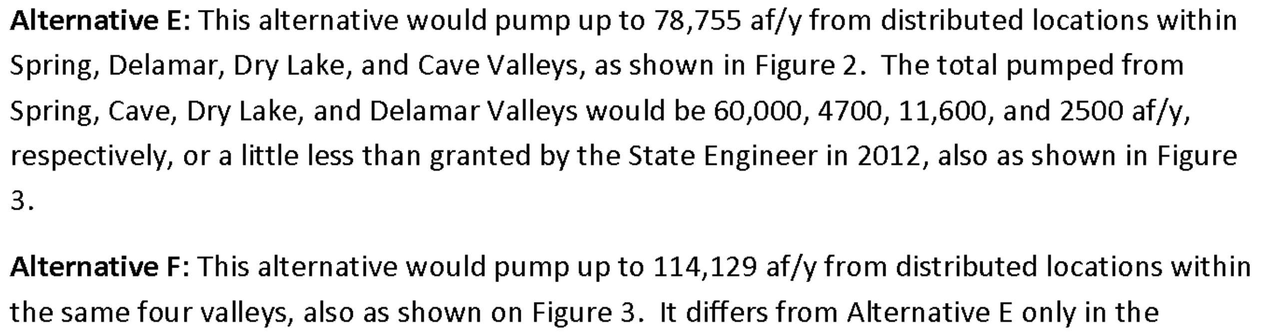


e: See Plate 1 for more details.

Figure 2-2
Regional Flow Systems within Study Area

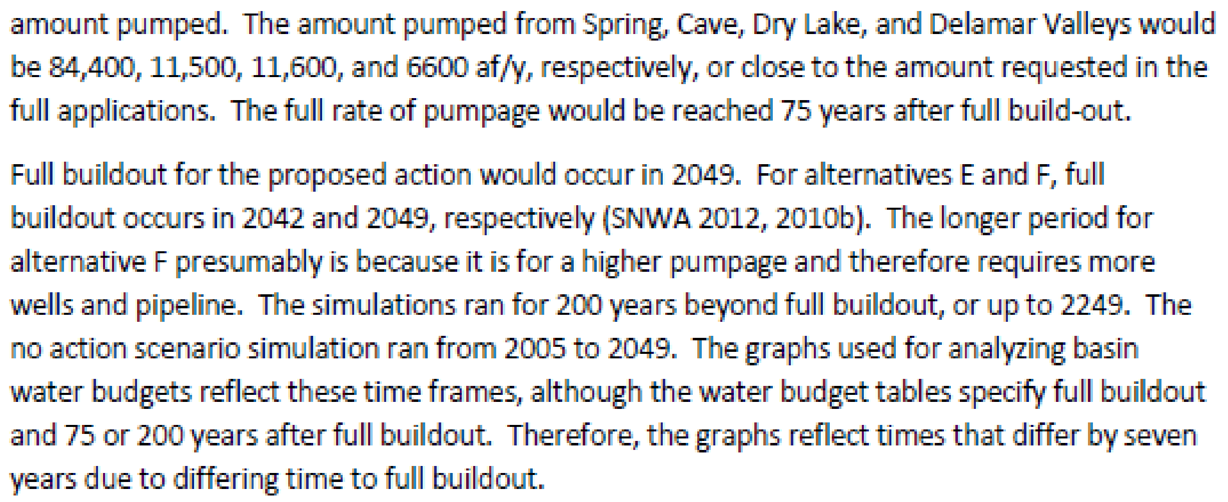
GBWN Exh_281, p 7

Figure 2: Figure 2-2 from SNWA (2009a) showing the overall Central Carbonate Rock System, regional flow systems and individual basins.



Alternative E: This alternative would pump up to 78,755 af/y from distributed locations within Spring, Delamar, Dry Lake, and Cave Valleys, as shown in Figure 2. The total pumped from Spring, Cave, Dry Lake, and Delamar Valleys would be 60,000, 4700, 11,600, and 2500 af/y, respectively, or a little less than granted by the State Engineer in 2012, also as shown in Figure 3.

Alternative F: This alternative would pump up to 114,129 af/y from distributed locations within the same four valleys, also as shown on Figure 3. It differs from Alternative E only in the



amount pumped. The amount pumped from Spring, Cave, Dry Lake, and Delamar Valleys would be 84,400, 11,500, 11,600, and 6600 af/y, respectively, or close to the amount requested in the full applications. The full rate of pumpage would be reached 75 years after full build-out.

Full buildout for the proposed action would occur in 2049. For alternatives E and F, full buildout occurs in 2042 and 2049, respectively (SNWA 2012, 2010b). The longer period for alternative F presumably is because it is for a higher pumpage and therefore requires more wells and pipeline. The simulations ran for 200 years beyond full buildout, or up to 2249. The no action scenario simulation ran from 2005 to 2049. The graphs used for analyzing basin water budgets reflect these time frames, although the water budget tables specify full buildout and 75 or 200 years after full buildout. Therefore, the graphs reflect times that differ by seven years due to differing time to full buildout.

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GBWN Exh_281, p 10

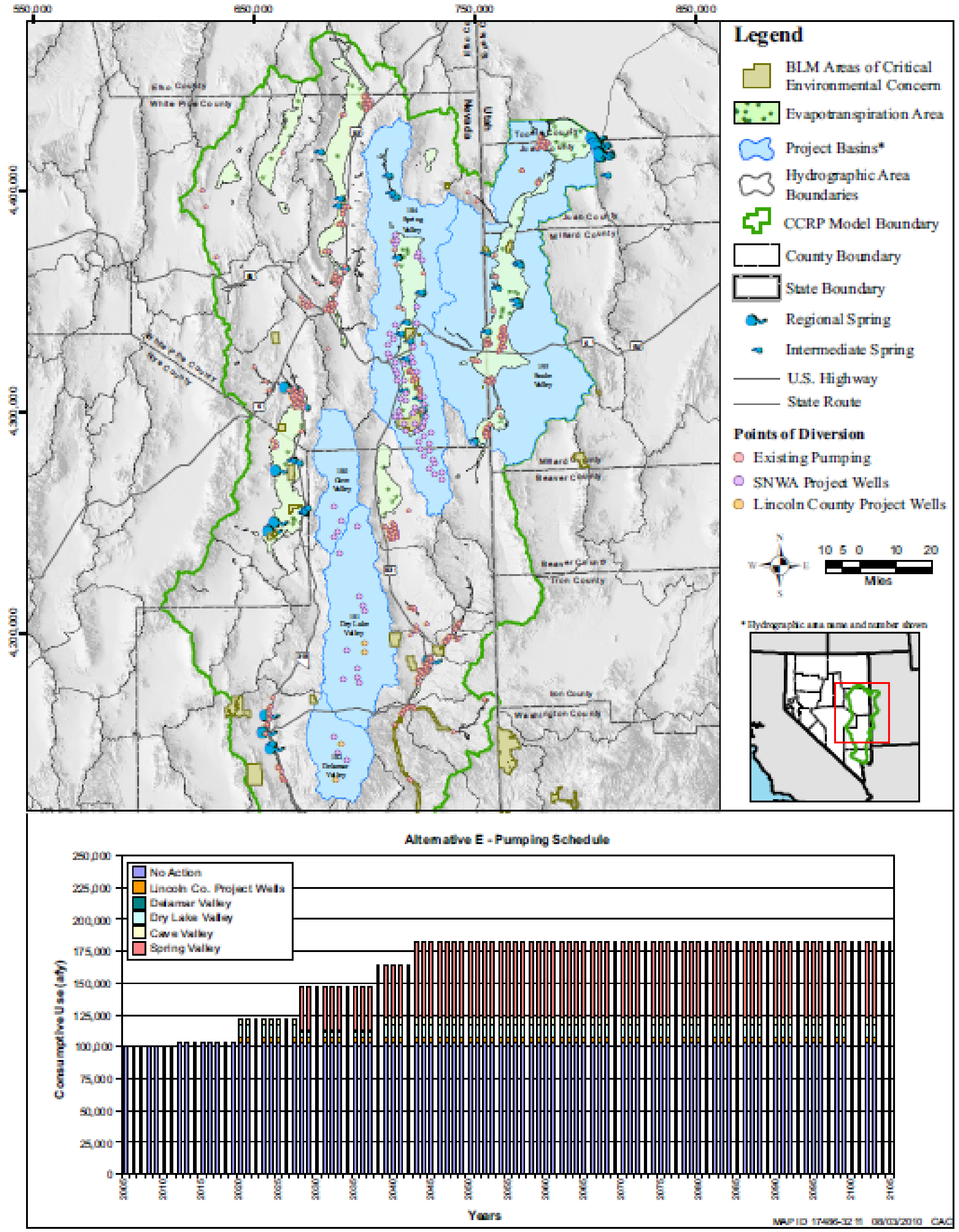
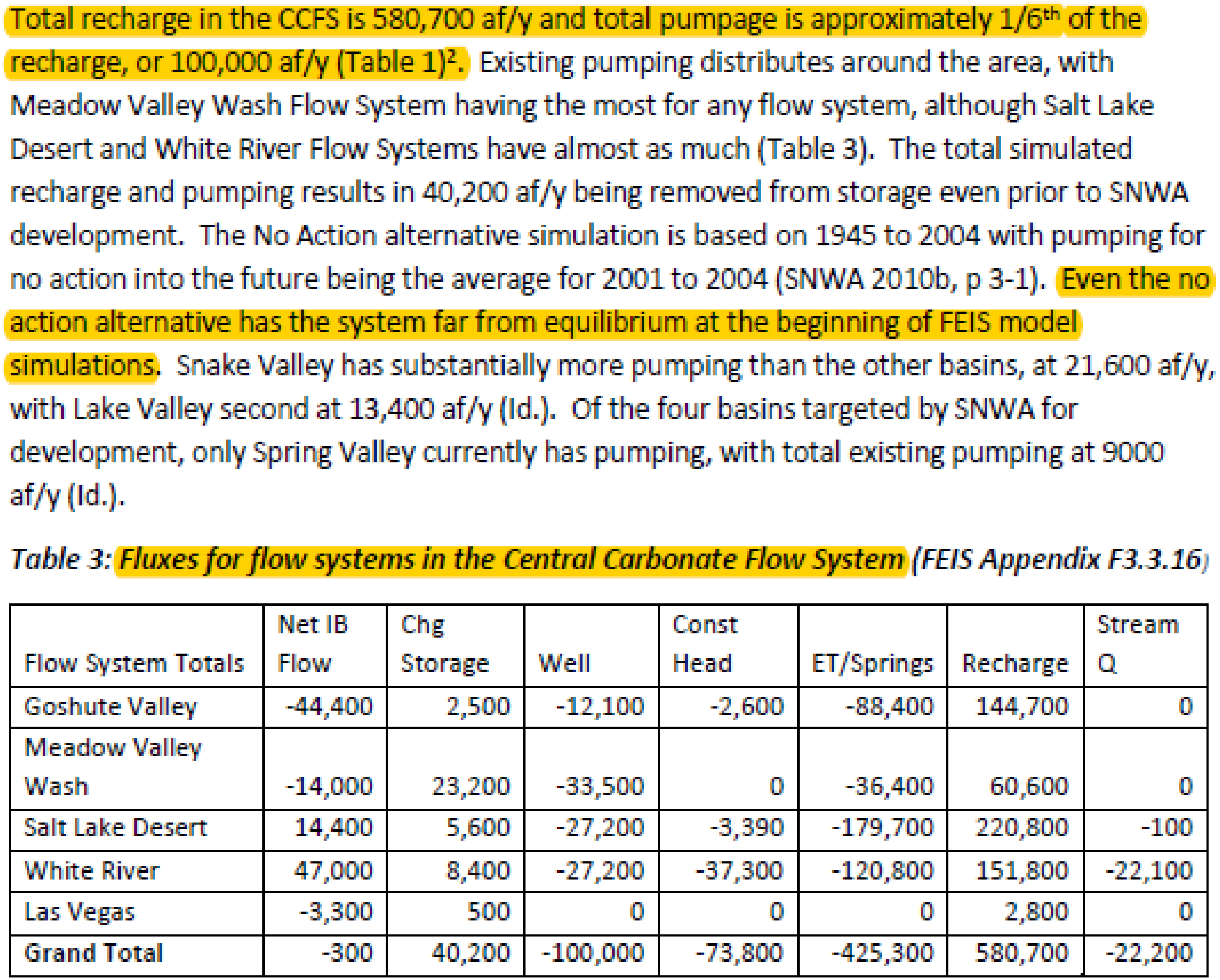


Figure 3-8
Pumping Distribution for Alternative E - Delamar, Dry Lake, Cave, and Spring Valleys



Total recharge in the CCFS is 580,700 af/y and total pumpage is approximately 1/6th of the recharge, or 100,000 af/y (Table 1)[2]. Existing pumping distributes around the area, with Meadow Valley Wash Flow System having the most for any flow system, although Salt Lake Desert and White River Flow Systems have almost as much (Table 3). The total simulated recharge and pumping results in 40,200 af/y being removed from storage even prior to SNWA development. The No Action alternative simulation is based on 1945 to 2004 with pumping for no action into the future being the average for 2001 to 2004 (SNWA 2010b, p 3-1). Even the no action alternative has the system far from equilibrium at the beginning of FEIS model simulations. Snake Valley has substantially more pumping than the other basins, at 21,600 af/y, with Lake Valley second at 13,400 af/y (Id.). Of the four basins targeted by SNWA for development, only Spring Valley currently has pumping, with total existing pumping at 9000 af/y (Id.).

Table 3: Fluxes for flow systems in the Central Carbonate Flow System (FEIS Appendix F3.3.16)

Flow System Totals	Net IB Flow	Chg Storage	Well	Const Head	ET/Springs	Recharge	Stream Q
Goshute Valley	-44,400	2,500	-12,100	-2,600	-88,400	144,700	0
Meadow Valley Wash	-14,000	23,200	-33,500	0	-36,400	60,600	0
Salt Lake Desert	14,400	5,600	-27,200	-3,390	-179,700	220,800	-100
White River	47,000	8,400	-27,200	-37,300	-120,800	151,800	-22,100
Las Vegas	-3,300	500	0	0	0	2,800	0
Grand Total	-300	40,200	-100,000	-73,800	-425,300	580,700	-22,200

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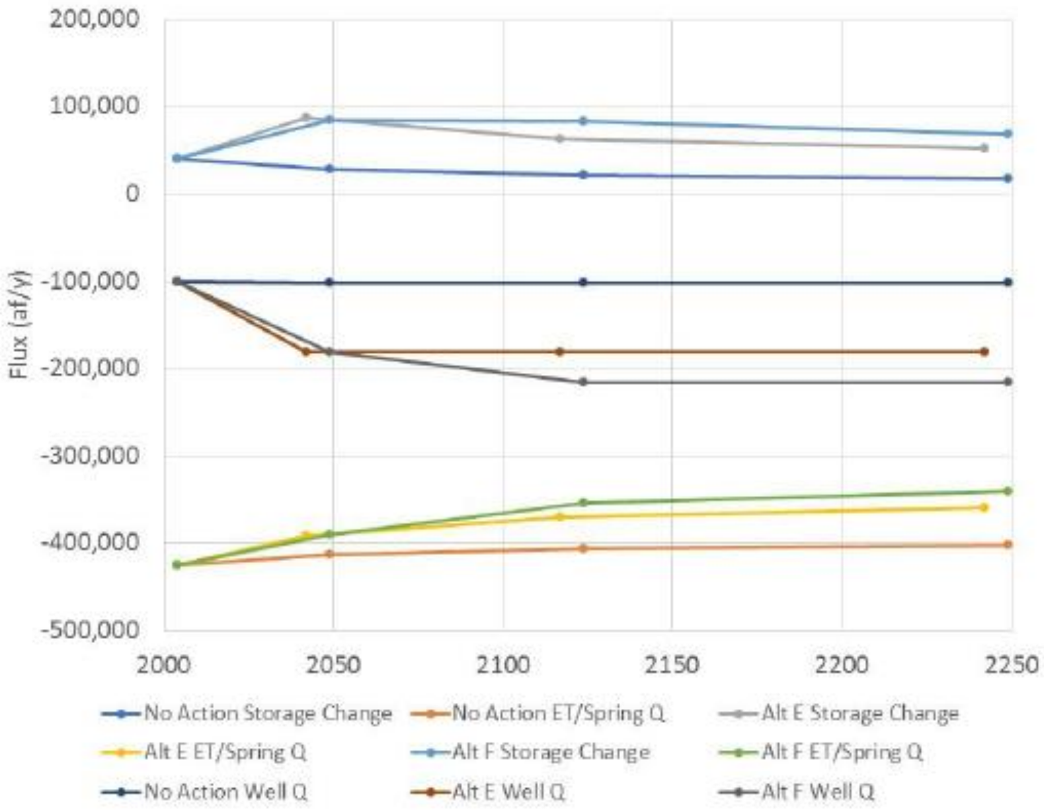

Figure 21: Water budget accounting including storage change, ET/spring discharge (Q), and well pumpage for the Central Carbonate Flow System for the No Action alternative and Alternatives E and F, as simulated for the FEIS (FEIS Appendix F3.3.16).

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Alternatives E and F would increase the amounts removed from storage to near 85,000 af/y at full buildout in 2050. By the end of the simulation in 2250, amounts removed from storage were reduced to 51,900 and 68,500 af/y for alternatives E and F, respectively (Figure 21). The difference in captured storage between alternatives is mostly due to the difference in the amount of ET/Spring discharge captured (FEIS Appendix F3.3, Table F3.3.16-8B) with additional small amounts of change in the amount of interbasin flow to or from the CCFS that is captured or the amount of stream discharge captured. To the extent that storage changes or ET/spring discharge within the target basins pumped for Alternatives E or F, discussed below, do not explain the differences in Figure 21, the differences are due to changes in surrounding basins.

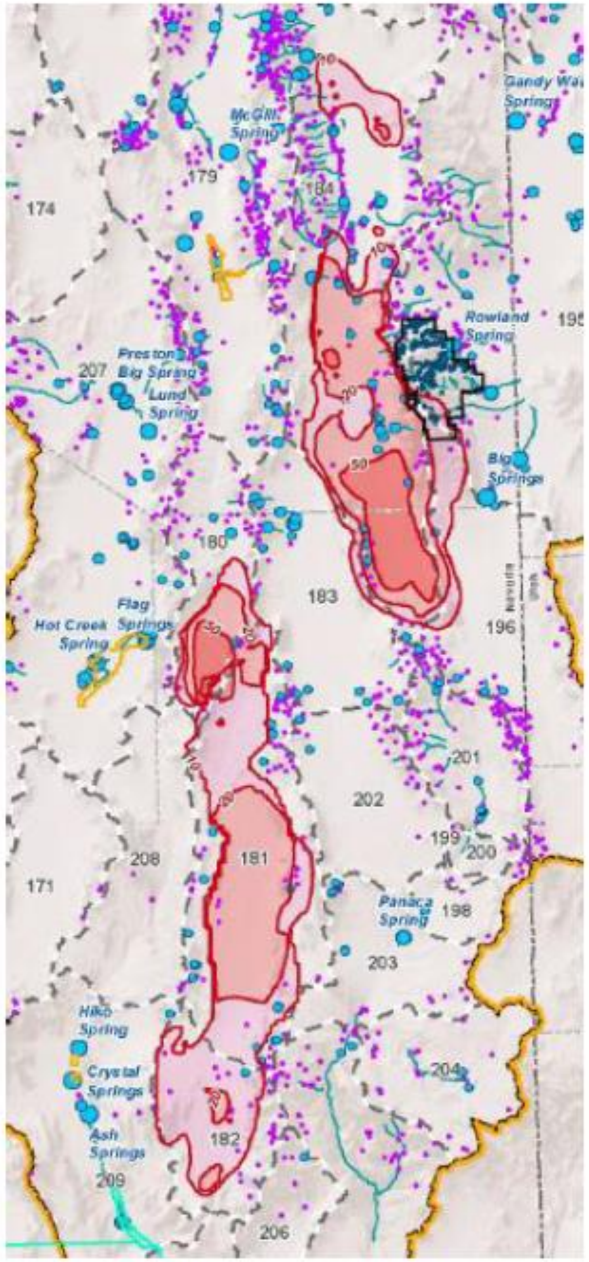

Figure 22: Snapshot of a portion of FEIS Figure 3.2.2.28 showing drawdown in the CCFS for Alternative E at 75 years after full buildout (year 2125).

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p 41, 42

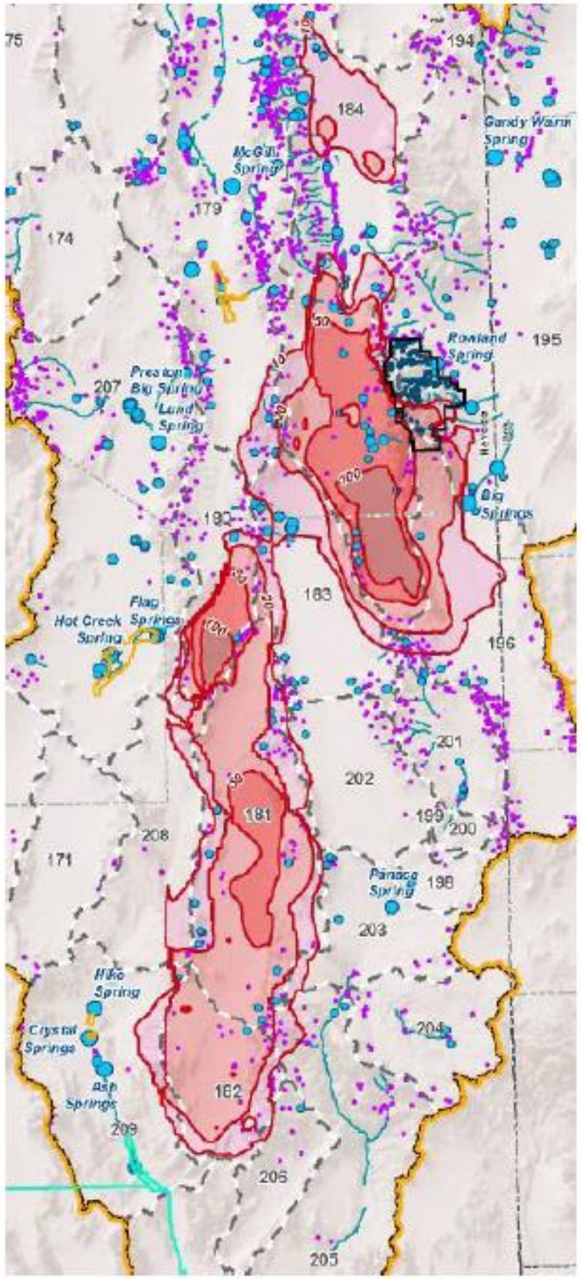

Figure 23: Snapshot of a portion of FEIS Figure 3.2.2.29 showing drawdown in the CCFS for Alternative E at 200 years after full buildout (year 2250).

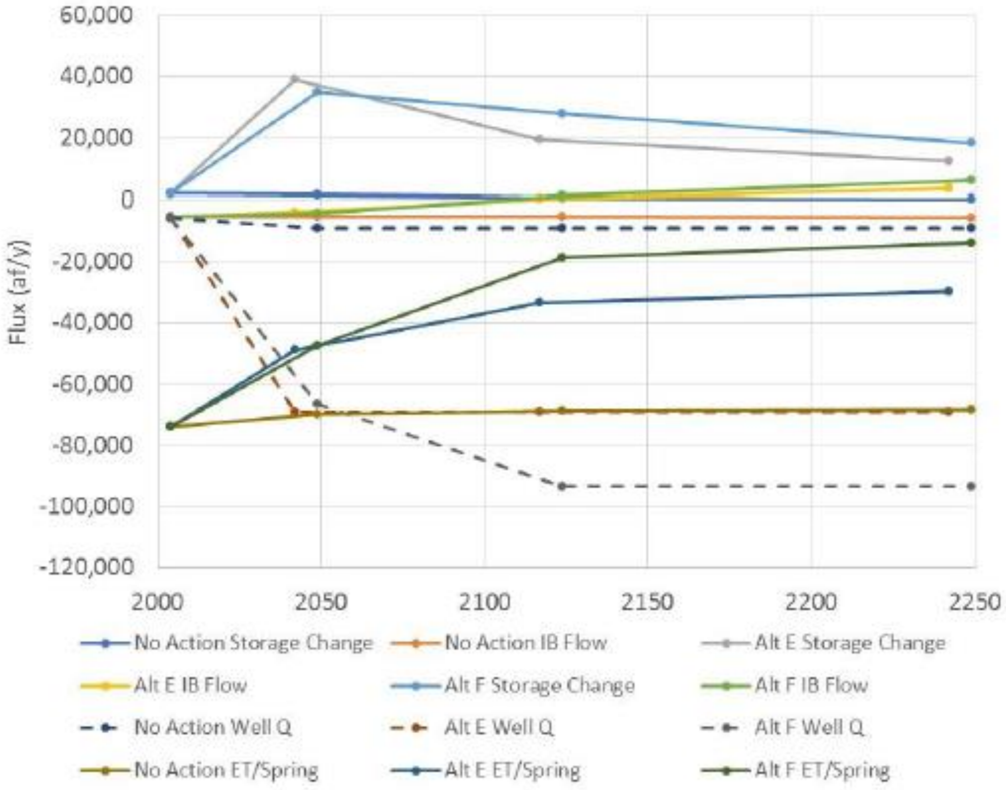

Figure 26: Water budget accounting including storage change, ET/spring discharge (Q), and well pumpage for Spring Valley for the No Action alternative and Alternatives E and F, as simulated for the FEIS (FEIS Appendix F3.3.16).

years after full buildout (Figure 25). Water level graphs for the simulated monitoring well also show that the water level drops up to 70 feet for alternatives E and F and that the downward slope is a straight line (Figure 27), which indicates drawdown will continue at a high rate far into the future. Even 200 years after full buildout, pumpage for alternatives E and F is still removing 18% and 20%, respectively, of the water from storage (Figure 26). Simulated interbasin flow changes from 5300 af/y leaving the basin, to 3800 or 6100 af/y being drawn into the basin for alternatives E and F, respectively (Figure 26), thus 10% of the simulated pumpage in Spring Valley eventually captures interbasin flow. Most of the existing flow is from Spring Valley to Snake Valley before development, while 200 years after full buildout additional amounts of water are drawn from Steptoe, Lake, and Tippet Valleys (FEIS Appendix F3.3.16).

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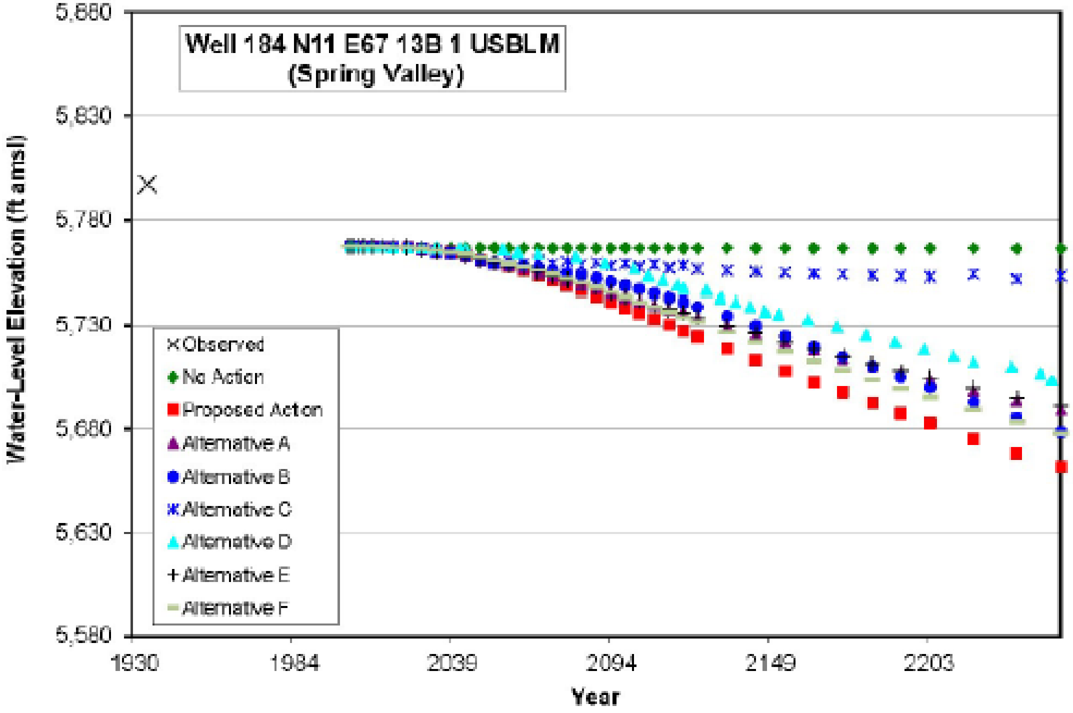

Figure 27: Snapshot of FEIS Figure 3.3.2-7 showing representative water-level hydrograph for Spring Valley.

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GBWN Exh_281, p 45

GBWN Exh_281, p 48

Changed groundwater elevations and gradients at basin boundaries caused by pumping result in the changes in interbasin flow discussed above and in Figure 26. Decreased interbasin flow affects spring flow downgradient in Snake Valley. Pumping according to Alternative E decreased Big Springs flow to about 20% of its 2004 discharge (Figure 28). The other project alternatives have a larger effect because they include pumping in Snake Valley.

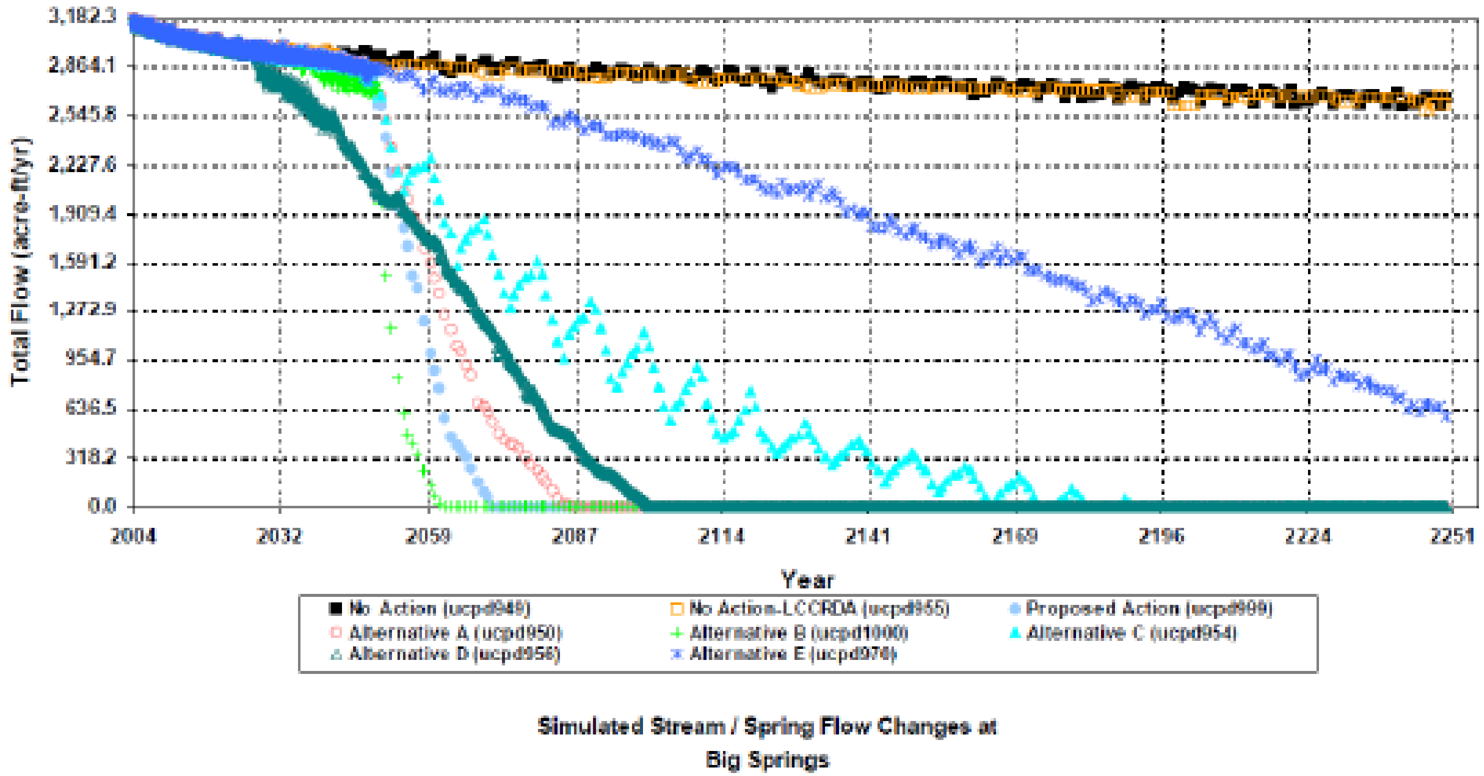
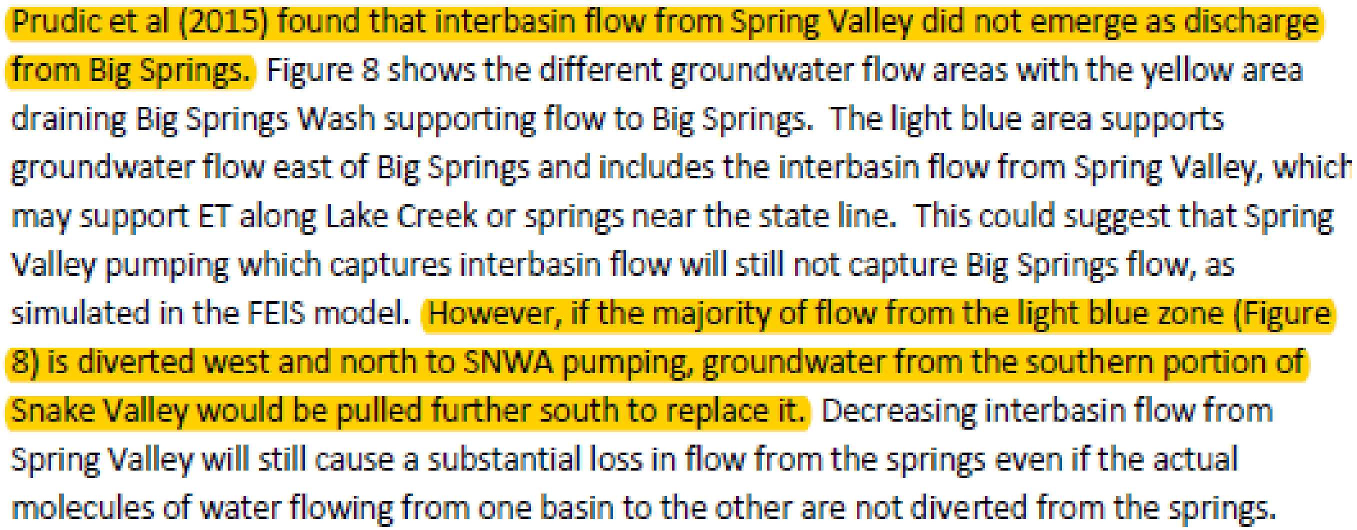


Figure 28: Snapshot of figure from file titled Springs_Hydrograph_Report_2005_2250 (BLM undated b). The graph shows flows at Big Spring for various alternatives. Alternative F was not included and a file with Alternative F was not available. Because it pumps at higher rates, the Big Springs flow would decrease more than for Alternative E.



Prudic et al (2015) found that interbasin flow from Spring Valley did not emerge as discharge from Big Springs. Figure 8 shows the different groundwater flow areas with the yellow area draining Big Springs Wash supporting flow to Big Springs. The light blue area supports groundwater flow east of Big Springs and includes the interbasin flow from Spring Valley, which may support ET along Lake Creek or springs near the state line. This could suggest that Spring Valley pumping which captures interbasin flow will still not capture Big Springs flow, as simulated in the FEIS model. However, if the majority of flow from the light blue zone (Figure 8) is diverted west and north to SNWA pumping, groundwater from the southern portion of Snake Valley would be pulled further south to replace it. Decreasing interbasin flow from Spring Valley will still cause a substantial loss in flow from the springs even if the actual molecules of water flowing from one basin to the other are not diverted from the springs.

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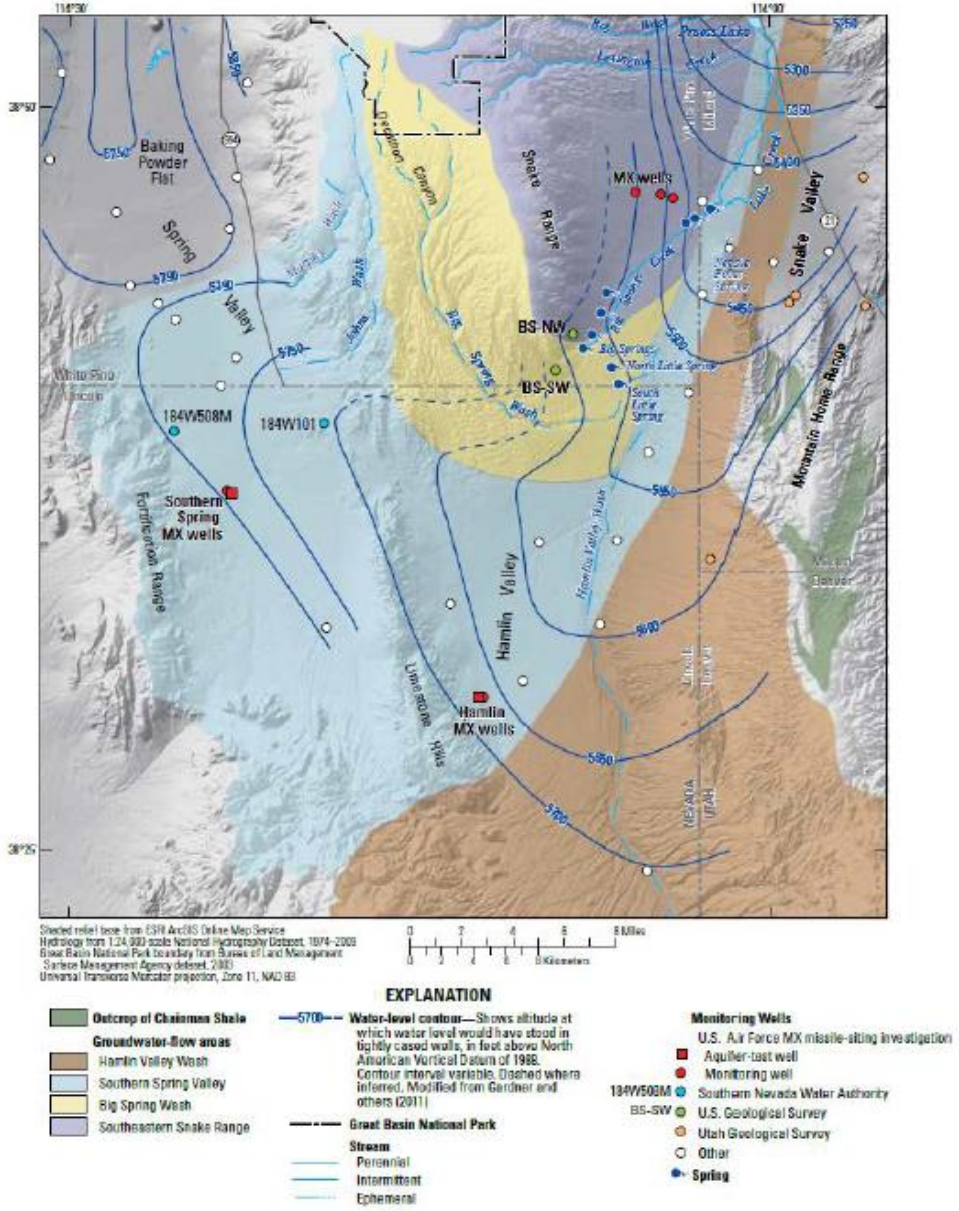

Figure 8: Snapshot of Figure 69 (Prudic et al 2015) showing a groundwater ridge in the southern third of Spring Valley and the conceptualization of groundwater flow from Spring Valley to Snake Valley and from Big Springs.

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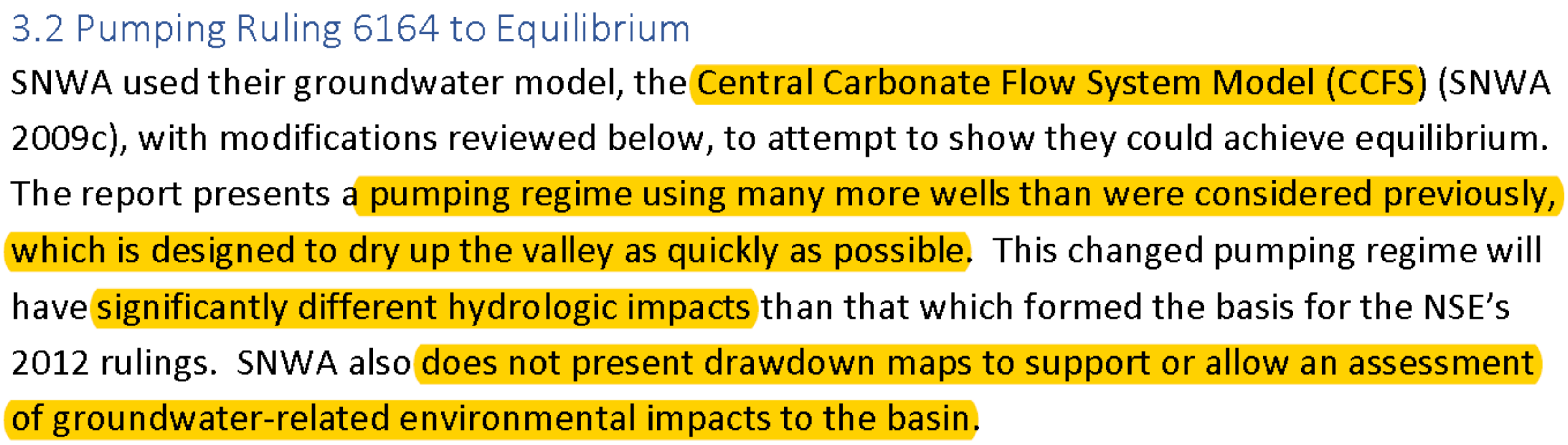
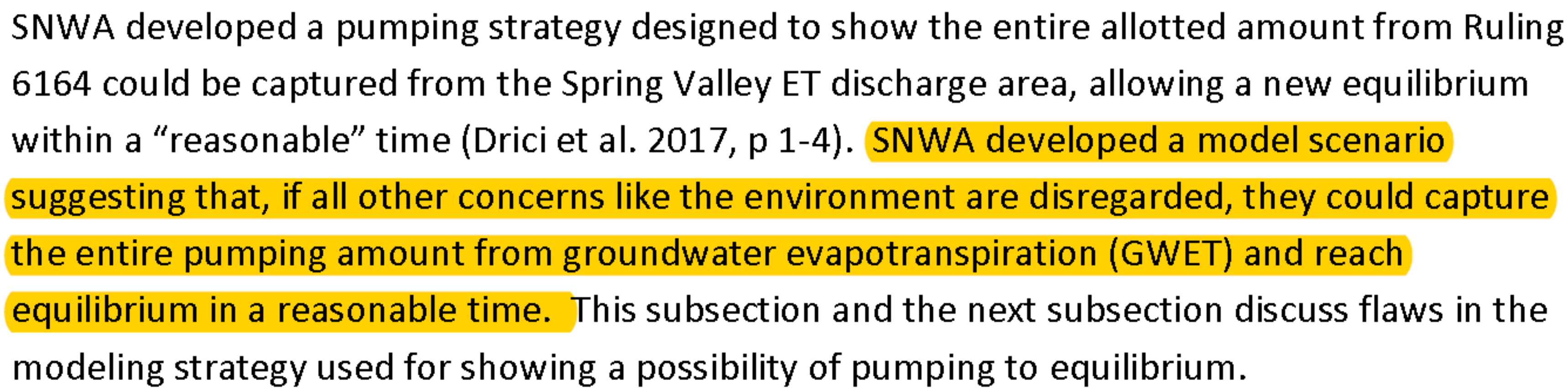


3.2 Pumping Ruling 6164 to Equilibrium

SNWA used their groundwater model, the Central Carbonate Flow System Model (CCFS) (SNWA 2009c), with modifications reviewed below, to attempt to show they could achieve equilibrium. The report presents a pumping regime using many more wells than were considered previously, which is designed to dry up the valley as quickly as possible. This changed pumping regime will have significantly different hydrologic impacts than that which formed the basis for the NSE's 2012 rulings. SNWA also does not present drawdown maps to support or allow an assessment of groundwater-related environmental impacts to the basin.

GBWN Exh_297, p 7



SNWA developed a pumping strategy designed to show the entire allotted amount from Ruling 6164 could be captured from the Spring Valley ET discharge area, allowing a new equilibrium within a "reasonable" time (Drici et al. 2017, p 1-4). SNWA developed a model scenario suggesting that, if all other concerns like the environment are disregarded, they could capture the entire pumping amount from groundwater evapotranspiration (GWET) and reach equilibrium in a reasonable time. This subsection and the next subsection discuss flaws in the modeling strategy used for showing a possibility of pumping to equilibrium.

pumping is less than the volume of ET discharge" (Drici et al. 2017, p 2-2). This claim does not follow logically because the requirement is for pumping to capture an amount of GWET equal to the amount of pumping, not a higher amount. If the entire PY of a valley is granted, the logic would suggest that each water right capture an amount of GWET equal to the amount of the right, not that SNWA capture all of the GWET.

Continuing the faulty logic, SNWA argues that "reducing the amount of water SNWA is allowed to pump would not ensure that the reduced appropriation would be fully captured from the ET discharge area" (Id.). It may not "ensure" it, but it certainly would make it much more likely because pumping would have to capture a smaller amount of GWET from a presumably similar area. The area would be similar if the applications were still spread around a similar area. Finally, SNWA fallaciously claims, "[t]o the contrary, ET capture would be decreased and be further delayed." (Id.) It would be decreased only because there is less pumping, but it does not follow that it would be delayed with respect to capturing GWET equal to the amount of water permitted. Capture would depend on the dispersion of wells.

SNWA limits its purpose in reanalyzing pumping in Spring Valley to showing it can specify a scenario that demonstrates "that ET discharge can be effectively captured by the pumping that was approved in Ruling 6164 within a reasonable time, using a model that is consistent with the NSE's estimate of ET discharge for Spring Valley" (Drici et al. 2017, p 2-2). To capture GWET, SNWA designed a well layout and pumping regime without regard to any other consideration, including [redacted] environmental impacts. To be consistent with the NSE's estimate of ET, SNWA adjusted the GWET rate within the CCFS model. I discuss these factors in the next subsections

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SNWA 475, p. 4-4

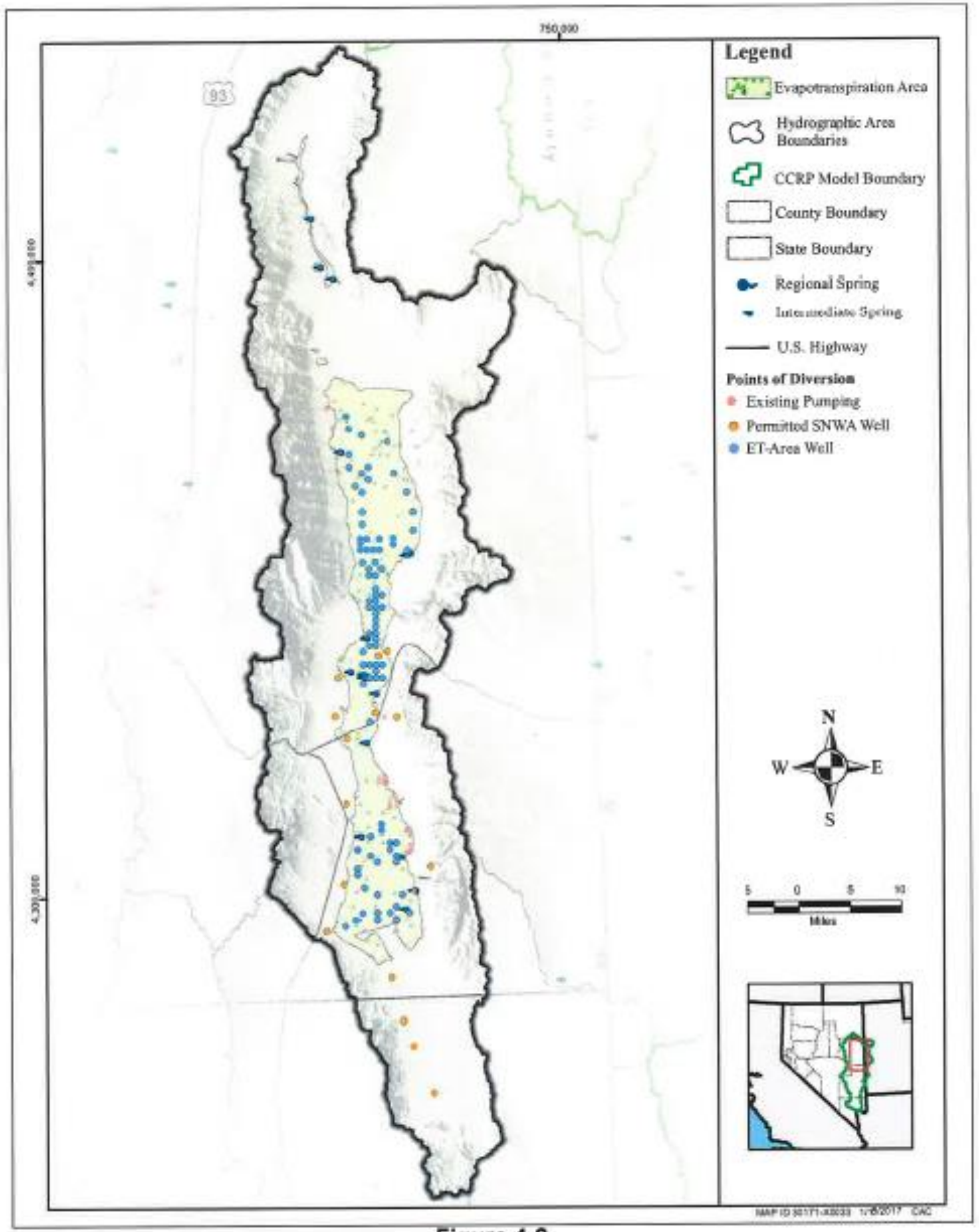

Figure 4-2
Locations of Pumping Wells for ET-Capture Scenario

GBWN Exh_297, p 10

3.22 SNWA Revised Pumping Scenario in the CCFS Model

SWNW simulated two scenarios to demonstrate an ability to capture ET, a baseline scenario and an ET-Capture scenario, using the recharge and GWET adjustments discussed in the previous sections. The baseline scenario was 2004 pumping as considered in the BLM's 2012 FEIS with adjusted GWET. The ET-capture scenario was SNWA's strategy of pumping all the Ruling 6164 permitted groundwater, not from the application points that were the basis for that Ruling, but from 101 wells spread throughout the simulated GWET areas within Spring Valley (Figure 1). "The spatial distribution and production volumes of wells were selected to present a modeling scenario that demonstrates how the model could be used to identify new well locations to increase the effectiveness of ET capture" (Drici et al. 2017, p 4-1). "The ET-capture wells are distributed spatially within the groundwater ET discharge area in locations that (1) avoid privately owned land, (2) avoid playa deposits, and (3) have the potential of capturing ET discharge remaining from the Baseline simulation" (Drici et al. 2017, p 4-3).

SNWA gave no attention to how this newly-created pumping regime would change the hydrologic or biological impacts analysis, to protecting the environment, or to how the stipulated agreement protecting groundwater resources would be implemented. Also, Drici et

GBWN Exh_297, p 11

al. (2017) does not discuss the depth of the pumping wells or the level at which they are screened. The report also does not provide the amount of water that each well would pump, other than to state that annual production volume of a given ET-capture well is based on its proximity to areas of high ET discharge.

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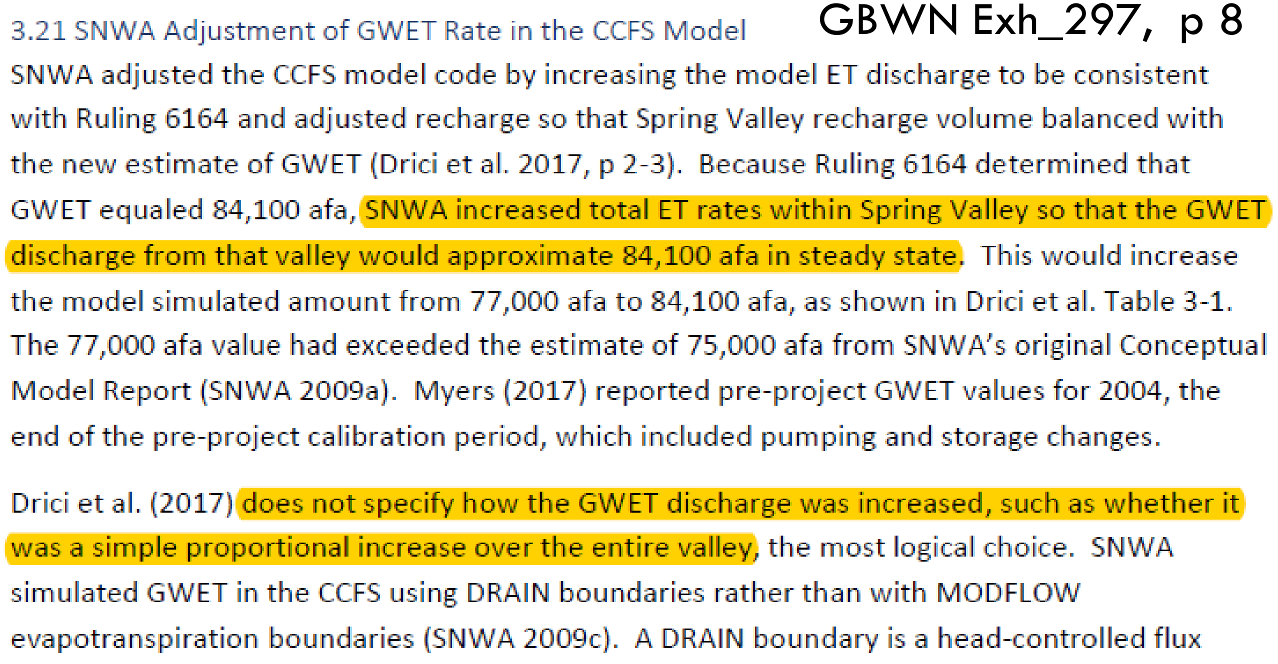
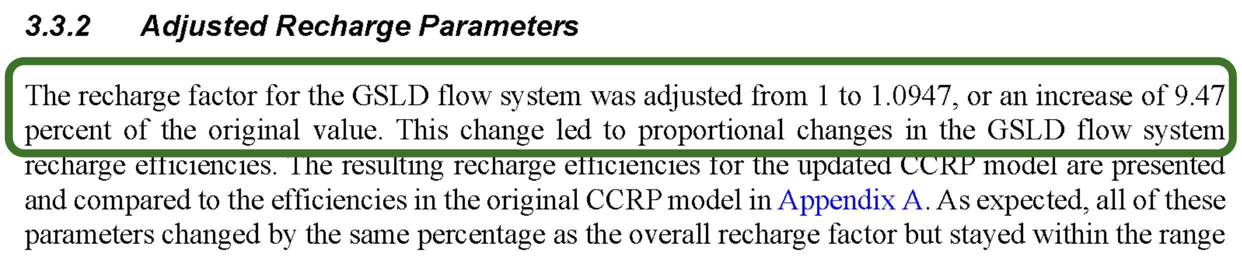


3.21 SNWA Adjustment of GWET Rate in the CCFS Model

SNWA adjusted the CCFS model code by increasing the model ET discharge to be consistent with Ruling 6164 and adjusted recharge so that Spring Valley recharge volume balanced with the new estimate of GWET (Drici et al. 2017, p 2-3). Because Ruling 6164 determined that GWET equaled 84,100 afa, SNWA increased total ET rates within Spring Valley so that the GWET discharge from that valley would approximate 84,100 afa in steady state. This would increase the model simulated amount from 77,000 afa to 84,100 afa, as shown in Drici et al. Table 3-1. The 77,000 afa value had exceeded the estimate of 75,000 afa from SNWA's original Conceptual Model Report (SNWA 2009a). Myers (2017) reported pre-project GWET values for 2004, the end of the pre-project calibration period, which included pumping and storage changes.

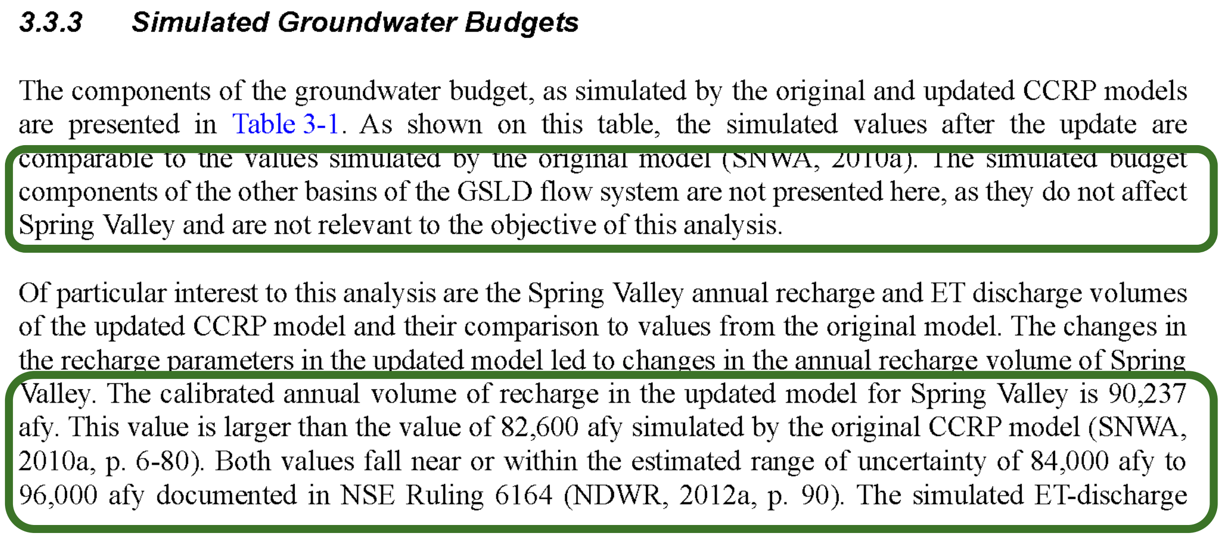
Drici et al. (2017) does not specify how the GWET discharge was increased, such as whether it was a simple proportional increase over the entire valley, the most logical choice. SNWA simulated GWET in the CCFS using DRAIN boundaries rather than with MODFLOW evapotranspiration boundaries (SNWA 2009c). A DRAIN boundary is a head-controlled flux



3.3.2 *Adjusted Recharge Parameters*

The recharge factor for the GSLD flow system was adjusted from 1 to 1.0947, or an increase of 9.47 percent of the original value. This change led to proportional changes in the GSLD flow system recharge efficiencies. The resulting recharge efficiencies for the updated CCRP model are presented and compared to the efficiencies in the original CCRP model in Appendix A. As expected, all of these parameters changed by the same percentage as the overall recharge factor but stayed within the range

SNWA Exh 475, 3-2



3.3.3 *Simulated Groundwater Budgets*

The components of the groundwater budget, as simulated by the original and updated CCRP models are presented in Table 3-1. As shown on this table, the simulated values after the update are comparable to the values simulated by the original model (SNWA, 2010a). The simulated budget components of the other basins of the GSLD flow system are not presented here, as they do not affect Spring Valley and are not relevant to the objective of this analysis.

Of particular interest to this analysis are the Spring Valley annual recharge and ET discharge volumes of the updated CCRP model and their comparison to values from the original model. The changes in the recharge parameters in the updated model led to changes in the annual recharge volume of Spring Valley. The calibrated annual volume of recharge in the updated model for Spring Valley is 90,237 afy. This value is larger than the value of 82,600 afy simulated by the original CCRP model (SNWA, 2010a, p. 6-80). Both values fall near or within the estimated range of uncertainty of 84,000 afy to 96,000 afy documented in NSE Ruling 6164 (NDWR, 2012a, p. 90). The simulated ET-discharge

SNWA Exh 475, p 3-3

GBWN Exh_297, p 9

SNWA did not justify its assumption that recharge efficiency should increase at a factor equivalent to the amount that GWET increased. SNWA assumed, without reference or supporting data, that because "discharge by ET is primarily a function of recharge, recharge had to be increased in Spring Valley to increase the simulated ET discharge" (Drici et al. 2017, p 3-2). The assumption appears based on a desire to simulate GWET from Spring Valley as being mostly recharge within Spring Valley. This assumption is incorrect because GWET within Spring Valley includes, in addition to within-basin recharge, net interbasin flow to Spring Valley. An increase in interbasin flow from Steptoe Valley could offset increased GWET.

SNWA did not increase GWET in other basins, but did change the recharge throughout the flow system. This would proportionally change the amount of water available in the different

1. Increasing recharge downgradient from Spring Valley in Hamlin, Tippet or Snake Valley without increasing the GWET in those basins would increase the simulated groundwater levels and decrease the gradient for flow from Spring Valley to those valleys. Thus, increased groundwater levels downgradient would decrease the simulated flow from Spring Valley and simulate more water available for capture within Spring Valley, without drawing from adjacent valleys, as described by Myers (2017). The potential for interbasin flow from Steptoe into Spring Valley by way of Lake Valley would increase the most. More specifically, it would simulate more water available within Spring Valley for capture.

GBWN Exh_297, p 10

As part of the evidence report prepared for another protestant to these hearings, the Corporation of the Presiding Bishop of the Church of Jesus Christ of Latter-day Saints (CPB), Jones and Mayo (2017) used a more detailed version of the SNWA CCFS groundwater model to show that equilibrium was not reached for 2000 years. Jones and Mayo demonstrated that after 2000 years, pumping the Ruling 6164 amount was drawing only 45,000 afa from GWET (Drains), about 15,000 afa from interbasin flow (Other sources), and about 1000 afa from storage (Figure 2). Interbasin flow increased from less than 5000 to 15,000 afa, a point emphasized in the figures presented by Myers (2017).

- Jones and Mayo's (2017) simulations demonstrate conclusively that pumping SNWA's applications would not be close to reaching equilibrium for 2000 years, and the project would capture flow from surrounding basins rather than from within Spring Valley.

GBWN Exh_297, p 12, 13

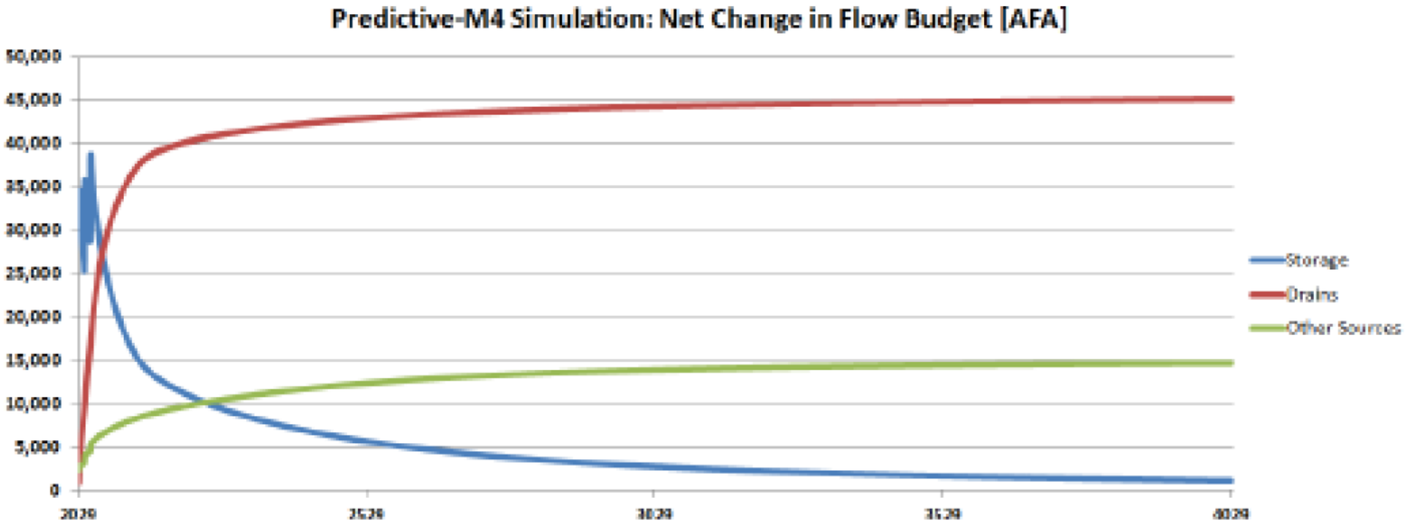
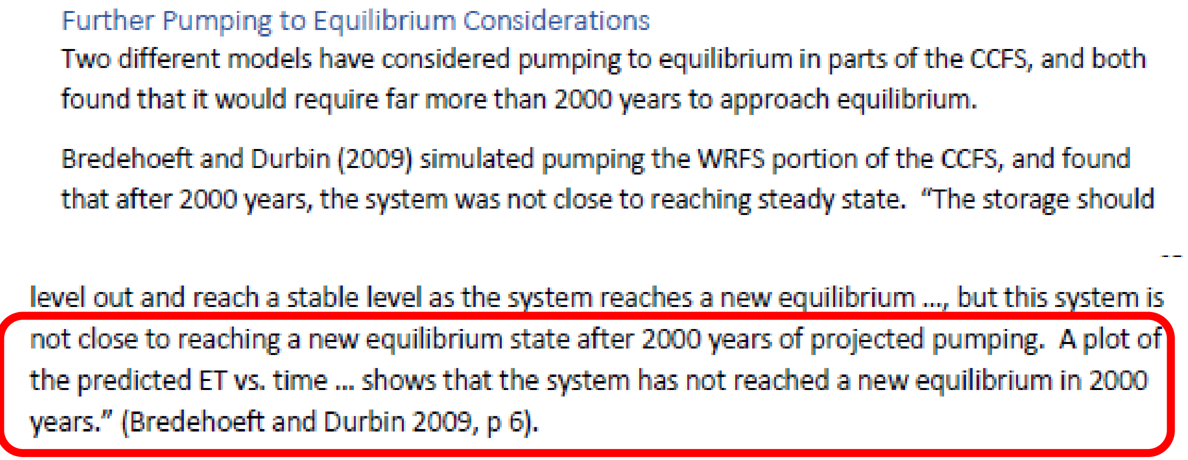


Figure 2: Figure 5-1 from Jones and Mayo (2017) showing the simulated flow budget for pumping SNWA's Ruling 6164 amount from SNWA's application points of diversion for 2000 years. Storage is groundwater storage, Drains is GWET, and Other sources was interbasin flow.

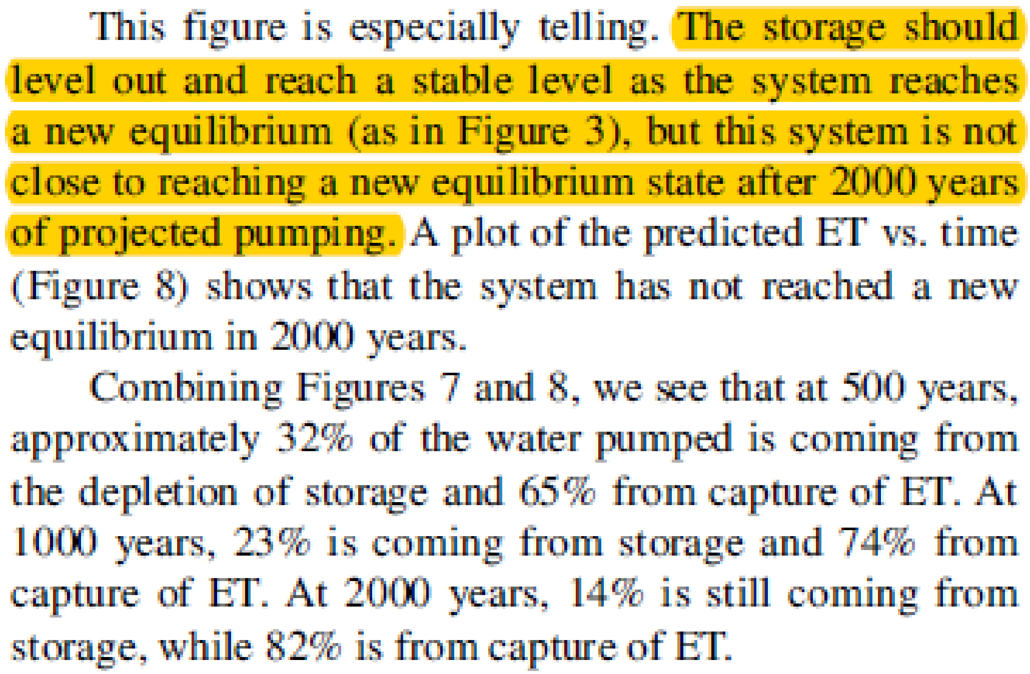


Further Pumping to Equilibrium Considerations

Two different models have considered pumping to equilibrium in parts of the CCFS, and both found that it would require far more than 2000 years to approach equilibrium.

Bredehoeft and Durbin (2009) simulated pumping the WRFS portion of the CCFS, and found that after 2000 years, the system was not close to reaching steady state. "The storage should level out and reach a stable level as the system reaches a new equilibrium ..., but this system is not close to reaching a new equilibrium state after 2000 years of projected pumping. A plot of the predicted ET vs. time ... shows that the system has not reached a new equilibrium in 2000 years." (Bredehoeft and Durbin 2009, p 6).

GBWN Exh_281, p 65, 66



This figure is especially telling. The storage should level out and reach a stable level as the system reaches a new equilibrium (as in Figure 3), but this system is not close to reaching a new equilibrium state after 2000 years of projected pumping. A plot of the predicted ET vs. time (Figure 8) shows that the system has not reached a new equilibrium in 2000 years.

Combining Figures 7 and 8, we see that at 500 years, approximately 32% of the water pumped is coming from the depletion of storage and 65% from capture of ET. At 1000 years, 23% is coming from storage and 74% from capture of ET. At 2000 years, 14% is still coming from storage, while 82% is from capture of ET.

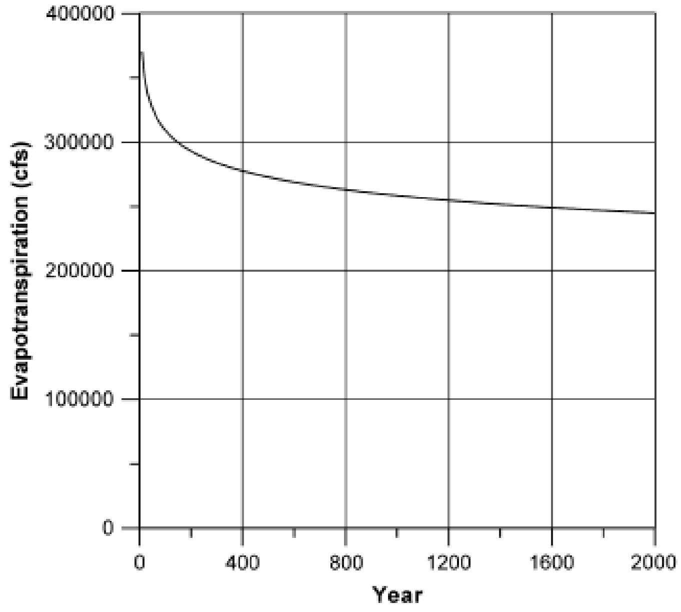


Figure 8. Computed plot of ET vs. time.

Bredehoeft, Durbin (2009), GBWN Exh_12

Pumpage from the WRFS for alternatives E and F, at 45,800 and 56,800 af/y at full build-out, respectively, including pre-existing pumpage (Figure 29), is a little less and a little more than 1/3rd of the recharge for the entire flow system, respectively. At full buildout, alternatives E and F remove 24,000 and 26,700 af/y, respectively, from the WRFS. And after 200 years pumpage still removes 19,400 and 27,100 af/y from storage for alternatives E and F, respectively (Figure 29). This mean that 42% and 47%, respectively, of the amount of water being pumped is water that is being permanently removed from WRFS storage by year 2250. Two hundred years after full buildout, simulations show that a substantial amount of the pumpage is being removed from storage and that the system is not close to coming to equilibrium. The simulations further demonstrate that the removal of water from storage and attendant drawdown spreads outward across the flow system because of the connectivity among the basins in the WRFS.

Simulated recharge in Cave, Dry Lake, and Delamar Valleys is 15,400, 17,300, and 7500 af/y, respectively. Initially large portions of the pumpage draw from storage, and even 200 years after full buildout, pumpage for alternatives E and F are still removing 18% and 20% of pumpage from storage (Figure 29). After 75 years, the 10-ft drawdown for both alternatives

GBWN Exh_281, p 49, 50

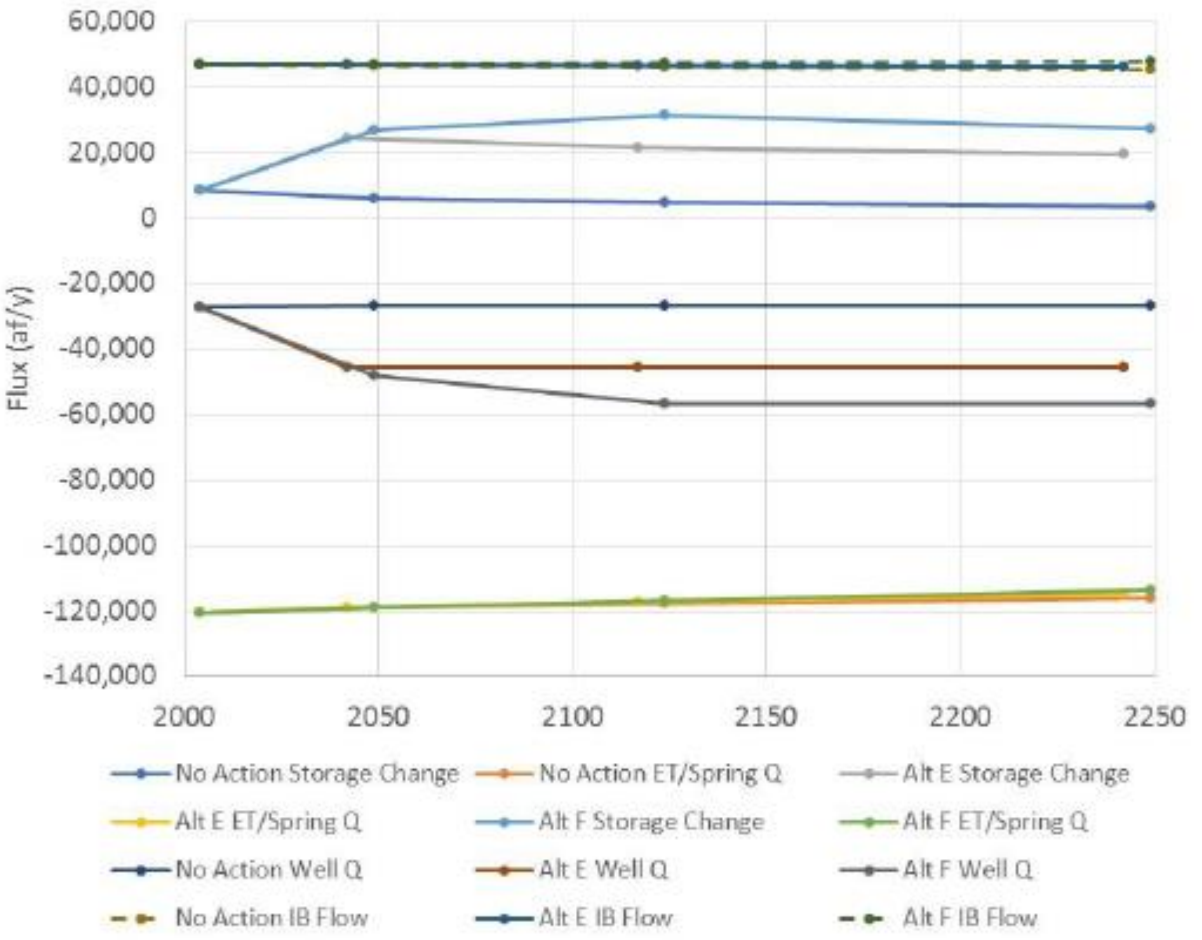


Figure 29: Water budget accounting including storage change, ET/spring discharge (Q), and well pumpage for the White River Flow System for the No Action alternative and Alternatives E and F, as simulated for the FEIS (FEIS Appendix F3.3.16).

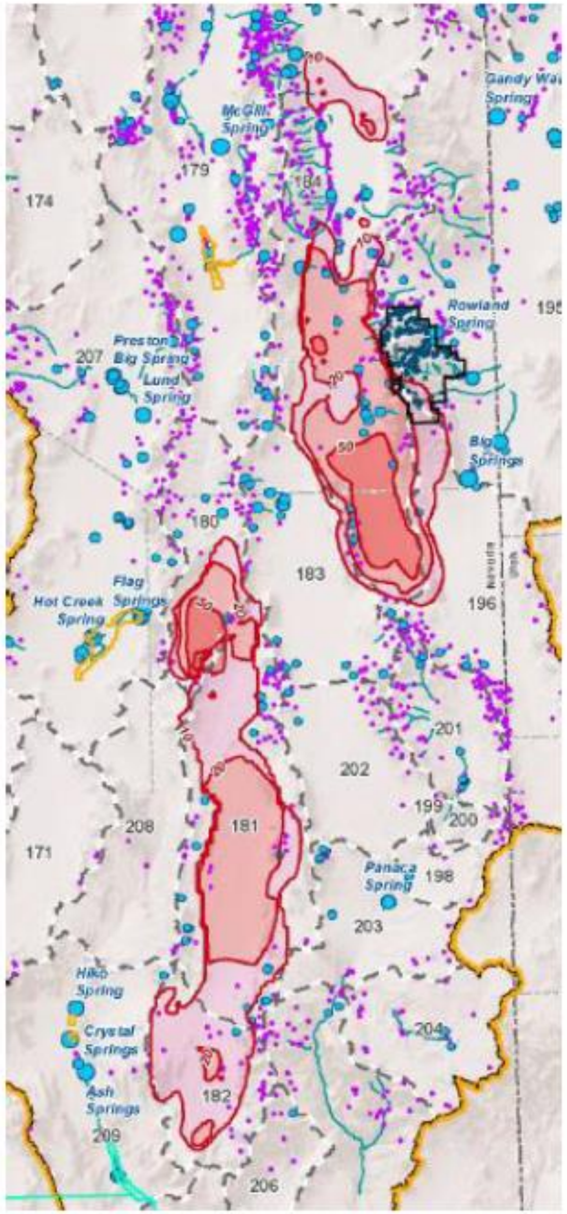


Figure 22: Snapshot of a portion of FEIS Figure 3.2.2.28 showing drawdown in the CCFS for Alternative E at 75 years after full buildout (year 2125).

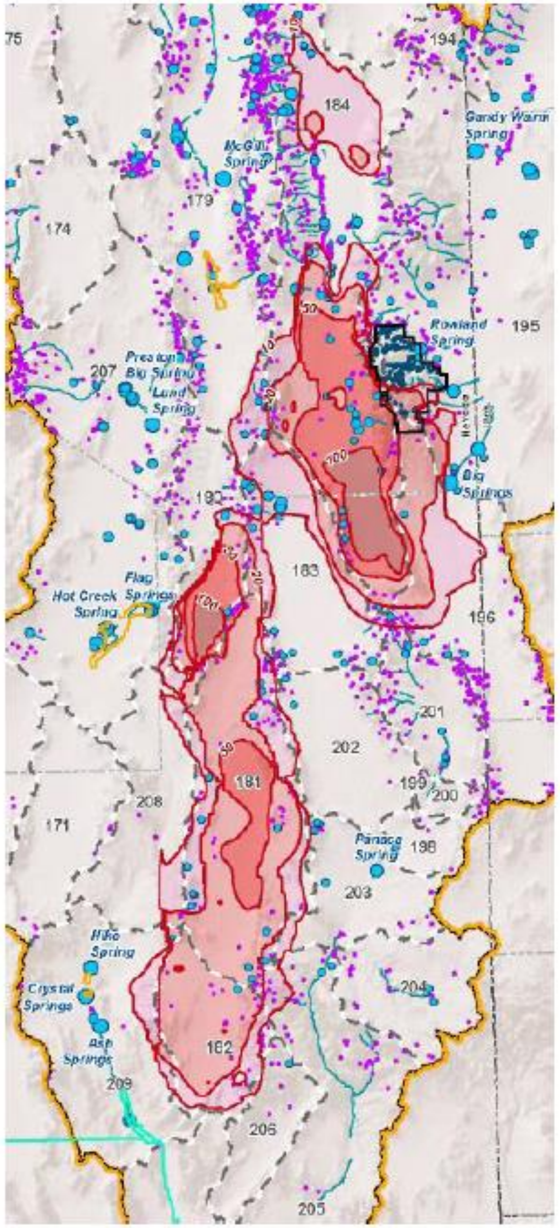
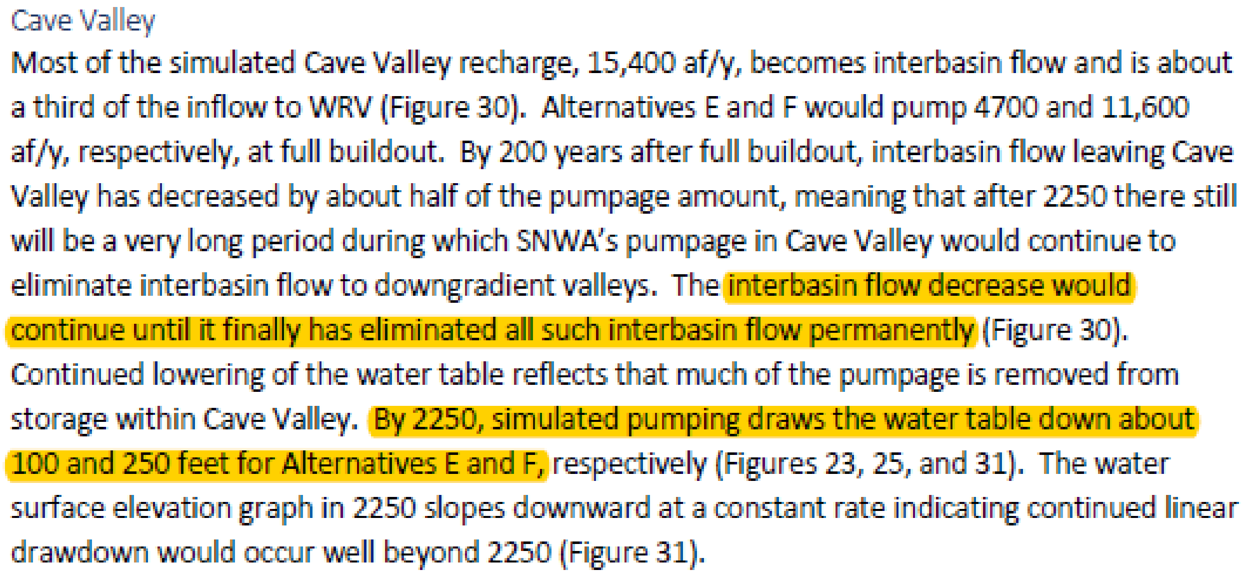


Figure 23: Snapshot of a portion of FEIS Figure 3.2.2.29 showing drawdown in the CCFS for Alternative E at 200 years after full buildout (year 2250).

GBWN Exh_281, p 41, 42



Cave Valley

Most of the simulated Cave Valley recharge, 15,400 af/y, becomes interbasin flow and is about a third of the inflow to WRV (Figure 30). Alternatives E and F would pump 4700 and 11,600 af/y, respectively, at full buildout. By 200 years after full buildout, interbasin flow leaving Cave Valley has decreased by about half of the pumpage amount, meaning that after 2250 there still will be a very long period during which SNWA's pumpage in Cave Valley would continue to eliminate interbasin flow to downgradient valleys. The interbasin flow decrease would continue until it finally has eliminated all such interbasin flow permanently (Figure 30). Continued lowering of the water table reflects that much of the pumpage is removed from storage within Cave Valley. By 2250, simulated pumping draws the water table down about 100 and 250 feet for Alternatives E and F, respectively (Figures 23, 25, and 31). The water surface elevation graph in 2250 slopes downward at a constant rate indicating continued linear drawdown would occur well beyond 2250 (Figure 31).

GBWN Exh_281, p 51

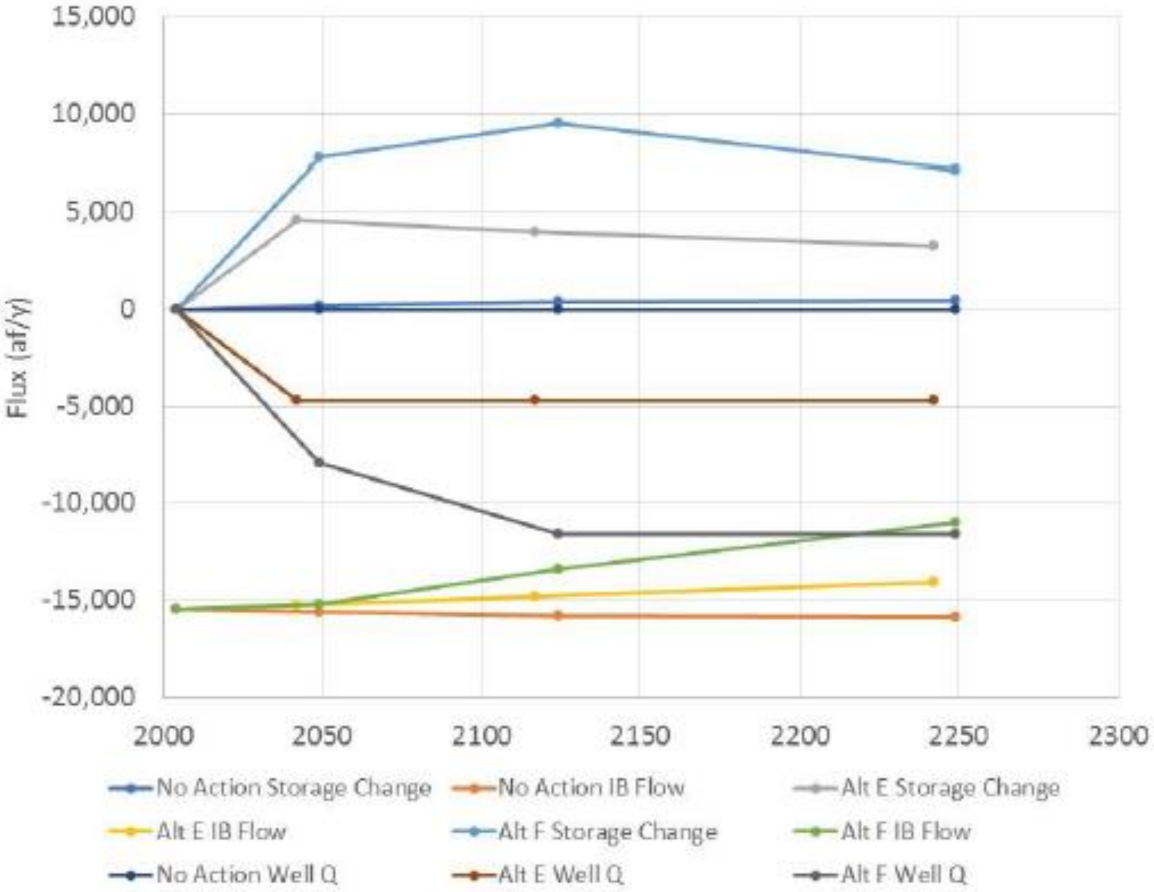


Figure 30: Water budget accounting including storage change, ET/spring discharge (Q), and well pumpage for Cave Valley for the No Action alternative and Alternatives E and F, as simulated for the FEIS (FEIS Appendix F3.3.16).

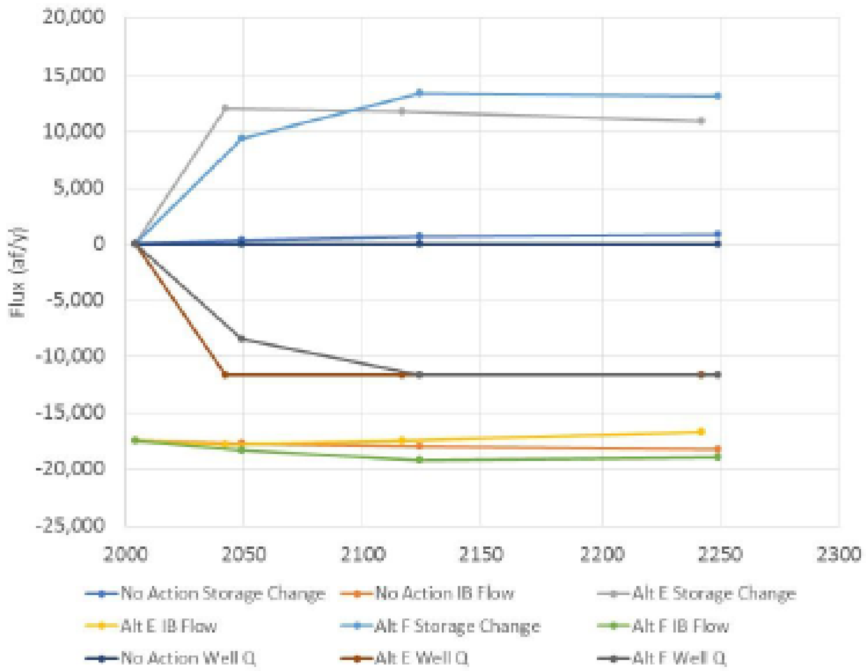


Figure 33: Water budget accounting including storage change, ET/spring discharge (Q), and well pumpage for Dry Lake Valley for the No Action alternative and Alternatives E and F, as simulated for the FEIS (FEIS Appendix F3.3.16).

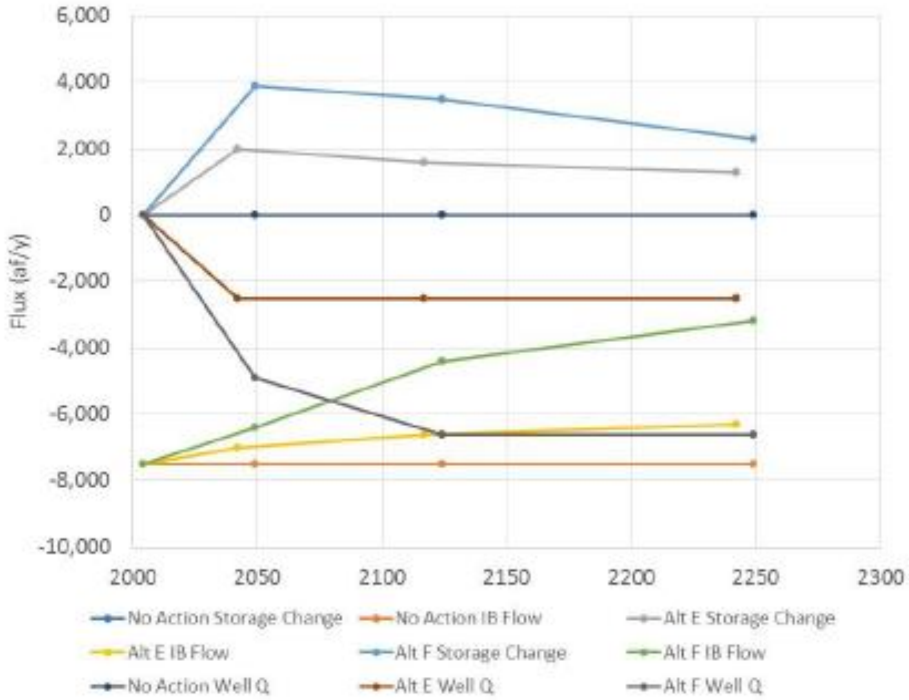


Figure 34: Water budget accounting including storage change, ET/spring discharge (Q), and well pumpage for Delamar Valley for the No Action alternative and Alternatives E and F, as simulated for the FEIS (FEIS Appendix F3.3.16).

GBWN Exh_281, p 55, 57

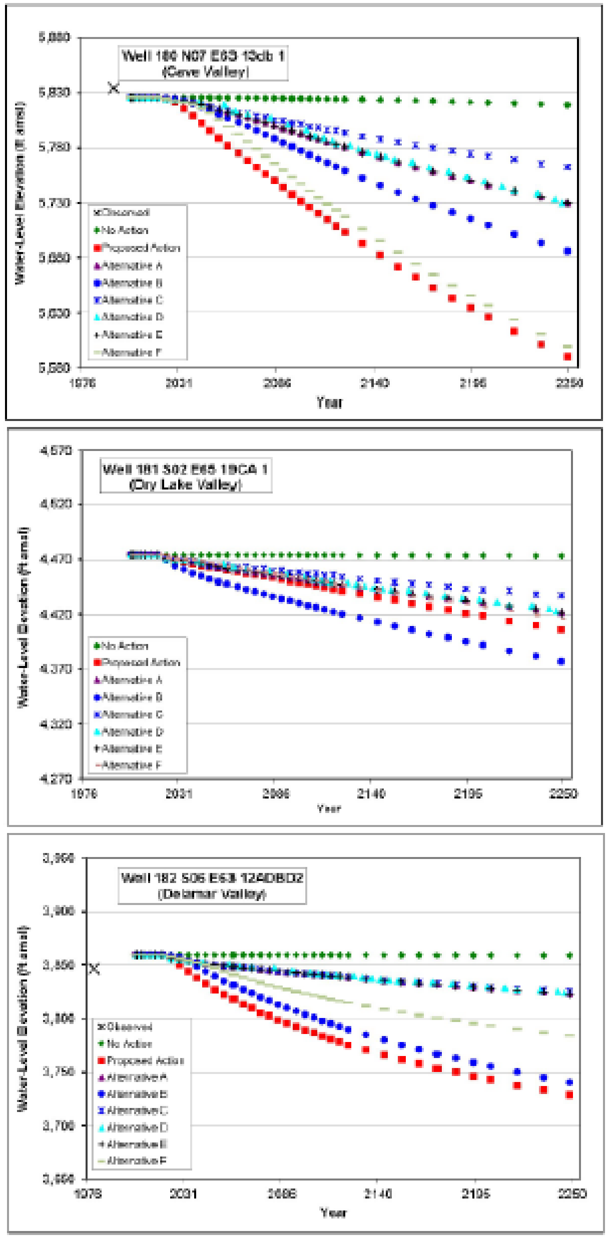


Figure 3.3.2-8 Representative Water-Level Hydrograph for Cave, Dry Lake, and Delamar Valleys

GBWN Exh_281, p 52

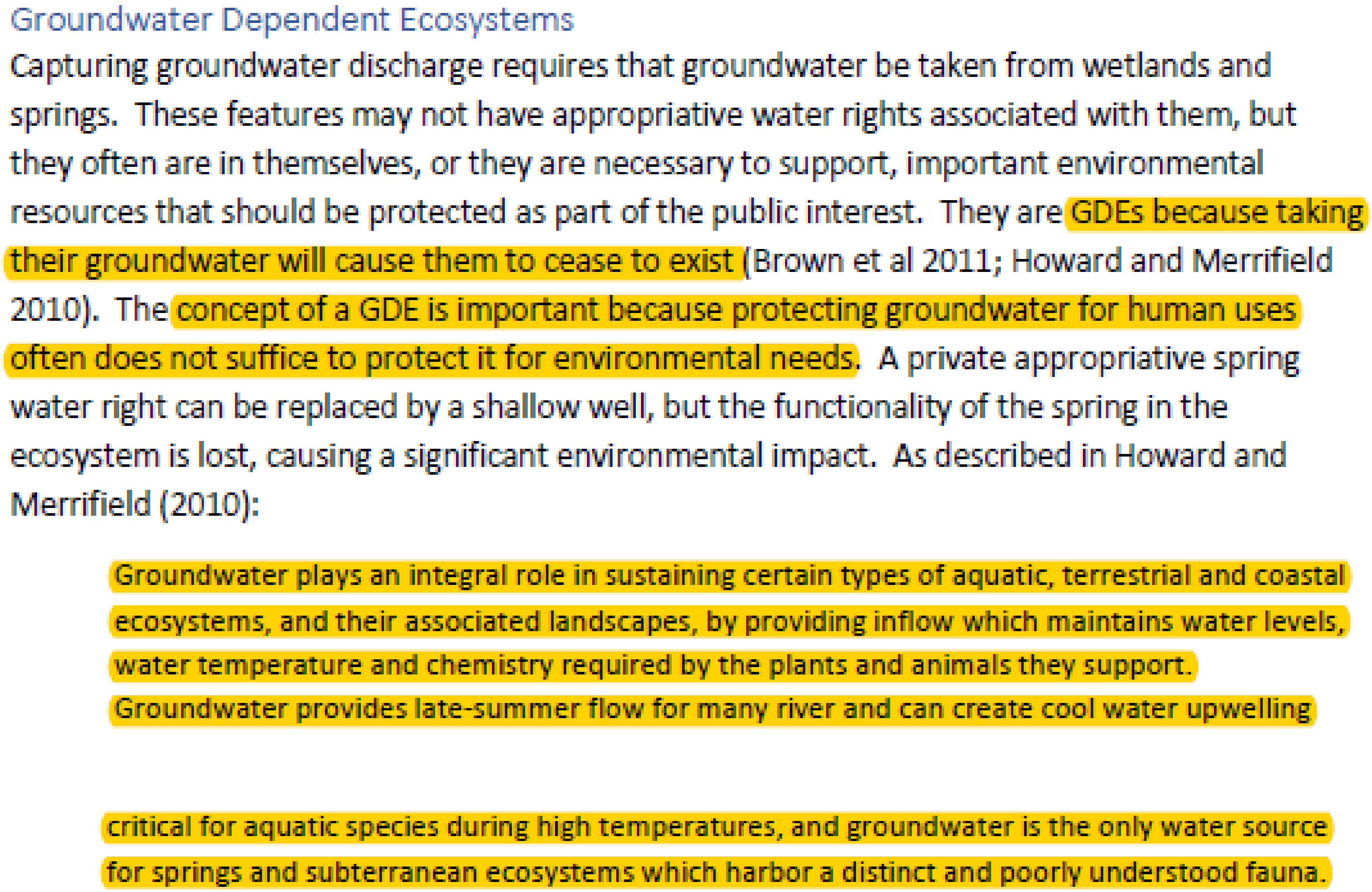
Figure 31: Snapshot of FEIS Figure 3.3.2-8 showing simulated water levels for monitoring points in Cave, Dry Lake and Delamar Valleys for all pumping alternatives.

5. SNWA Monitoring Plans

Myers (2017) presented an outline for the monitoring necessary for Spring Valley and the WRFS. This section discusses details of the monitoring as proposed by SNWA. Myers (2017) provided some details of what is necessary for a monitoring plan, as quoted here.

> Four steps emerge as being necessary for the establishment of an adequate monitoring plan.
>
> 1. Identify the GDEs and water rights that should be protected. Determine what is necessary to protect them. Groundwater rights and wetlands may require a minimum depth to water whereas a spring may require minimum flow rates.
> 2. Develop a localized conceptual flow model that describes the hydrologic system that supports each GDE and water right. This would be more detailed than a CFM used for the entire region because broad-scale flows do not describe small features well. For example, some springs may be perched but could be affected by long-term drawdown beneath a confining layer.
> 3. Implement the more refined CFM to determine the level of drawdown or other measurable effect that would signal impending impacts to the GDE and water right. This may require numerical modeling or data collection to do correlation analysis of the relationship between the data and the protected feature. These levels are the triggers that monitoring would be designed to detect and prompt management changes. A regional model used for the overall project probably would not be sufficiently detailed to understand flow at individual sites.
> 4. Determine the type and location of monitoring that would allow the prediction of changes at the GDE or water right. Where does drawdown occur in advance of problematic changes in the flow rate or prior to reaching the GDE or water right being protected? Uncertainty should inform these decisions, with more monitoring required and more conservative trigger levels applied where impacts are less certain. (Myers 2017, p 69)

GBWN Exh_297, p 32



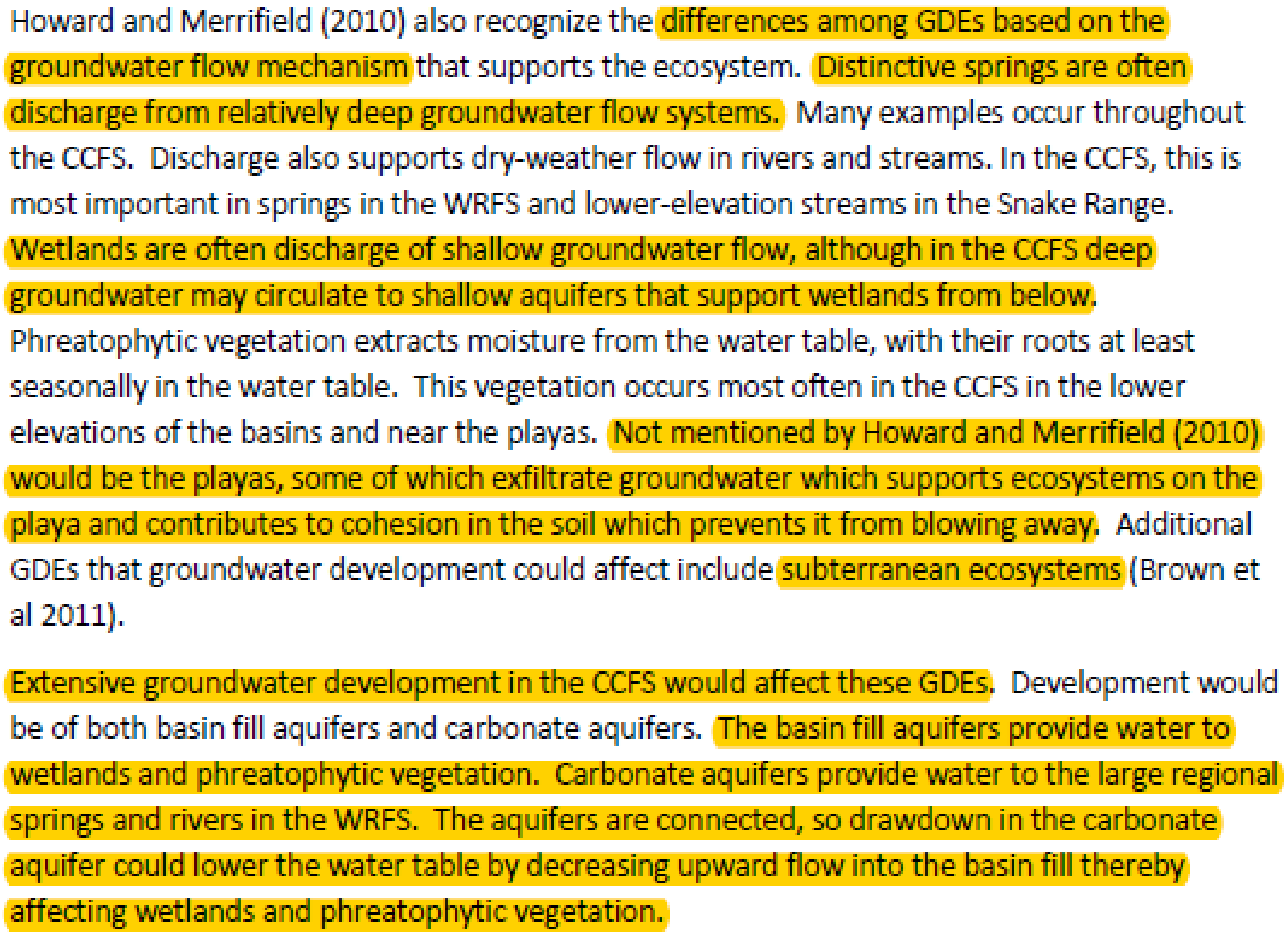
Groundwater Dependent Ecosystems

Capturing groundwater discharge requires that groundwater be taken from wetlands and springs. These features may not have appropriative water rights associated with them, but they often are in themselves, or they are necessary to support, important environmental resources that should be protected as part of the public interest. They are GDEs because taking their groundwater will cause them to cease to exist (Brown et al 2011; Howard and Merrifield 2010). The concept of a GDE is important because protecting groundwater for human uses often does not suffice to protect it for environmental needs. A private appropriative spring water right can be replaced by a shallow well, but the functionality of the spring in the ecosystem is lost, causing a significant environmental impact. As described in Howard and Merrifield (2010):

> Groundwater plays an integral role in sustaining certain types of aquatic, terrestrial and coastal ecosystems, and their associated landscapes, by providing inflow which maintains water levels, water temperature and chemistry required by the plants and animals they support. Groundwater provides late-summer flow for many river and can create cool water upwelling

> critical for aquatic species during high temperatures, and groundwater is the only water source for springs and subterranean ecosystems which harbor a distinct and poorly understood fauna.

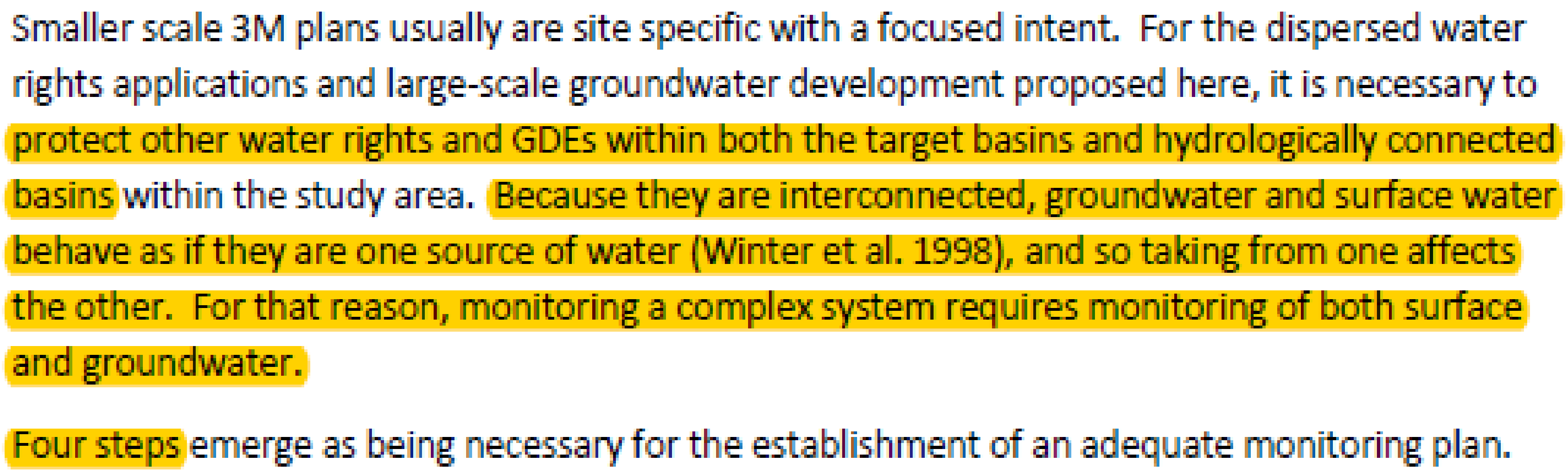
GBWN Exh_281, p 67, 68



Howard and Merrifield (2010) also recognize the differences among GDEs based on the groundwater flow mechanism that supports the ecosystem. Distinctive springs are often discharge from relatively deep groundwater flow systems. Many examples occur throughout the CCFS. Discharge also supports dry-weather flow in rivers and streams. In the CCFS, this is most important in springs in the WRFS and lower-elevation streams in the Snake Range. Wetlands are often discharge of shallow groundwater flow, although in the CCFS deep groundwater may circulate to shallow aquifers that support wetlands from below. Phreatophytic vegetation extracts moisture from the water table, with their roots at least seasonally in the water table. This vegetation occurs most often in the CCFS in the lower elevations of the basins and near the playas. Not mentioned by Howard and Merrifield (2010) would be the playas, some of which exfiltrate groundwater which supports ecosystems on the playa and contributes to cohesion in the soil which prevents it from blowing away. Additional GDEs that groundwater development could affect include subterranean ecosystems (Brown et al 2011).

Extensive groundwater development in the CCFS would affect these GDEs. Development would be of both basin fill aquifers and carbonate aquifers. The basin fill aquifers provide water to wetlands and phreatophytic vegetation. Carbonate aquifers provide water to the large regional springs and rivers in the WRFS. The aquifers are connected, so drawdown in the carbonate aquifer could lower the water table by decreasing upward flow into the basin fill thereby affecting wetlands and phreatophytic vegetation.

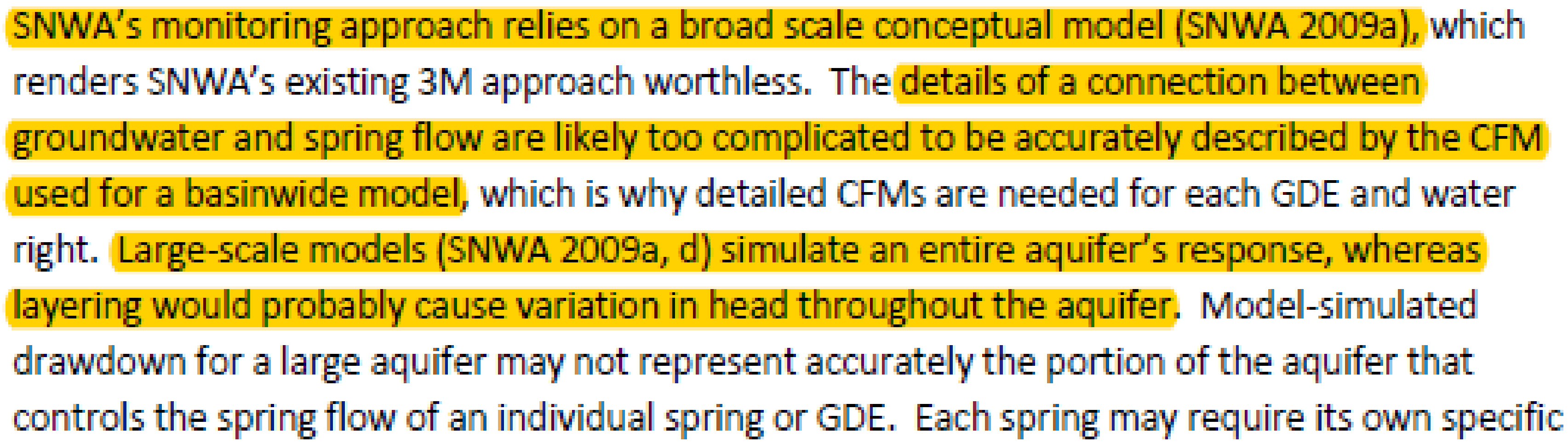
GBWN Exh_281, p 68



Smaller scale 3M plans usually are site specific with a focused intent. For the dispersed water rights applications and large-scale groundwater development proposed here, it is necessary to protect other water rights and GDEs within both the target basins and hydrologically connected basins within the study area. Because they are interconnected, groundwater and surface water behave as if they are one source of water (Winter et al. 1998), and so taking from one affects the other. For that reason, monitoring a complex system requires monitoring of both surface and groundwater.

Four steps emerge as being necessary for the establishment of an adequate monitoring plan.

GBWN Exh_281, p 69



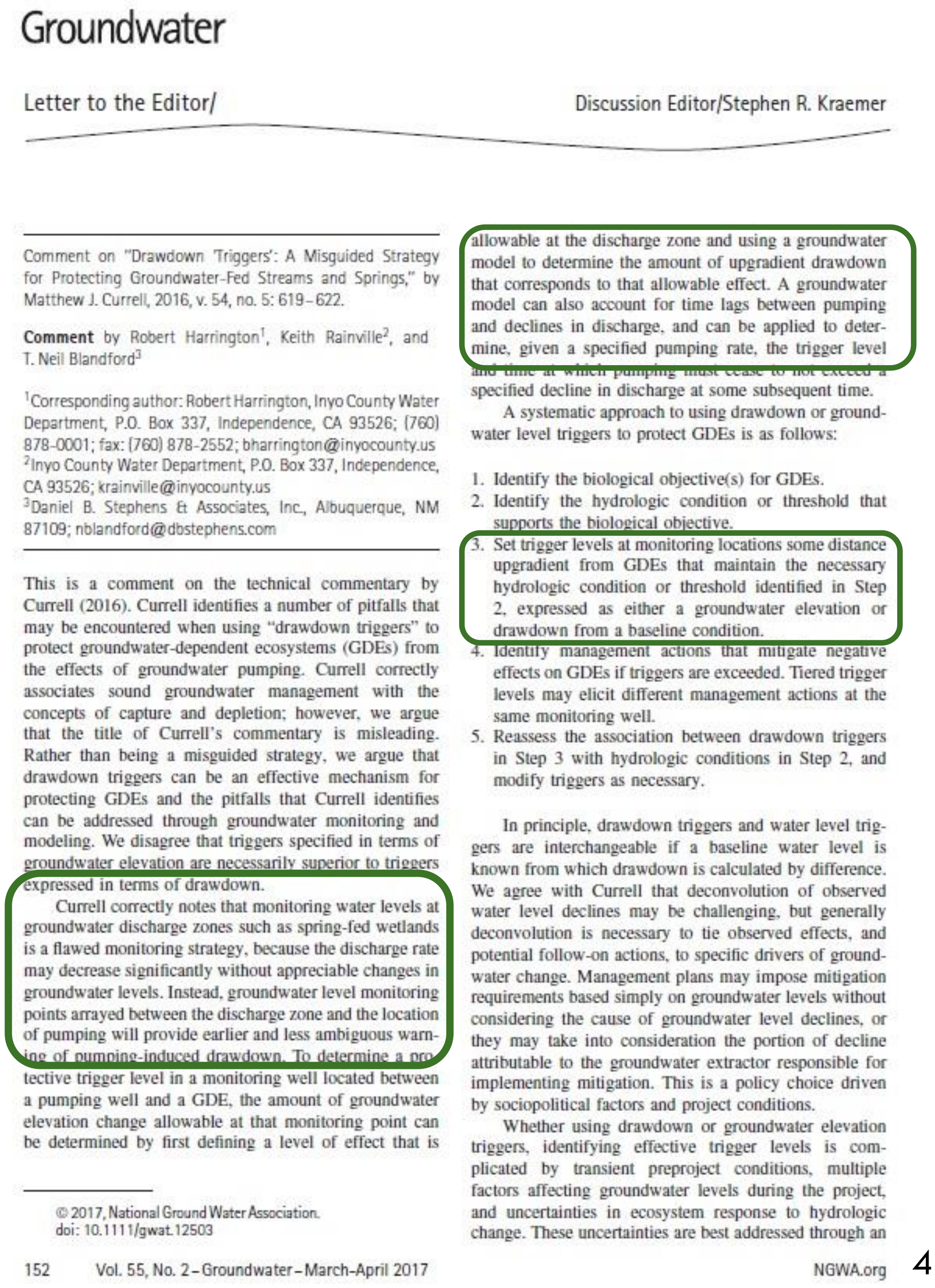
SNWA's monitoring approach relies on a broad scale conceptual model (SNWA 2009a), which renders SNWA's existing 3M approach worthless. The details of a connection between groundwater and spring flow are likely too complicated to be accurately described by the CFM used for a basinwide model, which is why detailed CFMs are needed for each GDE and water right. Large-scale models (SNWA 2009a, d) simulate an entire aquifer's response, whereas layering would probably cause variation in head throughout the aquifer. Model-simulated drawdown for a large aquifer may not represent accurately the portion of the aquifer that controls the spring flow of an individual spring or GDE. Each spring may require its own specific

CFM. Even if the correct portion of the aquifer is identified for monitoring by a large scale CFM, setting triggers based on the larger scale model will not be reliably accurate.

Springs require monitoring of both discharge and groundwater levels at a location appropriate for predicting the discharge. Groundwater level would correlate with discharge, and could provide a warning if properly sited. Monitoring perched springs could require paired piezometers to monitor gradient between shallow and deeper aquifers. SNWA's modeling to date either was not accurate for many springs or did not attempt to simulate some of them. Many of the springs are either perched or a combination of flow from deep and shallow aquifers. The models do not distinguish among the contribution of different aquifers very well. At a reasonable distance from the GDE or water right, monitoring should be of shallow as well as deeper groundwater to understand the vertical gradient controlling the flows to the spring. It is essential to monitor groundwater far enough from the point of discharge to detect a difference that will cause a flow change because spring flow can decrease without there being a drawdown at the site but only a change in gradient (Currell 2016).

GBWN Exh_281, p 70

SNWA Exh 602



Groundwater

Letter to the Editor/ Discussion Editor/Stephen R. Kraemer

Comment on "Drawdown 'Triggers': A Misguided Strategy for Protecting Groundwater-Fed Streams and Springs," by Matthew J. Currell, 2016, v. 54, no. 5: 619–622.

Comment by Robert Harrington[1], Keith Rainville[2], and T. Neil Blandford[3]

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This is a comment on the technical commentary by Currell (2016). Currell identifies a number of pitfalls that may be encountered when using "drawdown triggers" to protect groundwater-dependent ecosystems (GDEs) from the effects of groundwater pumping. Currell correctly associates sound groundwater management with the concepts of capture and depletion; however, we argue that the title of Currell's commentary is misleading. Rather than being a misguided strategy, we argue that drawdown triggers can be an effective mechanism for protecting GDEs and the pitfalls that Currell identifies can be addressed through groundwater monitoring and modeling. We disagree that triggers specified in terms of groundwater elevation are necessarily superior to triggers expressed in terms of drawdown.

Currell correctly notes that monitoring water levels at groundwater discharge zones such as spring-fed wetlands is a flawed monitoring strategy, because the discharge rate may decrease significantly without appreciable changes in groundwater levels. Instead, groundwater level monitoring points arrayed between the discharge zone and the location of pumping will provide earlier and less ambiguous warning of pumping-induced drawdown. To determine a protective trigger level in a monitoring well located between a pumping well and a GDE, the amount of groundwater elevation change allowable at that monitoring point can be determined by first defining a level of effect that is allowable at the discharge zone and using a groundwater model to determine the amount of upgradient drawdown that corresponds to that allowable effect. A groundwater model can also account for time lags between pumping and declines in discharge, and can be applied to determine, given a specified pumping rate, the trigger level and time at which pumping must cease to not exceed a specified decline in discharge at some subsequent time.

A systematic approach to using drawdown or groundwater level triggers to protect GDEs is as follows:

1. Identify the biological objective(s) for GDEs.
2. Identify the hydrologic condition or threshold that supports the biological objective.
3. Set trigger levels at monitoring locations some distance upgradient from GDEs that maintain the necessary hydrologic condition or threshold identified in Step 2, expressed as either a groundwater elevation or drawdown from a baseline condition.
4. Identify management actions that mitigate negative effects on GDEs if triggers are exceeded. Tiered trigger levels may elicit different management actions at the same monitoring well.
5. Reassess the association between drawdown triggers in Step 3 with hydrologic conditions in Step 2, and modify triggers as necessary.

In principle, drawdown triggers and water level triggers are interchangeable if a baseline water level is known from which drawdown is calculated by difference. We agree with Currell that deconvolution of observed water level declines may be challenging, but generally deconvolution is necessary to tie observed effects, and potential follow-on actions, to specific drivers of groundwater change. Management plans may impose mitigation requirements based simply on groundwater levels without considering the cause of groundwater level declines, or they may take into consideration the portion of decline attributable to the groundwater extractor responsible for implementing mitigation. This is a policy choice driven by sociopolitical factors and project conditions.

Whether using drawdown or groundwater elevation triggers, identifying effective trigger levels is complicated by transient preproject conditions, multiple factors affecting groundwater levels during the project, and uncertainties in ecosystem response to hydrologic change. These uncertainties are best addressed through an

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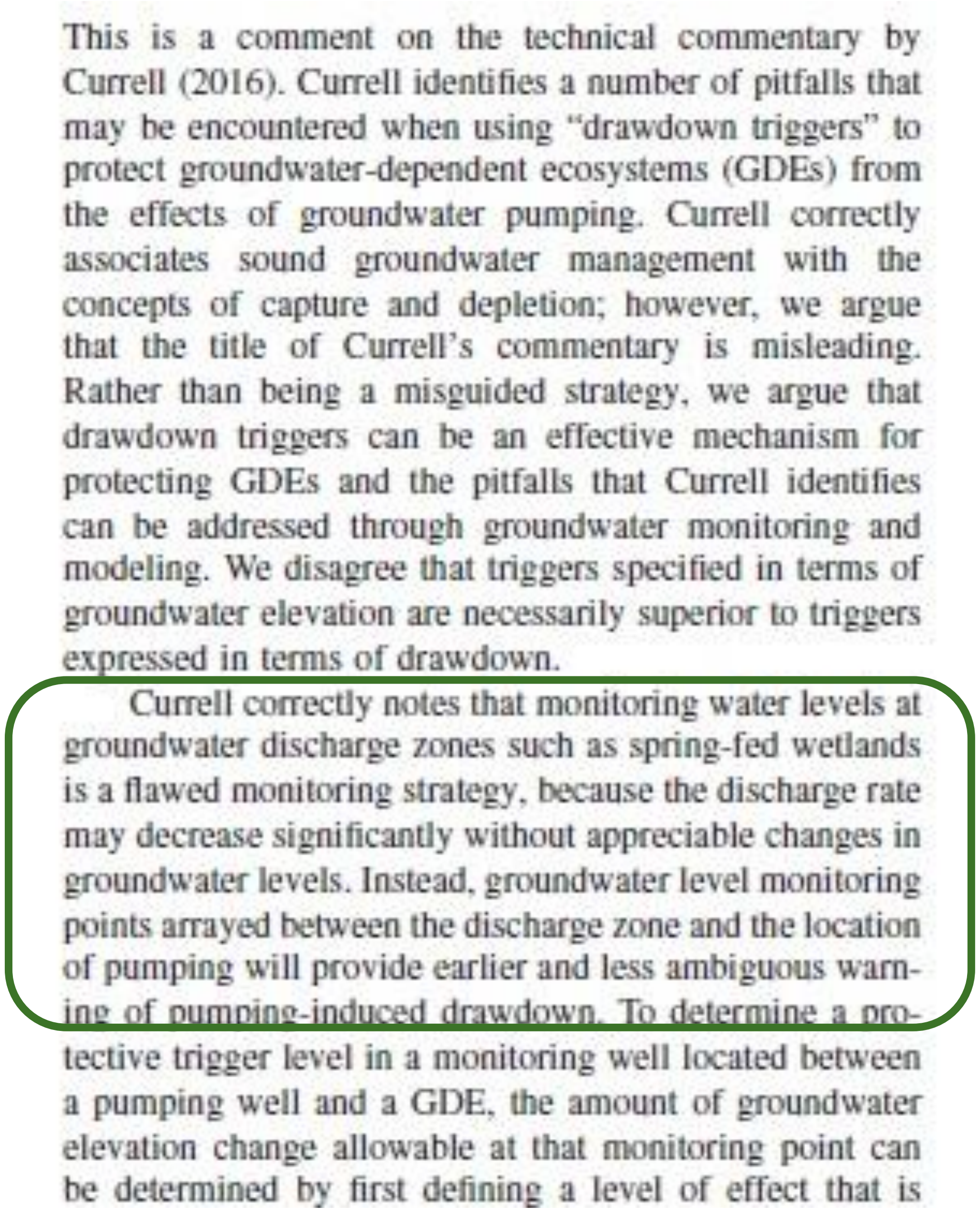

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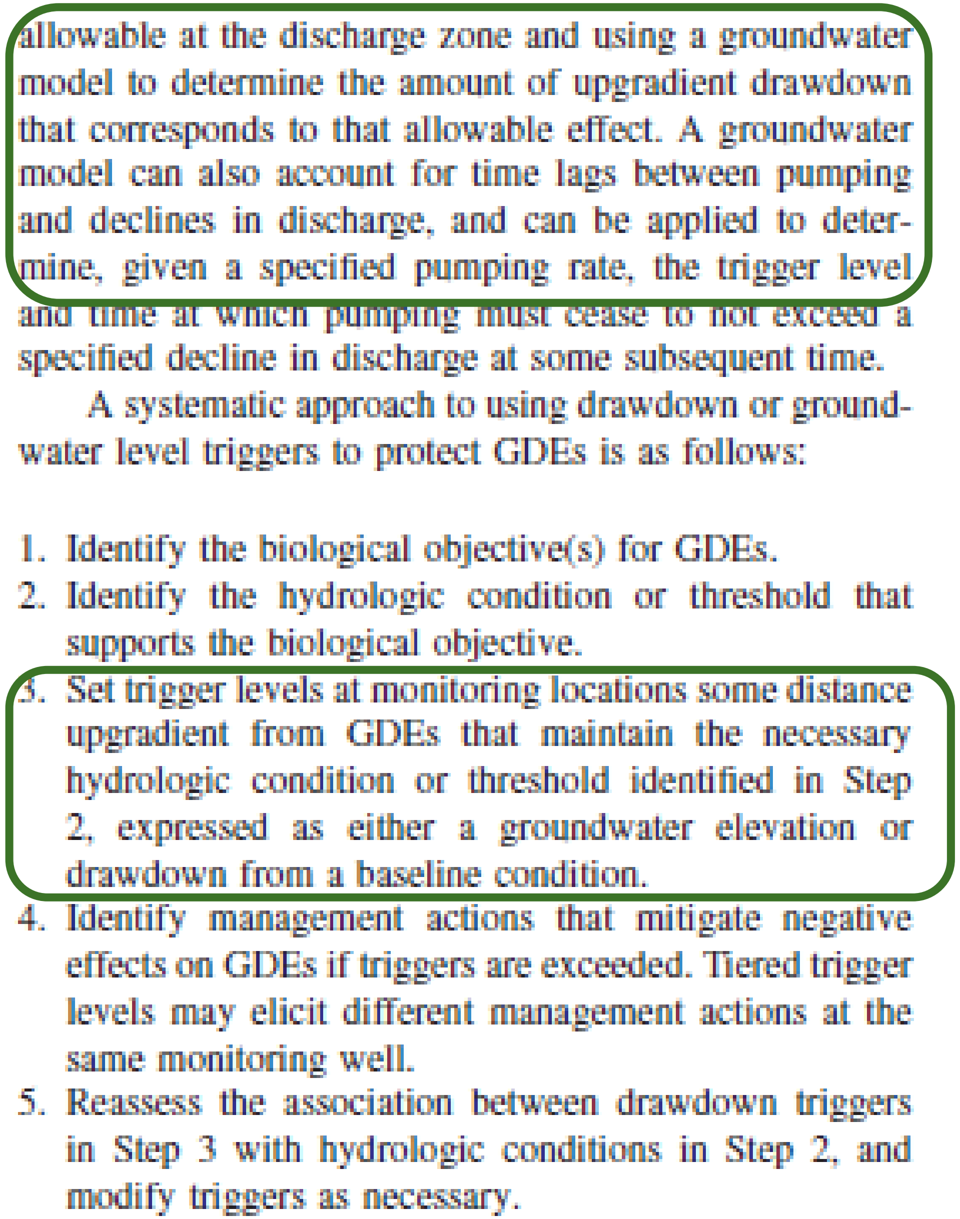

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A systematic approach to using drawdown or groundwater level triggers to protect GDEs is as follows:

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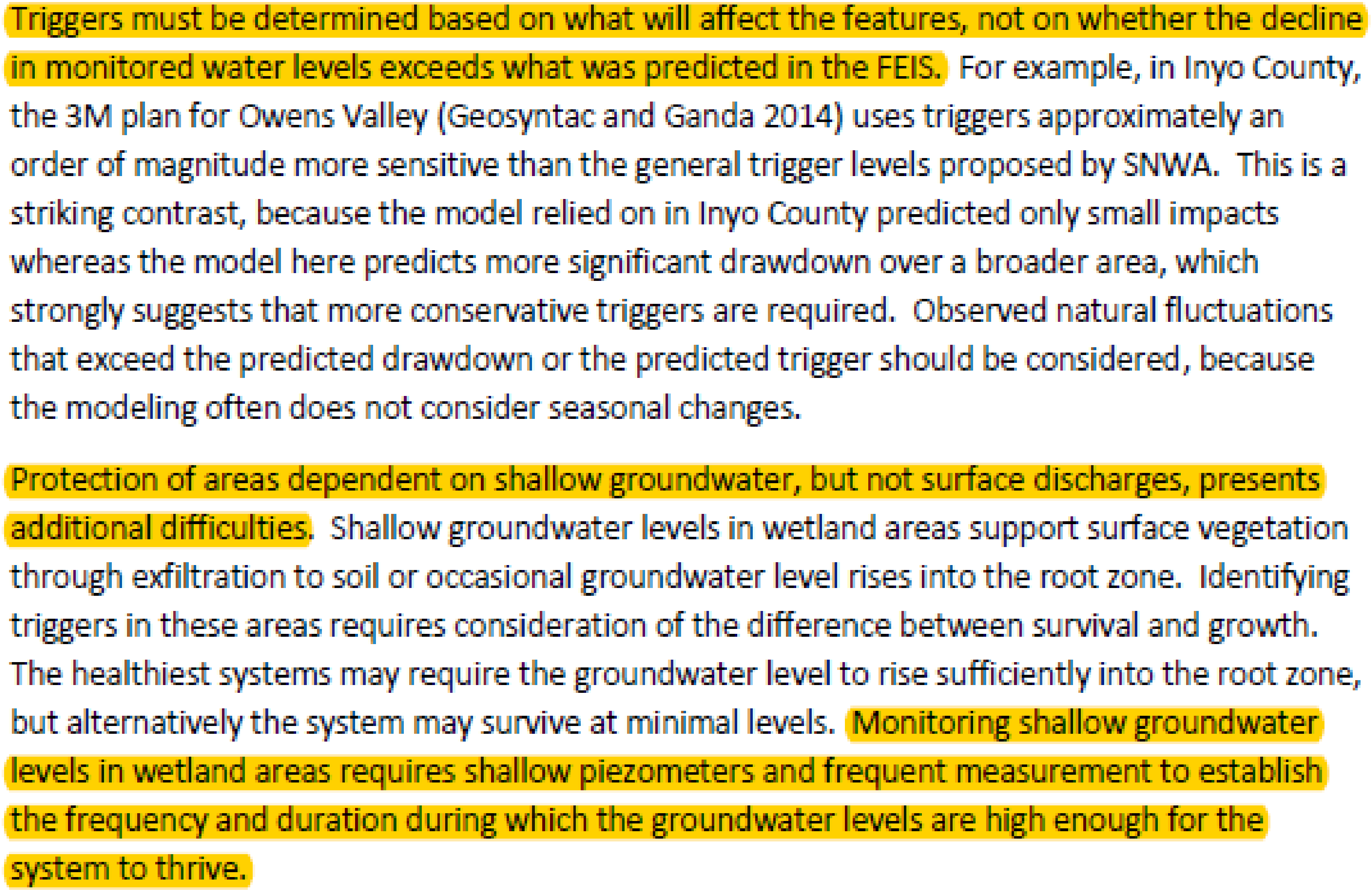
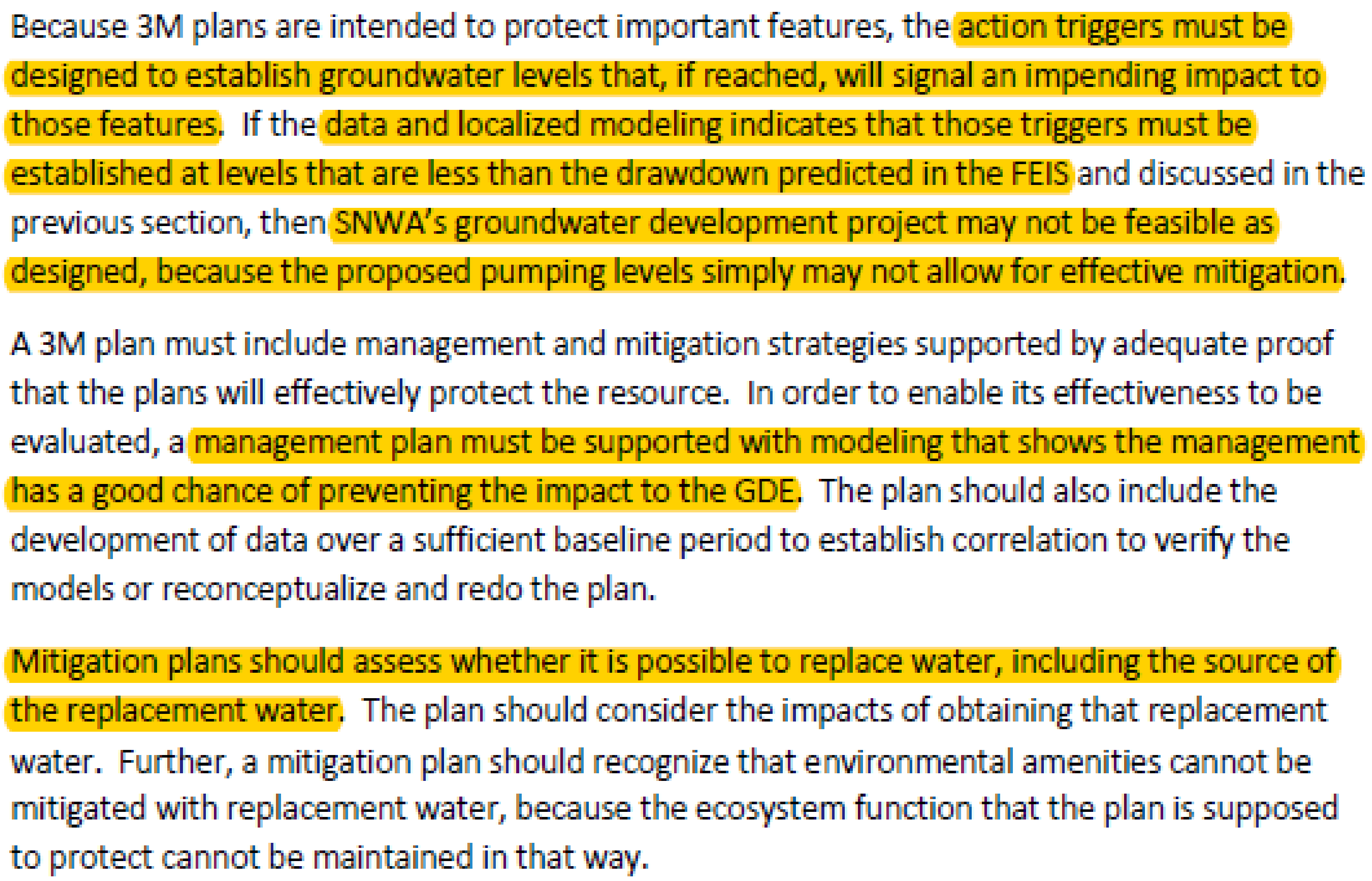
SNWA Exh 602



Triggers must be determined based on what will affect the features, not on whether the decline in monitored water levels exceeds what was predicted in the FEIS. For example, in Inyo County, the 3M plan for Owens Valley (Geosyntac and Ganda 2014) uses triggers approximately an order of magnitude more sensitive than the general trigger levels proposed by SNWA. This is a striking contrast, because the model relied on in Inyo County predicted only small impacts whereas the model here predicts more significant drawdown over a broader area, which strongly suggests that more conservative triggers are required. Observed natural fluctuations that exceed the predicted drawdown or the predicted trigger should be considered, because the modeling often does not consider seasonal changes.

Protection of areas dependent on shallow groundwater, but not surface discharges, presents additional difficulties. Shallow groundwater levels in wetland areas support surface vegetation through exfiltration to soil or occasional groundwater level rises into the root zone. Identifying triggers in these areas requires consideration of the difference between survival and growth. The healthiest systems may require the groundwater level to rise sufficiently into the root zone, but alternatively the system may survive at minimal levels. Monitoring shallow groundwater levels in wetland areas requires shallow piezometers and frequent measurement to establish the frequency and duration during which the groundwater levels are high enough for the system to thrive.

GBWN Exh_281, p 70



Because 3M plans are intended to protect important features, the action triggers must be designed to establish groundwater levels that, if reached, will signal an impending impact to those features. If the data and localized modeling indicates that those triggers must be established at levels that are less than the drawdown predicted in the FEIS and discussed in the previous section, then SNWA's groundwater development project may not be feasible as designed, because the proposed pumping levels simply may not allow for effective mitigation.

A 3M plan must include management and mitigation strategies supported by adequate proof that the plans will effectively protect the resource. In order to enable its effectiveness to be evaluated, a management plan must be supported with modeling that shows the management has a good chance of preventing the impact to the GDE. The plan should also include the development of data over a sufficient baseline period to establish correlation to verify the models or reconceptualize and redo the plan.

Mitigation plans should assess whether it is possible to replace water, including the source of the replacement water. The plan should consider the impacts of obtaining that replacement water. Further, a mitigation plan should recognize that environmental amenities cannot be mitigated with replacement water, because the ecosystem function that the plan is supposed to protect cannot be maintained in that way.

GBWN Exh_281, p 71

5.1 Spring Valley

SNWA presented a monitoring plan (SNWA 2017b) based on points of diversion, or wells, approved in Ruling 6164, not the pumping plan used to attempt to demonstrate pumping to equilibrium discussed in section 1 above. Thus, SNWA has not presented evidence that any pumping regime can both reach equilibrium within a reasonable time and avoid conflicts with existing rights and unreasonable environmental impacts. SNWA divided Spring Valley into five management areas (Figure 13). Management area 1 is the south end of the valley, which generally includes the area that produces interbasin flow to southern Snake Valley.

Outside of Spring Valley, SNWA's proposed 3M plan includes only part of northern Hamlin Valley and southern Snake Valley near Big Springs (Figure 13). It does not include Tippett or Pleasant Valley or consider any potential for the project to affect Gandy Warm Springs, meaning the SNWA monitoring plan does not consider interbasin connections found in BARCASS (Welch et al. 2008) and even SNWA's own modeling (Myers 2017).

SNWA (2017b) divided the senior water rights into five management categories, labeled as A through E based on distance from a SNWA production well and on whether the location is in an adjacent basin. The intent is to segregate risk based on distance and connectivity with the proposed PODs. However, SNWA at no point provides any analysis or justification for its proposed categories.

GBWN Exh_297, p 32-34

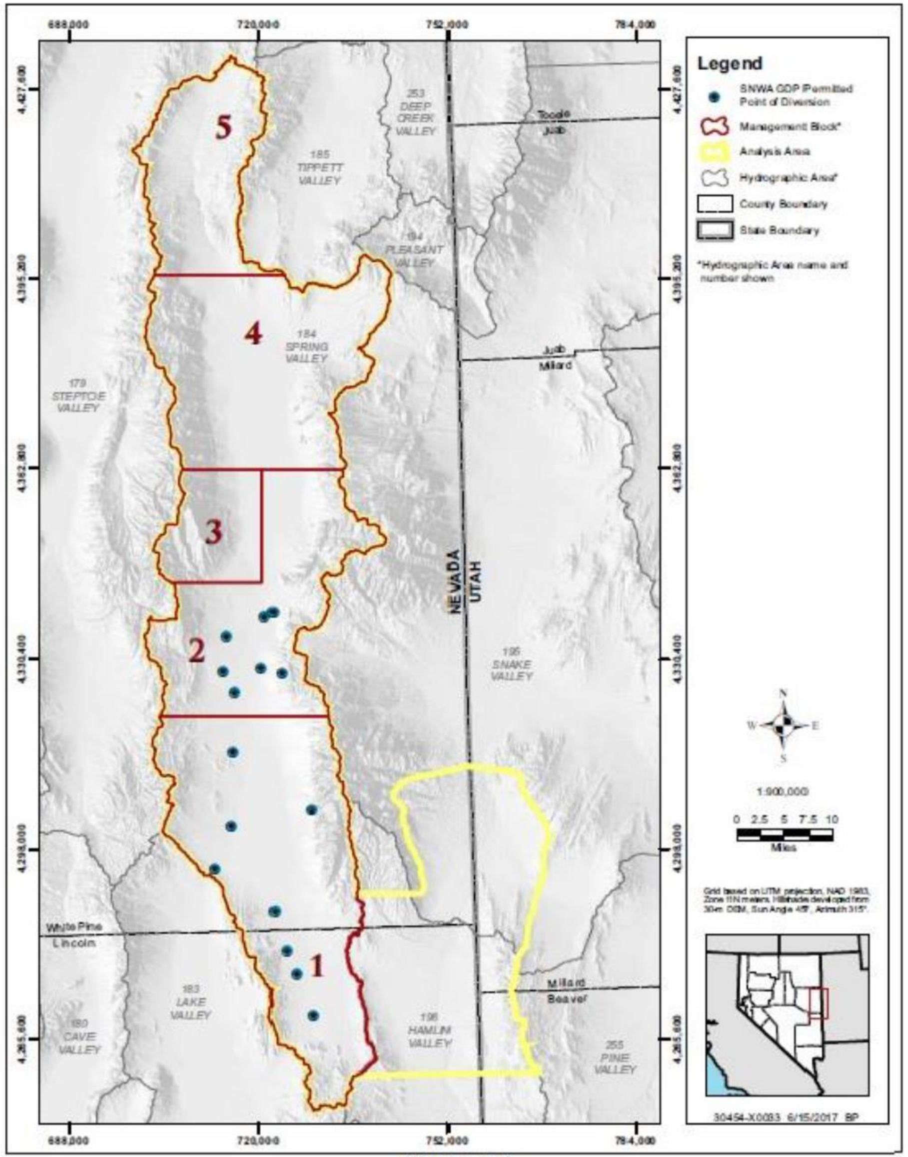


Figure 1-1
3M Plan Area for SNWA GDP Pumping in Spring Valley

Figure 13: Portion of Figure 1-1 from SNWA (2017b) showing SNWA's plan for monitoring in Spring Valley and surrounding valleys.

SNWA_507

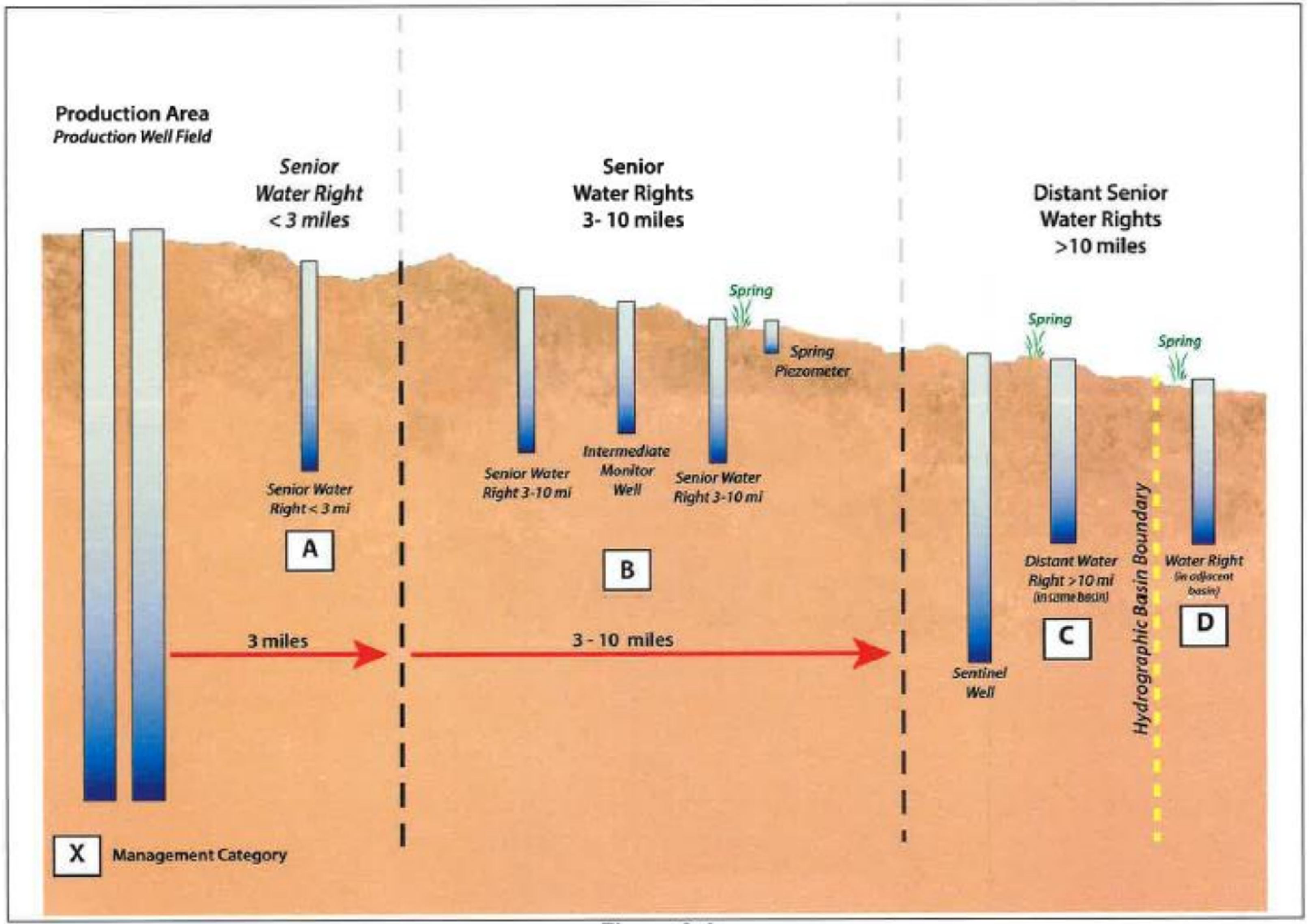


Figure 3-4
Profile Illustration of Management Strategy Categories

SNWA Exh 507, p 3-20

GBWN Exh_297, p 35, 36

SNWA (2017b) Table 2-1 lists all the monitoring sites proposed for Spring Valley and Figure 2-1 (reproduced here as Figure 14) shows them. There is much less to that table than is apparent by simply considering its length, five pages long. There has been little added to it since 2011, the plan of which was reviewed by Myers (2017). Management area 1 would have 29 monitoring locations, many of which are already installed and several of which are simply spring flow monitoring or shallow piezometers. This is for an area that is about 30 by 10 miles. Management area 2 would have 26 monitoring locations, including several spring flow sites and piezometers. These also include as two locations various paired monitoring wells, such as SPR7005X and M or SPR7008X and M. This is for an area about 20 by 10 miles. Very little monitoring would occur north of the Cleveland Ranch which has only the sentinel wells and a spring proposed for Management Area 3 (Figure 14).

SNWA (2017b) does identify most of the groundwater dependent ecosystems (GDEs) and water rights within the valley, but does not present a localized conceptual flow model (CFM) for the specific locations, and so it is not possible to determine whether SNWA's monitoring could be effective. SNWA does not estimate the time for drawdown to pass from the monitoring points to the GDE or water right; there are no triggers proposed that would be an adequate warning for the sites. The proposed monitoring is a "one size fits all approach", with little monitoring specific to the CFM of the sites.

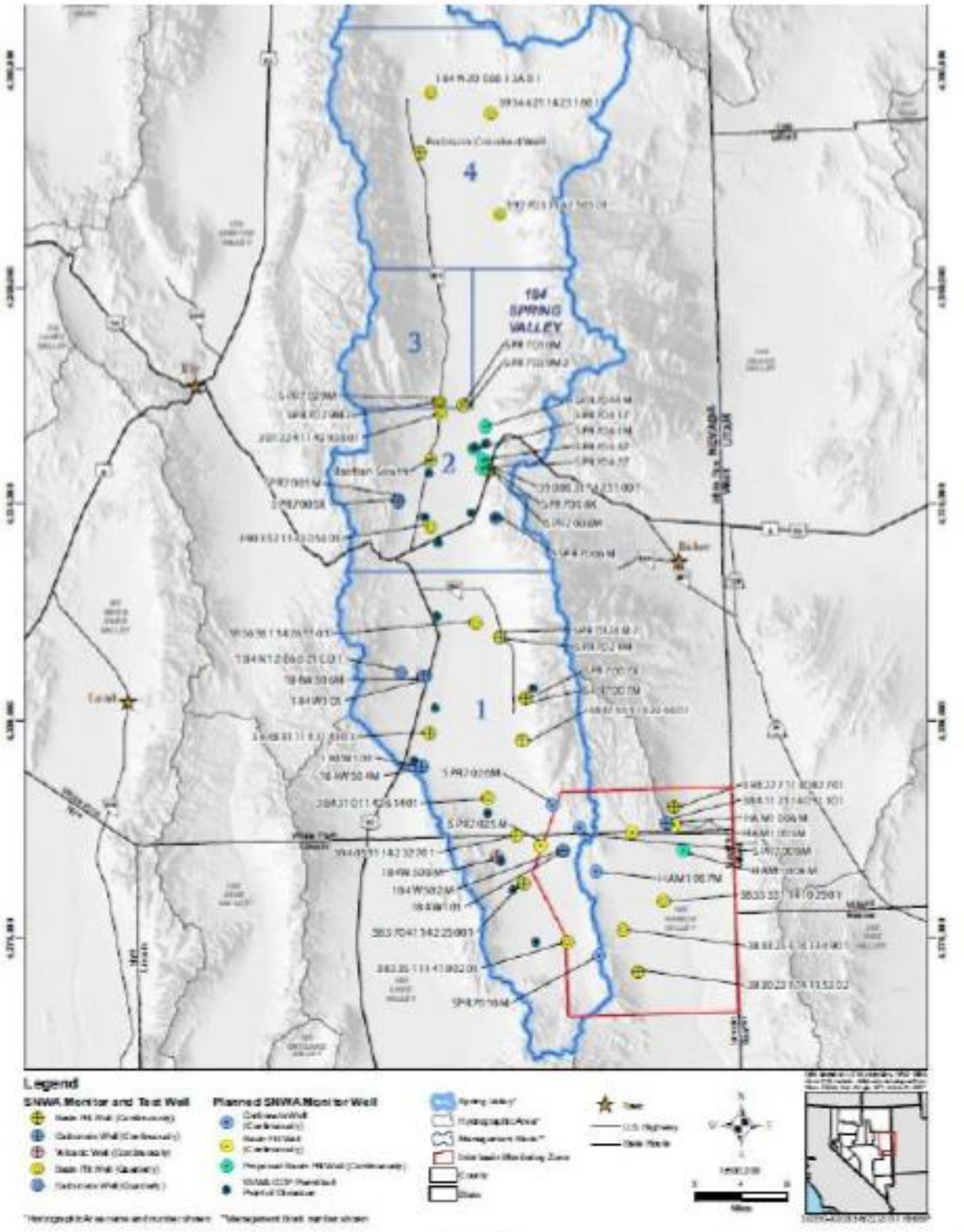


Figure 2-1
Spring Valley 3M Plan Monitor Well Network Locations

Figure 14: Figure 2-1 from SNWA (2017b) showing the location of proposed monitoring for Spring Valley.

Figure 15 shows most monitoring proposed for Management unit 2, which lies south of the Cleveland Ranch (Figure 13). The sentinel wells just described would also be responsible for monitoring at least ten additional water rights, not on the Cleveland Ranch (Table 2-4, SNWA 2017b). Monitor well SPR7044M is an additional monitor well southeast of the Cleveland Ranch. (Id.) Piezometer SPR7012Z and SPR7016Z would monitor about 15 additional water rights. (Id.) At least eleven water rights would be monitored only at the right's POD. (Id.) Wells SPR7041M and Z, and piezometers SPR7042Z and SPR7043Z would monitor the Swamp Cedar area. (Id.) The monitoring near the Swamp Cedars area is intended to be related to the conditions of the area, such as tree density and health, rather than provide a trigger for management and mitigation (SNWA 2017b, p 2-51). As can be seen on Figure 15, these are the sole wells available for monitoring an area of about twelve by 24 miles, which is inadequate on its face.

GBWN Exh_297, p 35, 37

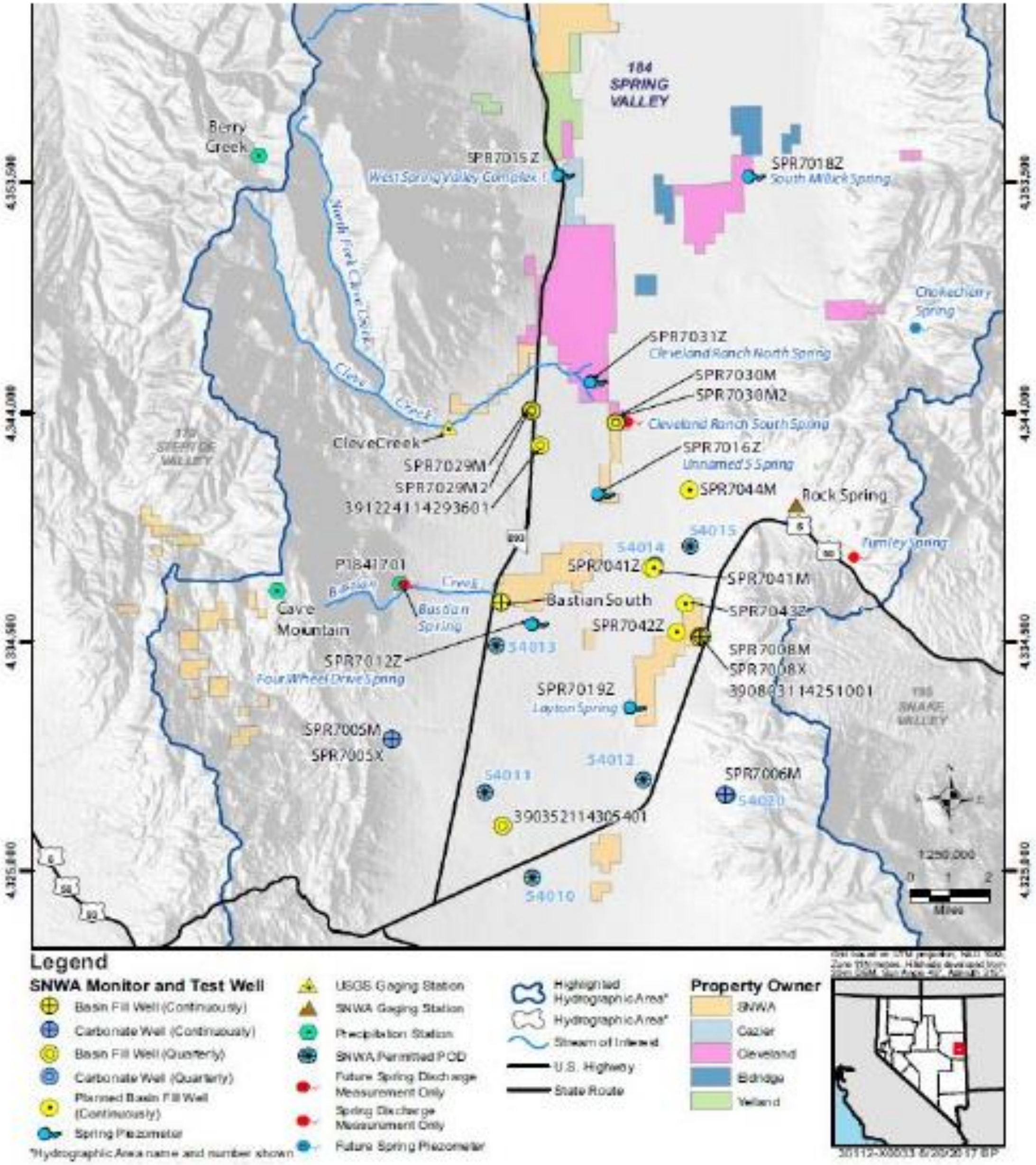
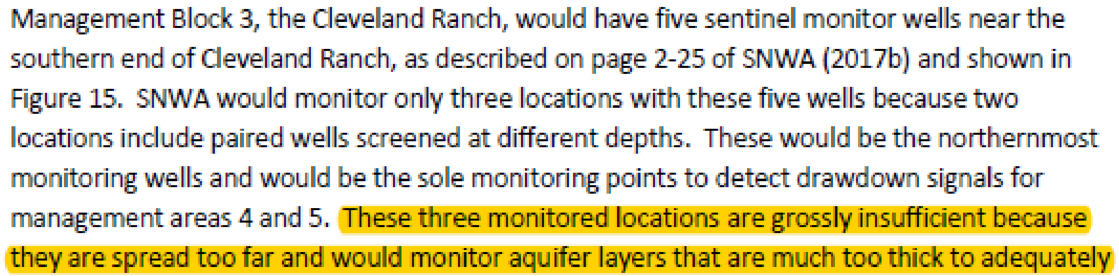
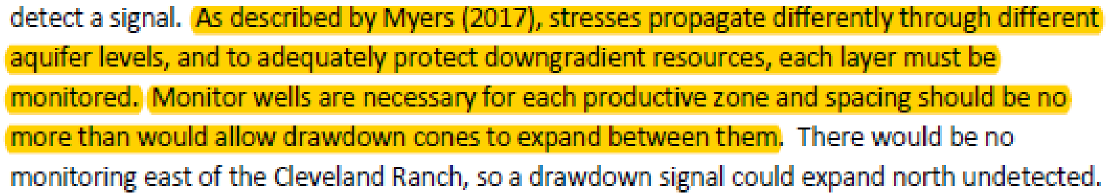


Figure 15: Portion of Figure 2-8 (SNWA 2017b) showing the SNWA PODs and proposed monitoring for the Cleveland Ranch/McCoy Creek Area.

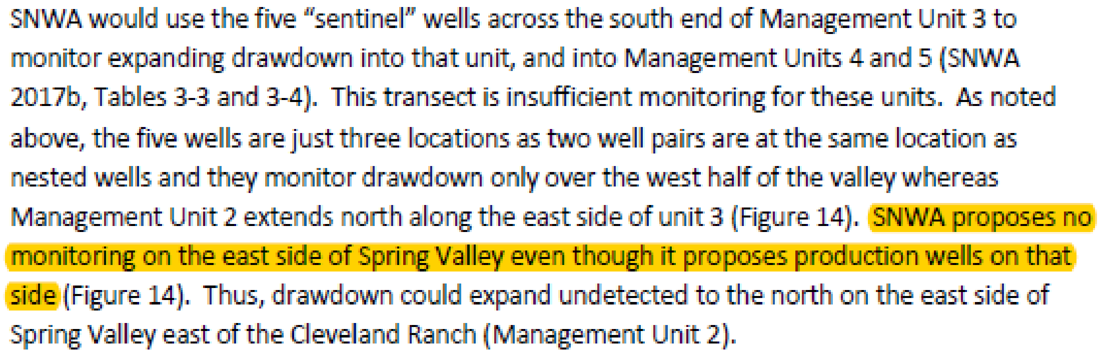


Management Block 3, the Cleveland Ranch, would have five sentinel monitor wells near the southern end of Cleveland Ranch, as described on page 2-25 of SNWA (2017b) and shown in Figure 15. SNWA would monitor only three locations with these five wells because two locations include paired wells screened at different depths. These would be the northernmost monitoring wells and would be the sole monitoring points to detect drawdown signals for management areas 4 and 5. These three monitored locations are grossly insufficient because they are spread too far and would monitor aquifer layers that are much too thick to adequately

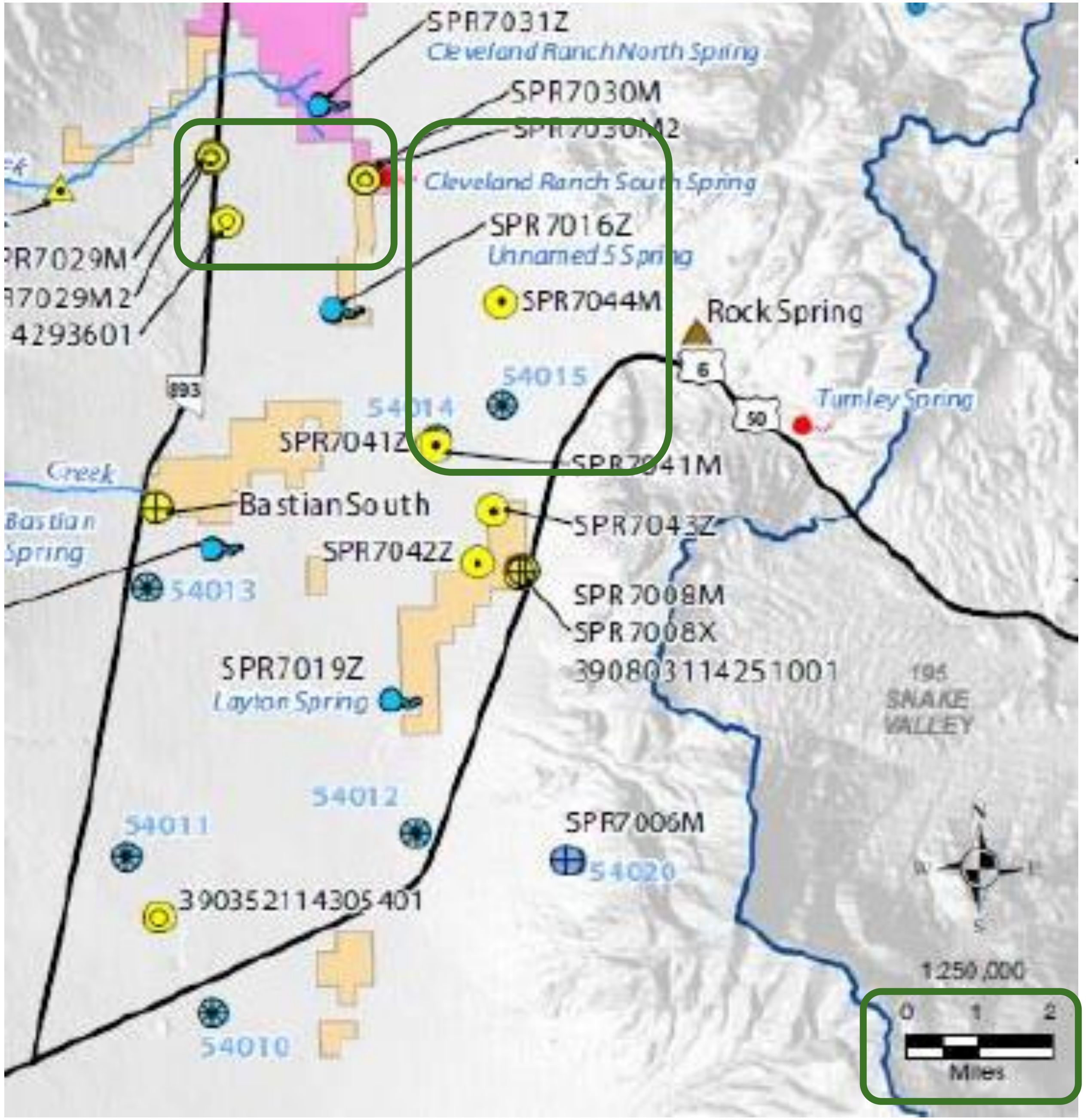


detect a signal. As described by Myers (2017), stresses propagate differently through different aquifer levels, and to adequately protect downgradient resources, each layer must be monitored. Monitor wells are necessary for each productive zone and spacing should be no more than would allow drawdown cones to expand between them. There would be no monitoring east of the Cleveland Ranch, so a drawdown signal could expand north undetected.

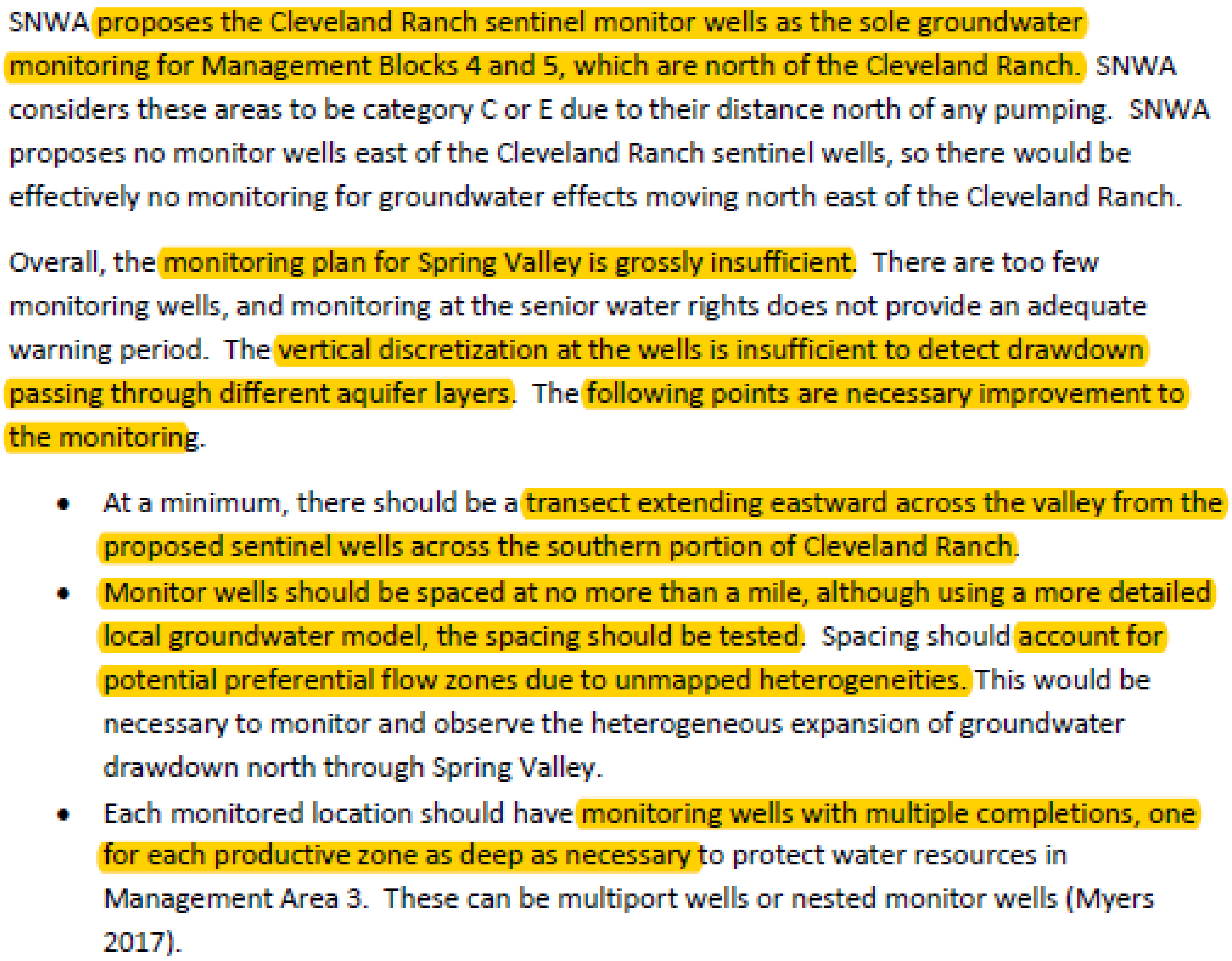
GBWN Exh_297, p 37, 38, 46



SNWA would use the five "sentinel" wells across the south end of Management Unit 3 to monitor expanding drawdown into that unit, and into Management Units 4 and 5 (SNWA 2017b, Tables 3-3 and 3-4). This transect is insufficient monitoring for these units. As noted above, the five wells are just three locations as two well pairs are at the same location as nested wells and they monitor drawdown only over the west half of the valley whereas Management Unit 2 extends north along the east side of unit 3 (Figure 14). SNWA proposes no monitoring on the east side of Spring Valley even though it proposes production wells on that side (Figure 14). Thus, drawdown could expand undetected to the north on the east side of Spring Valley east of the Cleveland Ranch (Management Unit 2).



Portion of GBWN Exh_297, Figure 15, p 37

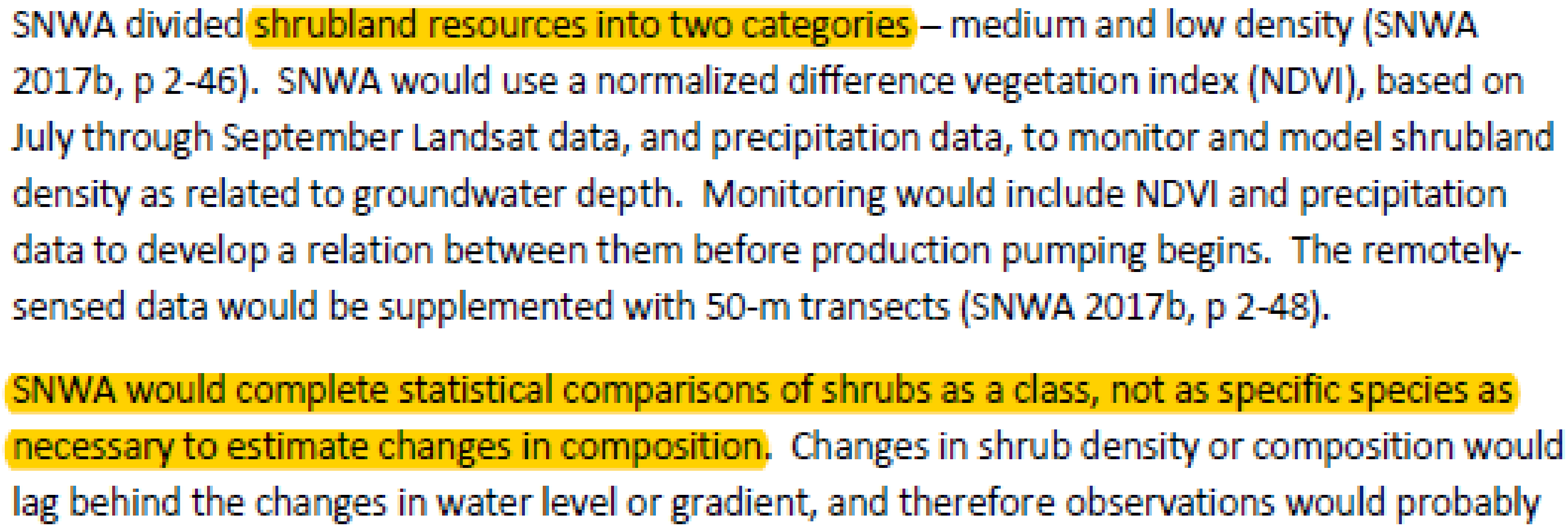


SNWA proposes the Cleveland Ranch sentinel monitor wells as the sole groundwater monitoring for Management Blocks 4 and 5, which are north of the Cleveland Ranch. SNWA considers these areas to be category C or E due to their distance north of any pumping. SNWA proposes no monitor wells east of the Cleveland Ranch sentinel wells, so there would be effectively no monitoring for groundwater effects moving north east of the Cleveland Ranch.

Overall, the monitoring plan for Spring Valley is grossly insufficient. There are too few monitoring wells, and monitoring at the senior water rights does not provide an adequate warning period. The vertical discretization at the wells is insufficient to detect drawdown passing through different aquifer layers. The following points are necessary improvement to the monitoring.

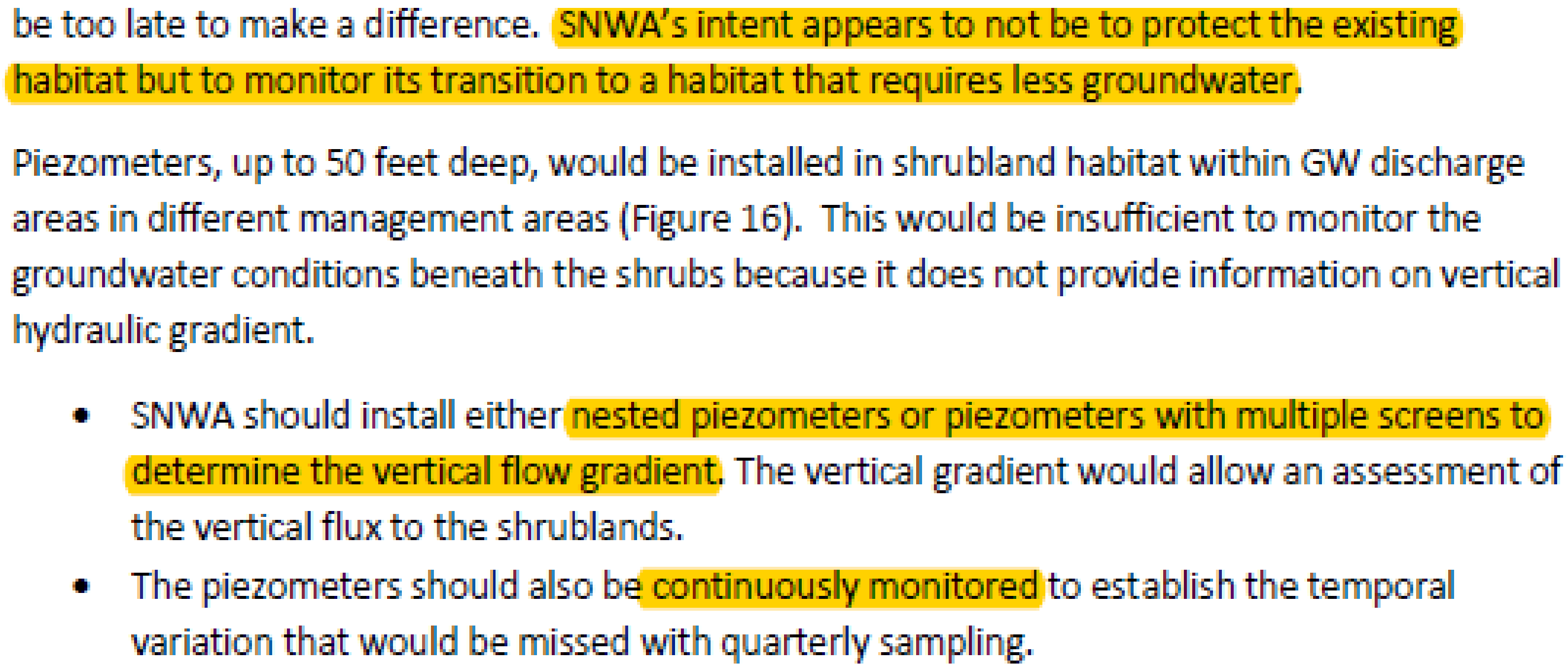
- At a minimum, there should be a transect extending eastward across the valley from the proposed sentinel wells across the southern portion of Cleveland Ranch.
- Monitor wells should be spaced at no more than a mile, although using a more detailed local groundwater model, the spacing should be tested. Spacing should account for potential preferential flow zones due to unmapped heterogeneities. This would be necessary to monitor and observe the heterogeneous expansion of groundwater drawdown north through Spring Valley.
- Each monitored location should have monitoring wells with multiple completions, one for each productive zone as deep as necessary to protect water resources in Management Area 3. These can be multiport wells or nested monitor wells (Myers 2017).

GBWN Exh_297, p 38



SNWA divided shrubland resources into two categories – medium and low density (SNWA 2017b, p 2-46). SNWA would use a normalized difference vegetation index (NDVI), based on July through September Landsat data, and precipitation data, to monitor and model shrubland density as related to groundwater depth. Monitoring would include NDVI and precipitation data to develop a relation between them before production pumping begins. The remotely-sensed data would be supplemented with 50-m transects (SNWA 2017b, p 2-48).

SNWA would complete statistical comparisons of shrubs as a class, not as specific species as necessary to estimate changes in composition. Changes in shrub density or composition would lag behind the changes in water level or gradient, and therefore observations would probably

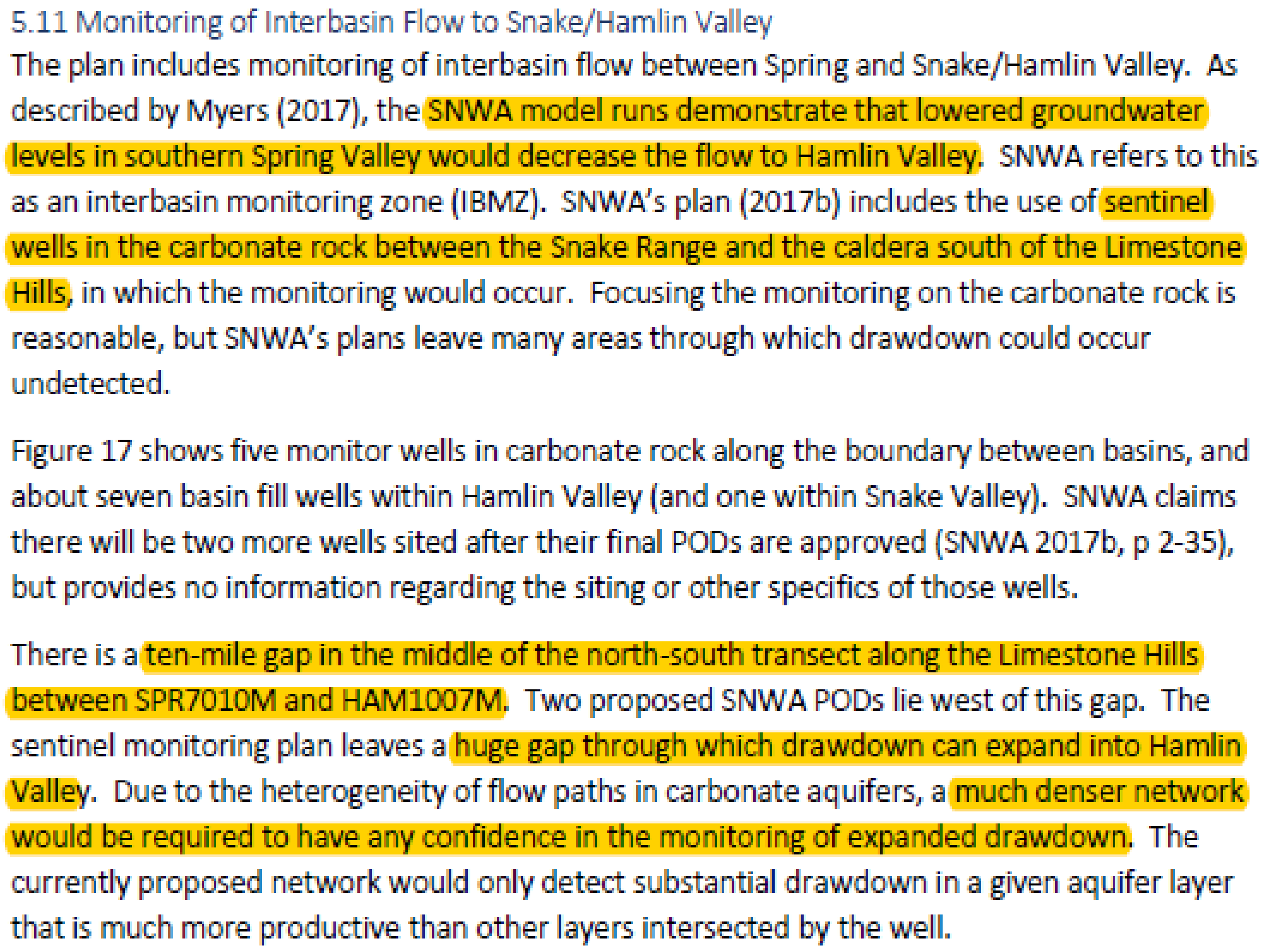


be too late to make a difference. SNWA's intent appears to not be to protect the existing habitat but to monitor its transition to a habitat that requires less groundwater.

Piezometers, up to 50 feet deep, would be installed in shrubland habitat within GW discharge areas in different management areas (Figure 16). This would be insufficient to monitor the groundwater conditions beneath the shrubs because it does not provide information on vertical hydraulic gradient.

- SNWA should install either nested piezometers or piezometers with multiple screens to determine the vertical flow gradient. The vertical gradient would allow an assessment of the vertical flux to the shrublands.
- The piezometers should also be continuously monitored to establish the temporal variation that would be missed with quarterly sampling.

GBWN Exh_297 ,
p 38, 39



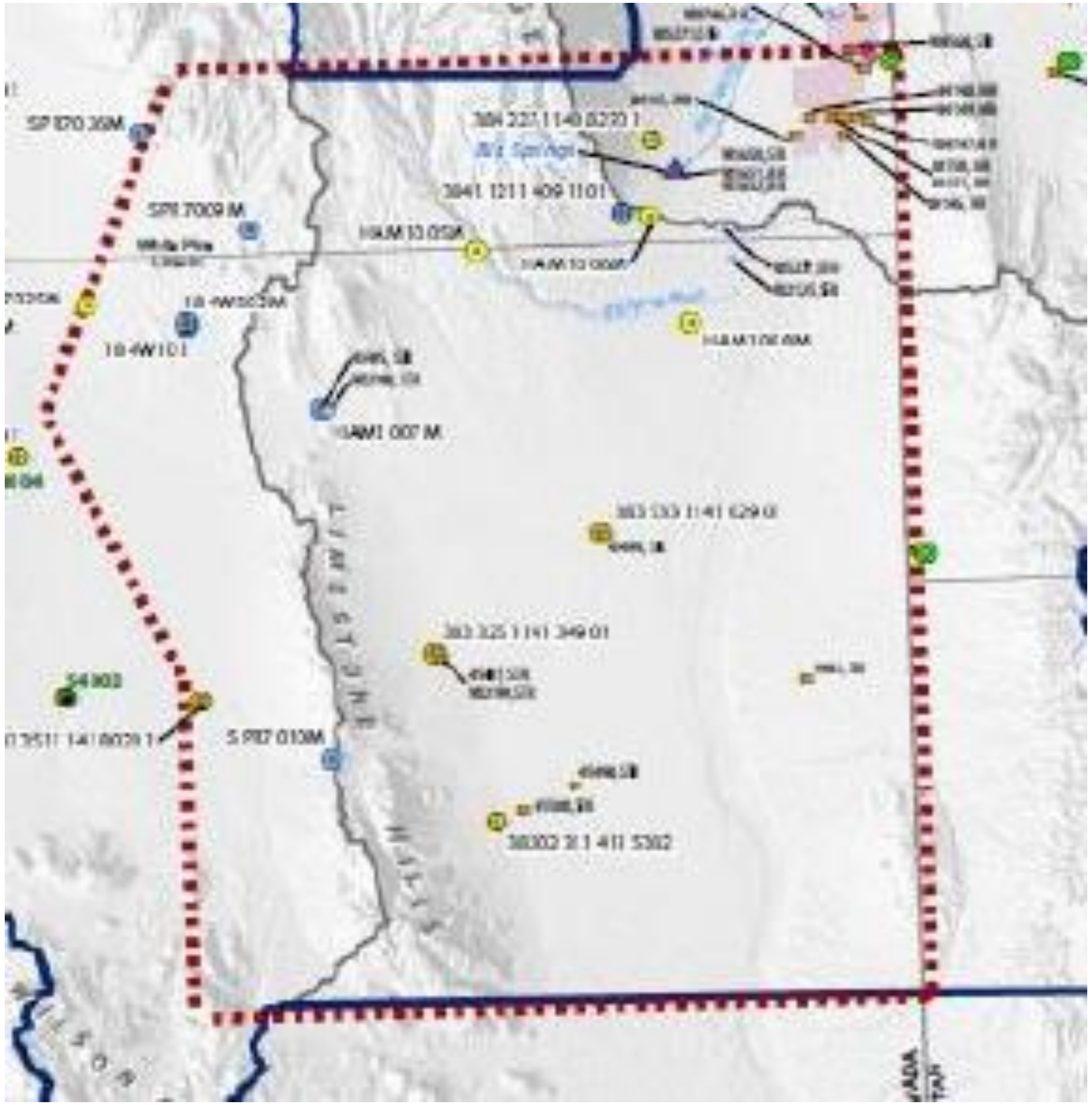
5.11 Monitoring of Interbasin Flow to Snake/Hamlin Valley

The plan includes monitoring of interbasin flow between Spring and Snake/Hamlin Valley. As described by Myers (2017), the SNWA model runs demonstrate that lowered groundwater levels in southern Spring Valley would decrease the flow to Hamlin Valley. SNWA refers to this as an interbasin monitoring zone (IBMZ). SNWA's plan (2017b) includes the use of sentinel wells in the carbonate rock between the Snake Range and the caldera south of the Limestone Hills, in which the monitoring would occur. Focusing the monitoring on the carbonate rock is reasonable, but SNWA's plans leave many areas through which drawdown could occur undetected.

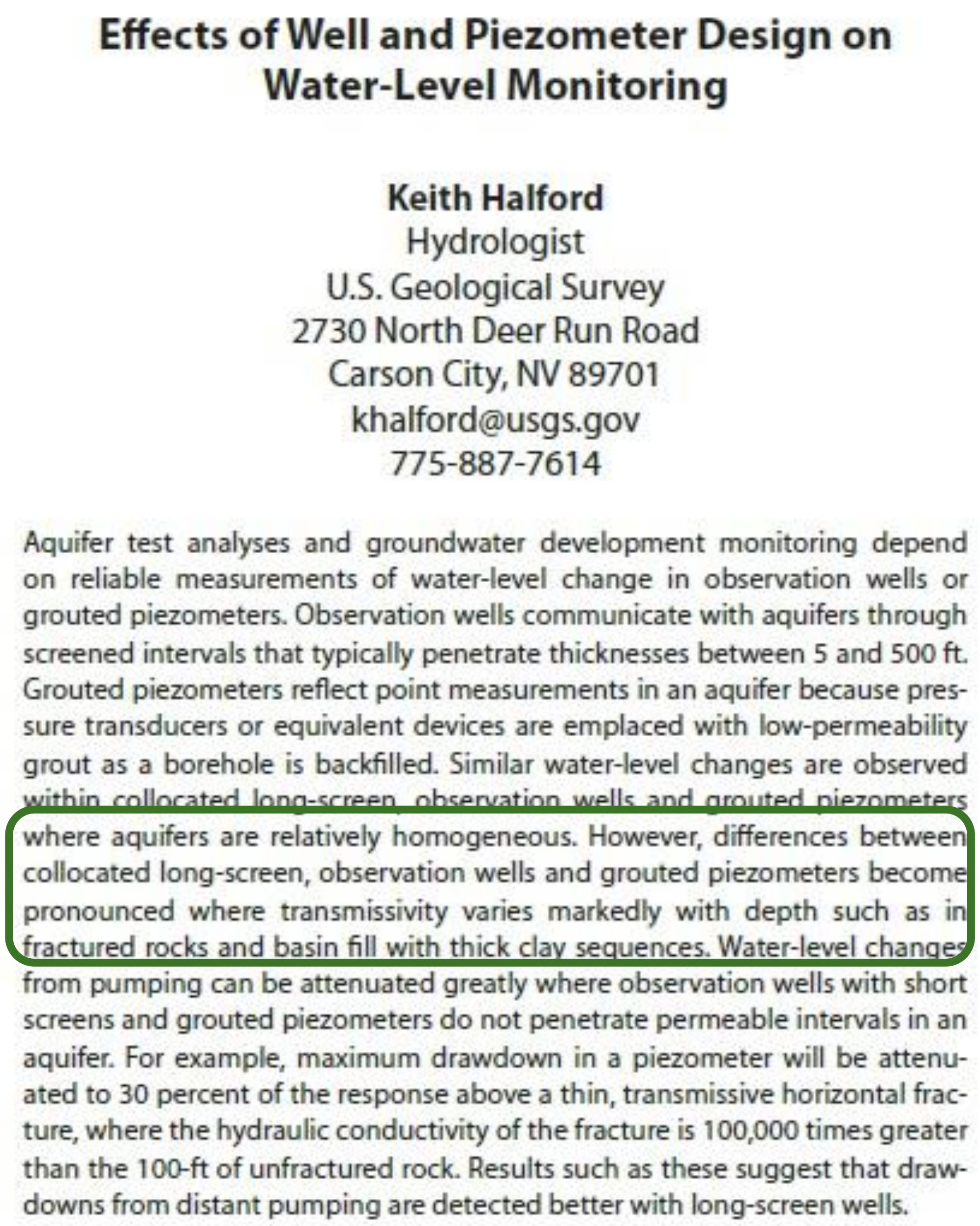
Figure 17 shows five monitor wells in carbonate rock along the boundary between basins, and about seven basin fill wells within Hamlin Valley (and one within Snake Valley). SNWA claims there will be two more wells sited after their final PODs are approved (SNWA 2017b, p 2-35), but provides no information regarding the siting or other specifics of those wells.

There is a ten-mile gap in the middle of the north-south transect along the Limestone Hills between SPR7010M and HAM1007M. Two proposed SNWA PODs lie west of this gap. The sentinel monitoring plan leaves a huge gap through which drawdown can expand into Hamlin Valley. Due to the heterogeneity of flow paths in carbonate aquifers, a much denser network would be required to have any confidence in the monitoring of expanded drawdown. The currently proposed network would only detect substantial drawdown in a given aquifer layer that is much more productive than other layers intersected by the well.

GBWN Exh_297, p 39



GBWN Exh_297, portion of Figure 17, p 41



Effects of Well and Piezometer Design on Water-Level Monitoring

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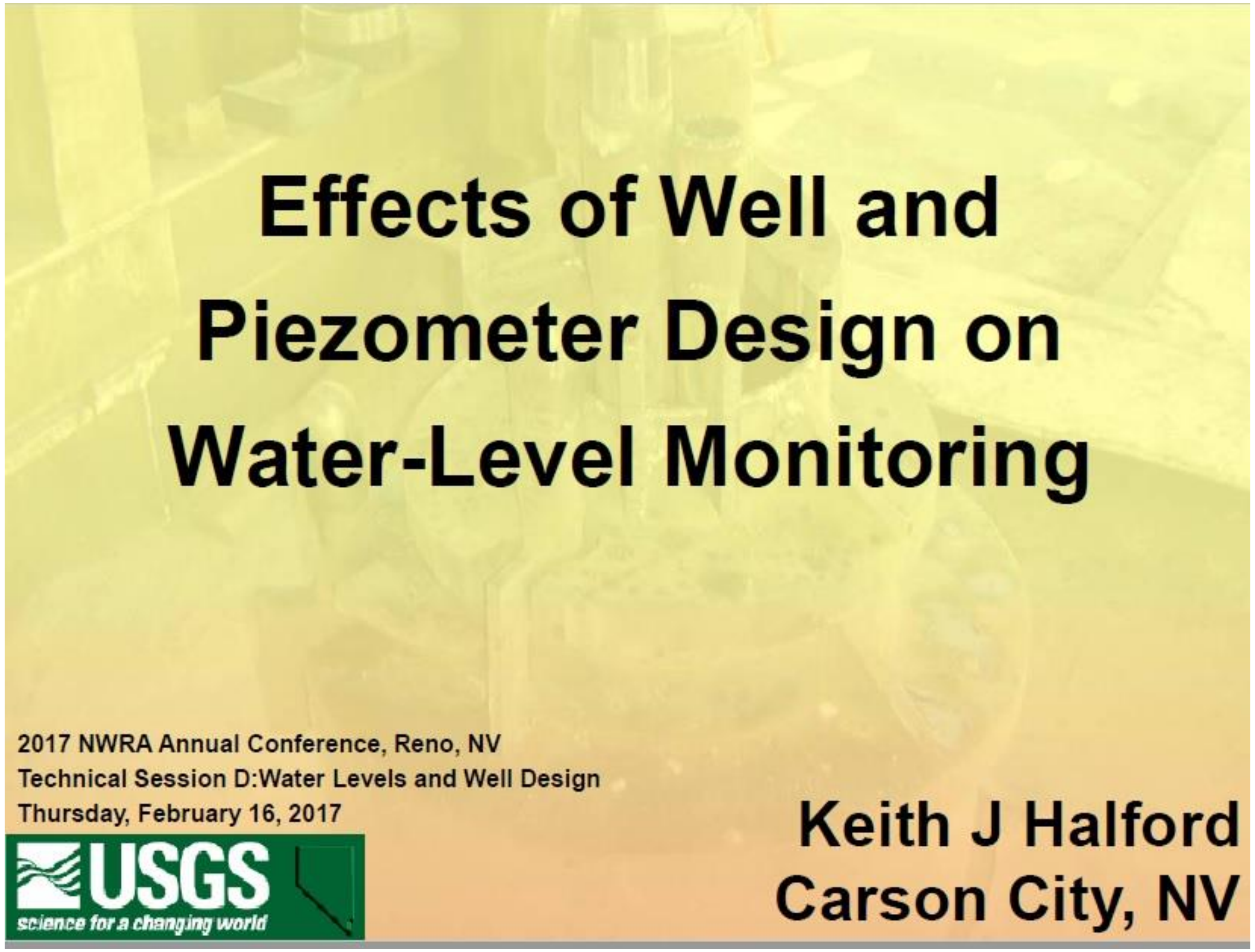
Aquifer test analyses and groundwater development monitoring depend on reliable measurements of water-level change in observation wells or grouted piezometers. Observation wells communicate with aquifers through screened intervals that typically penetrate thicknesses between 5 and 500 ft. Grouted piezometers reflect point measurements in an aquifer because pressure transducers or equivalent devices are emplaced with low-permeability grout as a borehole is backfilled. Similar water-level changes are observed within collocated long-screen, observation wells and grouted piezometers where aquifers are relatively homogeneous. However, differences between collocated long-screen, observation wells and grouted piezometers become pronounced where transmissivity varies markedly with depth such as in fractured rocks and basin fill with thick clay sequences. Water-level changes from pumping can be attenuated greatly where observation wells with short screens and grouted piezometers do not penetrate permeable intervals in an aquifer. For example, maximum drawdown in a piezometer will be attenuated to 30 percent of the response above a thin, transmissive horizontal fracture, where the hydraulic conductivity of the fracture is 100,000 times greater than the 100-ft of unfractured rock. Results such as these suggest that drawdowns from distant pumping are detected better with long-screen wells.

Halford abstract, SNWA Exh #604



Effects of Well and Piezometer Design on Water-Level Monitoring

2017 NWRA Annual Conference, Reno, NV
Technical Session D:Water Levels and Well Design
Thursday, February 16, 2017

Keith J Halford
Carson City, NV

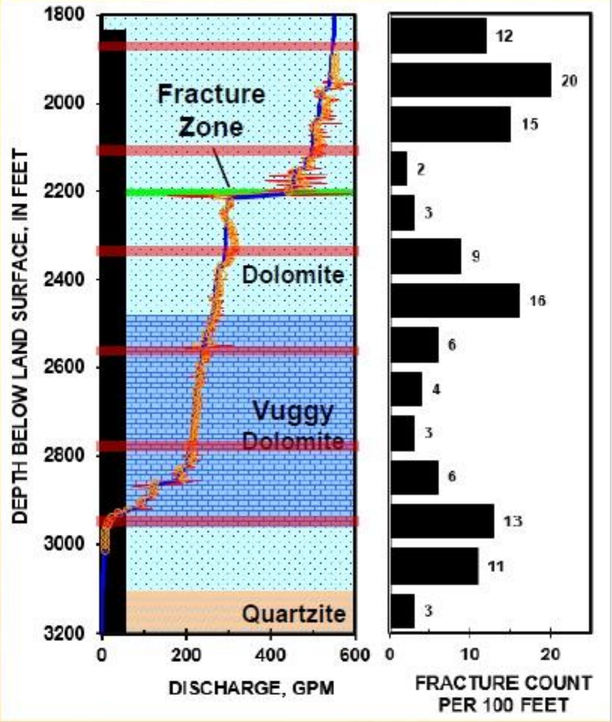
Title page, SNWA Exh #605

Short / Long Screens

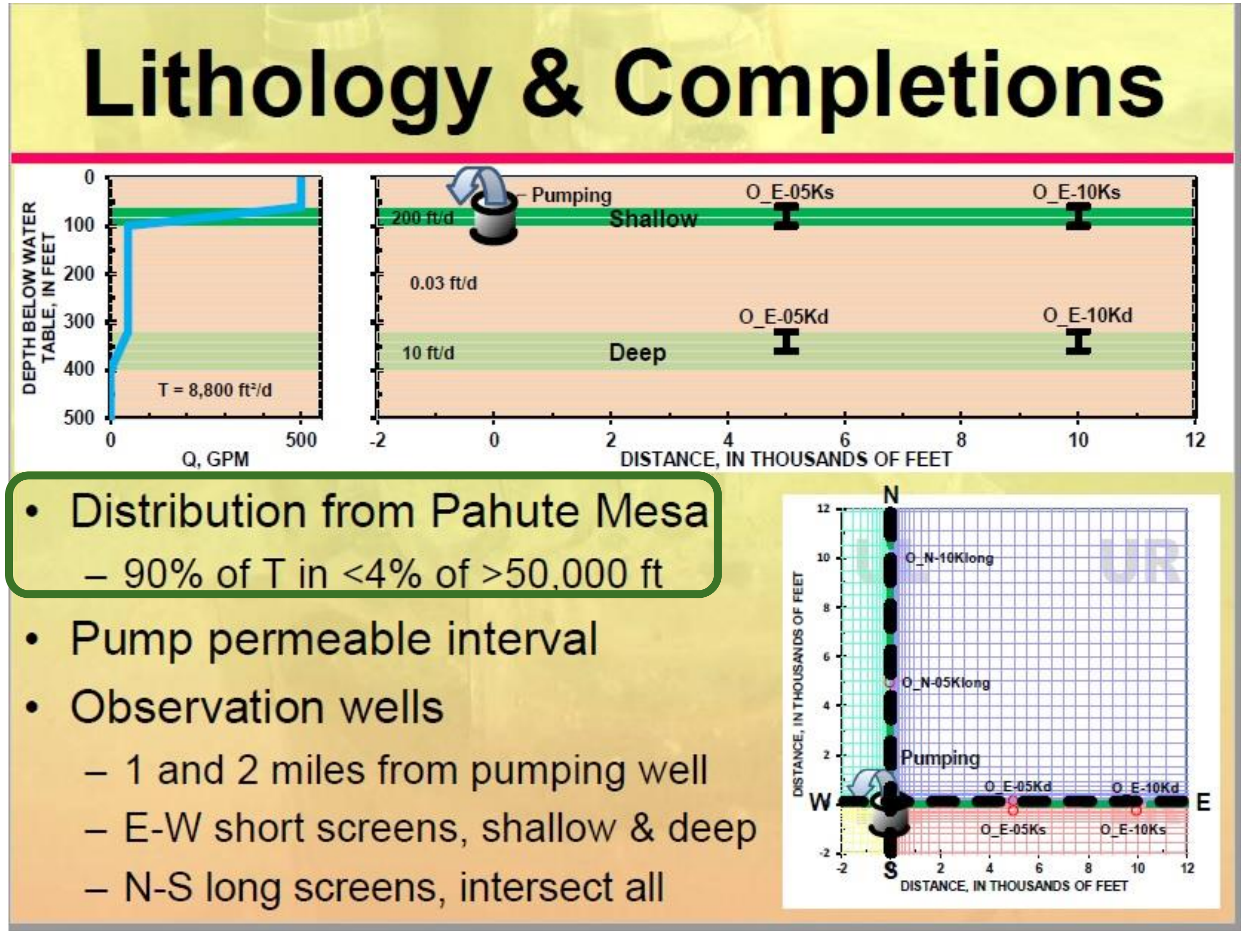
- Short screens <20 ft and piezometers
  - Discrete interval, point
  - Head and QW differences observable
  - Minimally disturbs flow system
- Long screens >100 ft
  - Integrates head and QW
  - Head skewed towards most transmissive interval
  - Well passively induces flow between units
  - QW skewed towards interval with higher head
- Bias towards short screens
  - Reduce apparent risk of contaminant migration
  - Less likely to observe water-level changes

Hard Rock

- ER-6-1 #2, Yucca Flat, NV
  - Open to 1,300 ft carbonate
  - >90% of transmissivity, in 2% of open hole
  - Determined with flow logs & aquifer testing
- Other indicators of T
  - Not rock type
  - Not fracture count
- More likely to miss permeable interval with short screen

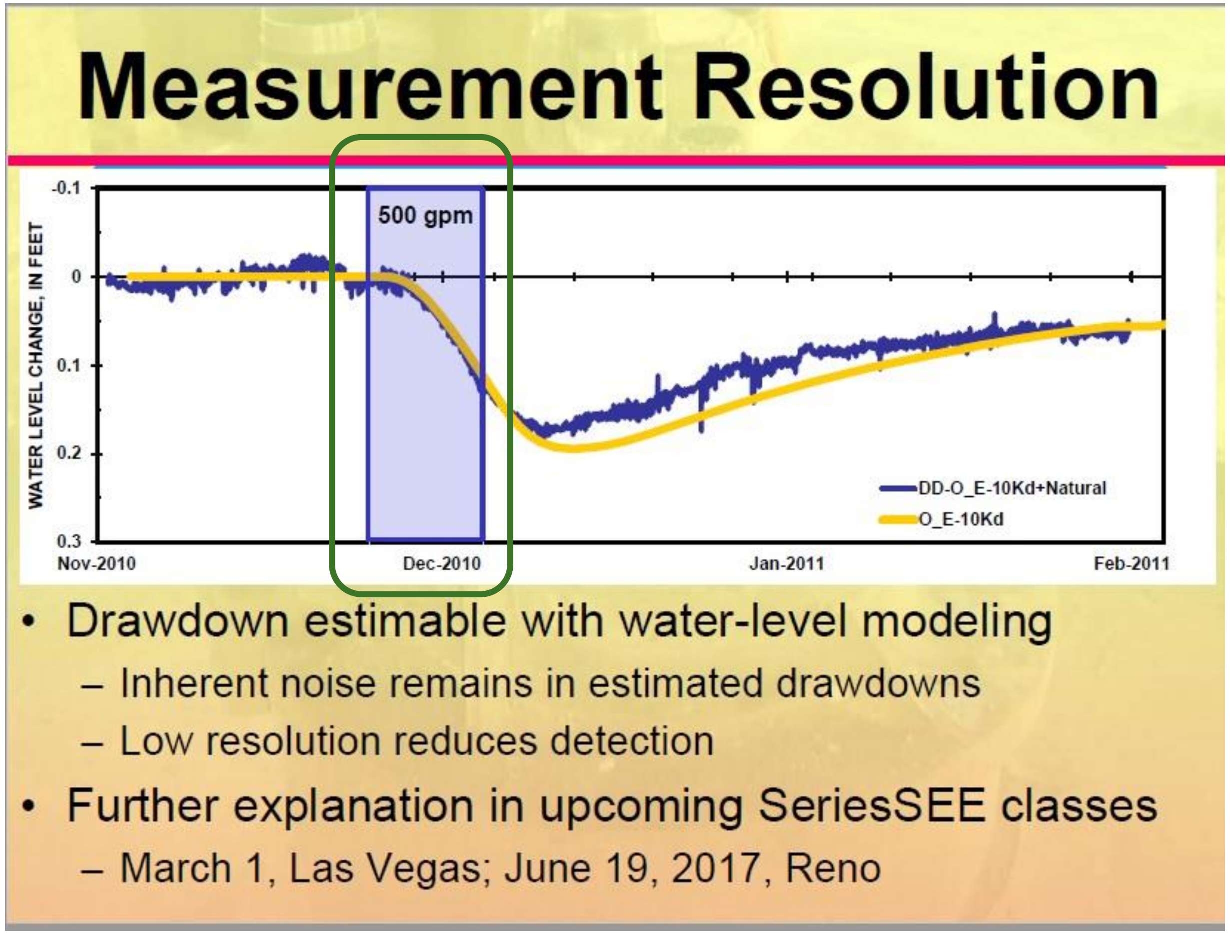


SNWA Exh #605



Lithology & Completions

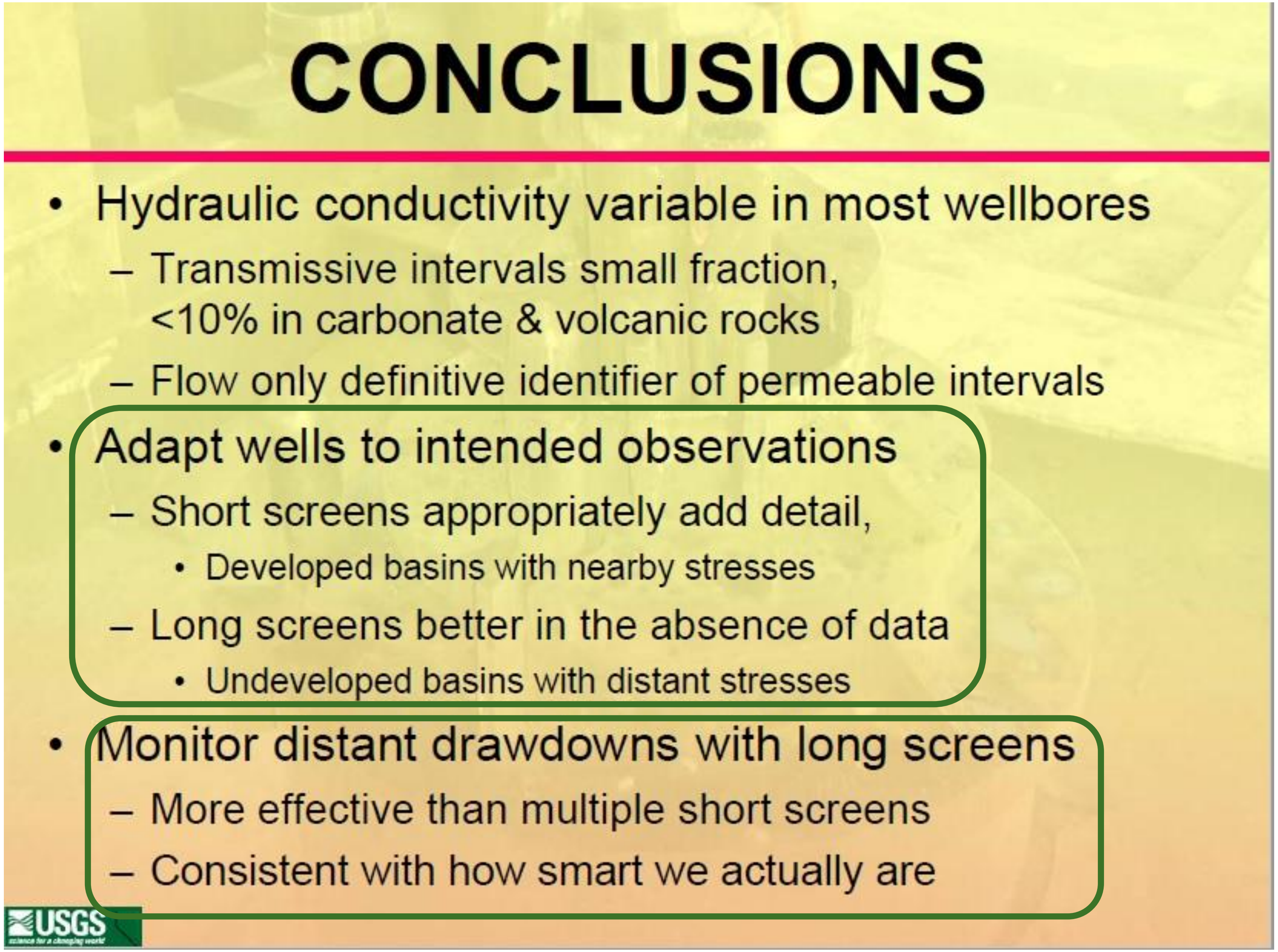
- Distribution from Pahute Mesa
  - 90% of T in <4% of >50,000 ft
- Pump permeable interval
- Observation wells
  - 1 and 2 miles from pumping well
  - E-W short screens, shallow & deep
  - N-S long screens, intersect all



Measurement Resolution

- Drawdown estimable with water-level modeling
  - Inherent noise remains in estimated drawdowns
  - Low resolution reduces detection
- Further explanation in upcoming SeriesSEE classes
  - March 1, Las Vegas; June 19, 2017, Reno

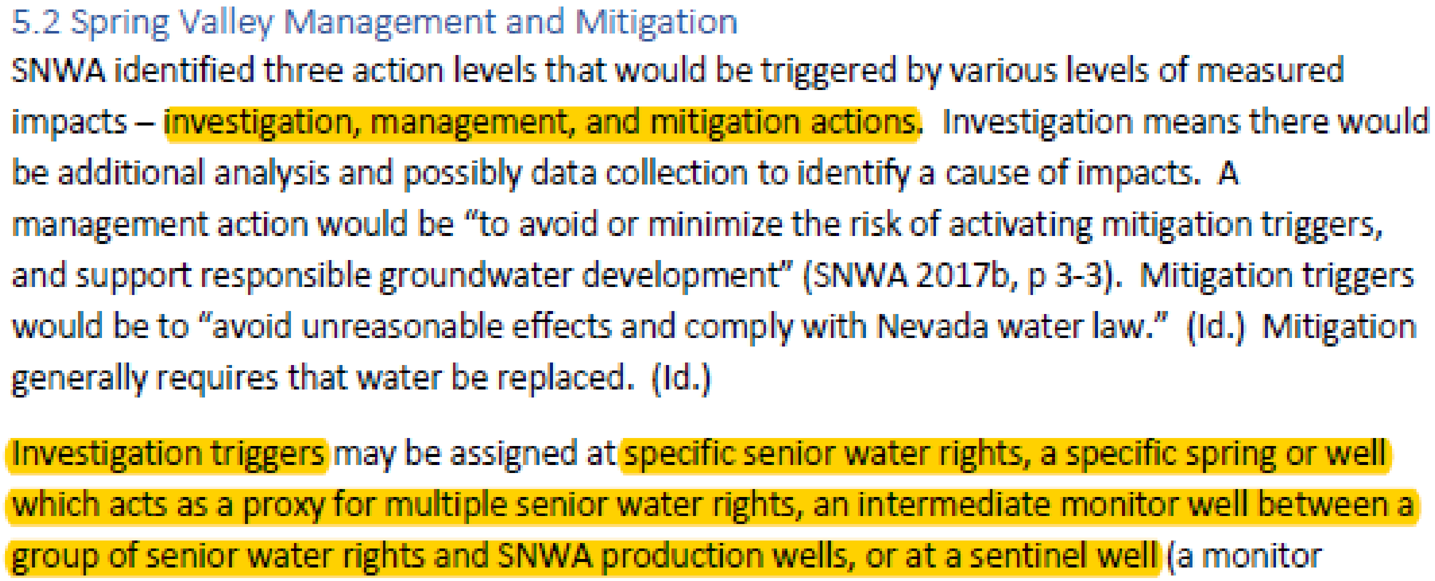
SNWA Exh #605



CONCLUSIONS

- Hydraulic conductivity variable in most wellbores
  - Transmissive intervals small fraction, <10% in carbonate & volcanic rocks
  - Flow only definitive identifier of permeable intervals
- Adapt wells to intended observations
  - Short screens appropriately add detail,
    - Developed basins with nearby stresses
  - Long screens better in the absence of data
    - Undeveloped basins with distant stresses
- Monitor distant drawdowns with long screens
  - More effective than multiple short screens
  - Consistent with how smart we actually are

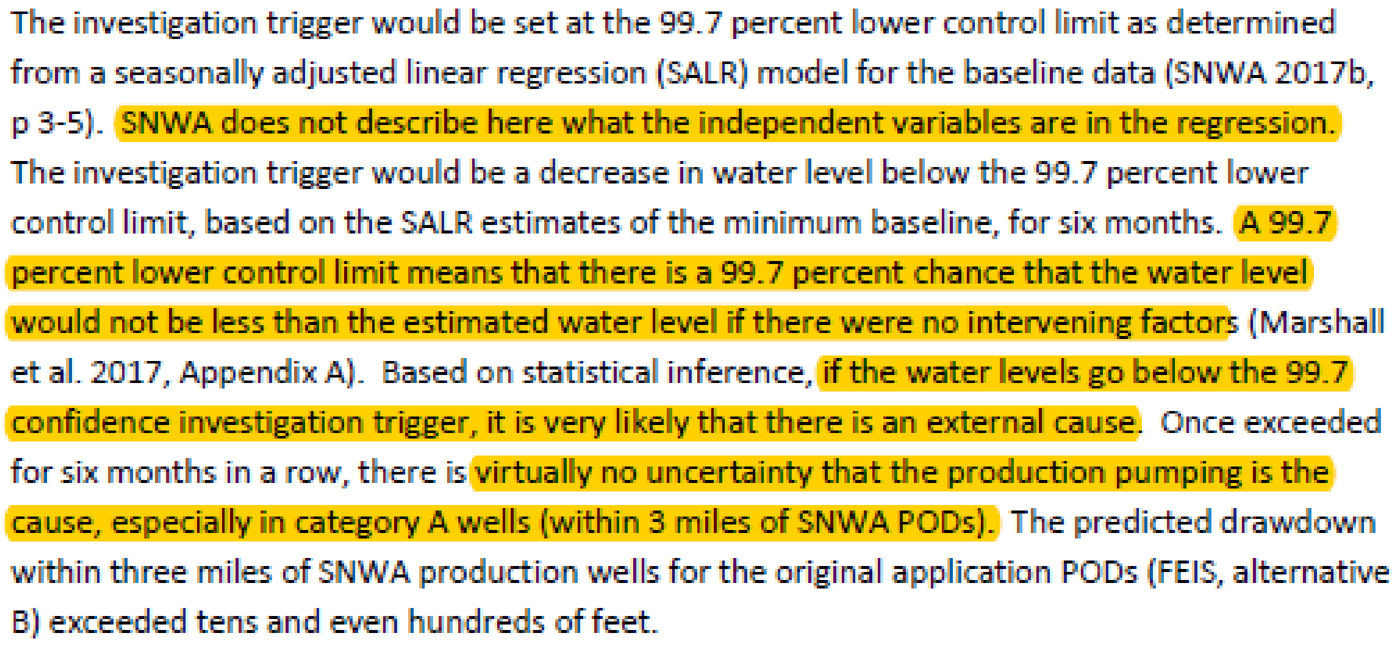
SNWA Exh #605



5.2 Spring Valley Management and Mitigation

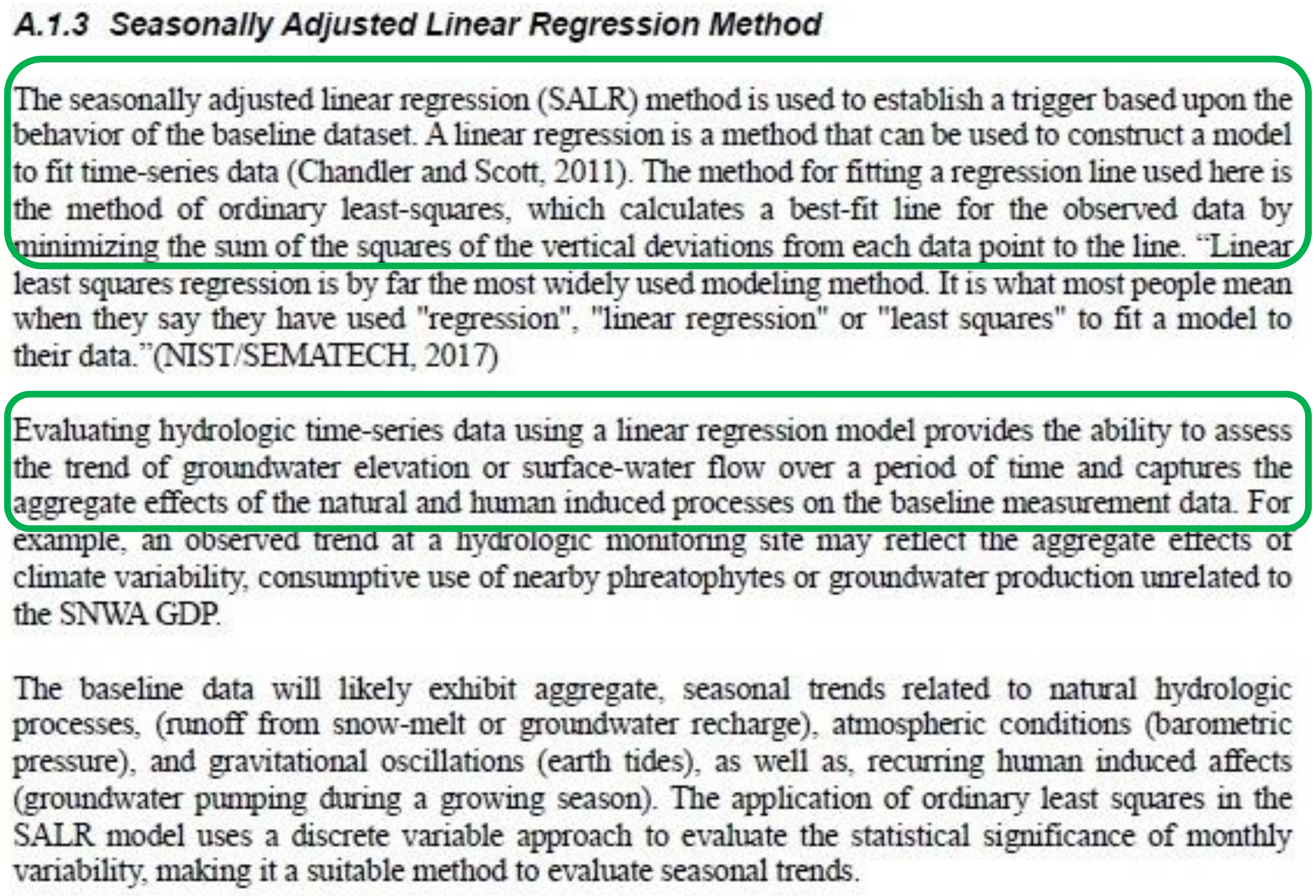
SNWA identified three action levels that would be triggered by various levels of measured impacts – investigation, management, and mitigation actions. Investigation means there would be additional analysis and possibly data collection to identify a cause of impacts. A management action would be "to avoid or minimize the risk of activating mitigation triggers, and support responsible groundwater development" (SNWA 2017b, p 3-3). Mitigation triggers would be to "avoid unreasonable effects and comply with Nevada water law." (Id.) Mitigation generally requires that water be replaced. (Id.)

Investigation triggers may be assigned at specific senior water rights, a specific spring or well which acts as a proxy for multiple senior water rights, an intermediate monitor well between a group of senior water rights and SNWA production wells, or at a sentinel well (a monitor



The investigation trigger would be set at the 99.7 percent lower control limit as determined from a seasonally adjusted linear regression (SALR) model for the baseline data (SNWA 2017b, p 3-5). SNWA does not describe here what the independent variables are in the regression. The investigation trigger would be a decrease in water level below the 99.7 percent lower control limit, based on the SALR estimates of the minimum baseline, for six months. A 99.7 percent lower control limit means that there is a 99.7 percent chance that the water level would not be less than the estimated water level if there were no intervening factors (Marshall et al. 2017, Appendix A). Based on statistical inference, if the water levels go below the 99.7 confidence investigation trigger, it is very likely that there is an external cause. Once exceeded for six months in a row, there is virtually no uncertainty that the production pumping is the cause, especially in category A wells (within 3 miles of SNWA PODs). The predicted drawdown within three miles of SNWA production wells for the original application PODs (FEIS, alternative B) exceeded tens and even hundreds of feet.

SNWA Exh_297, p 42, 43



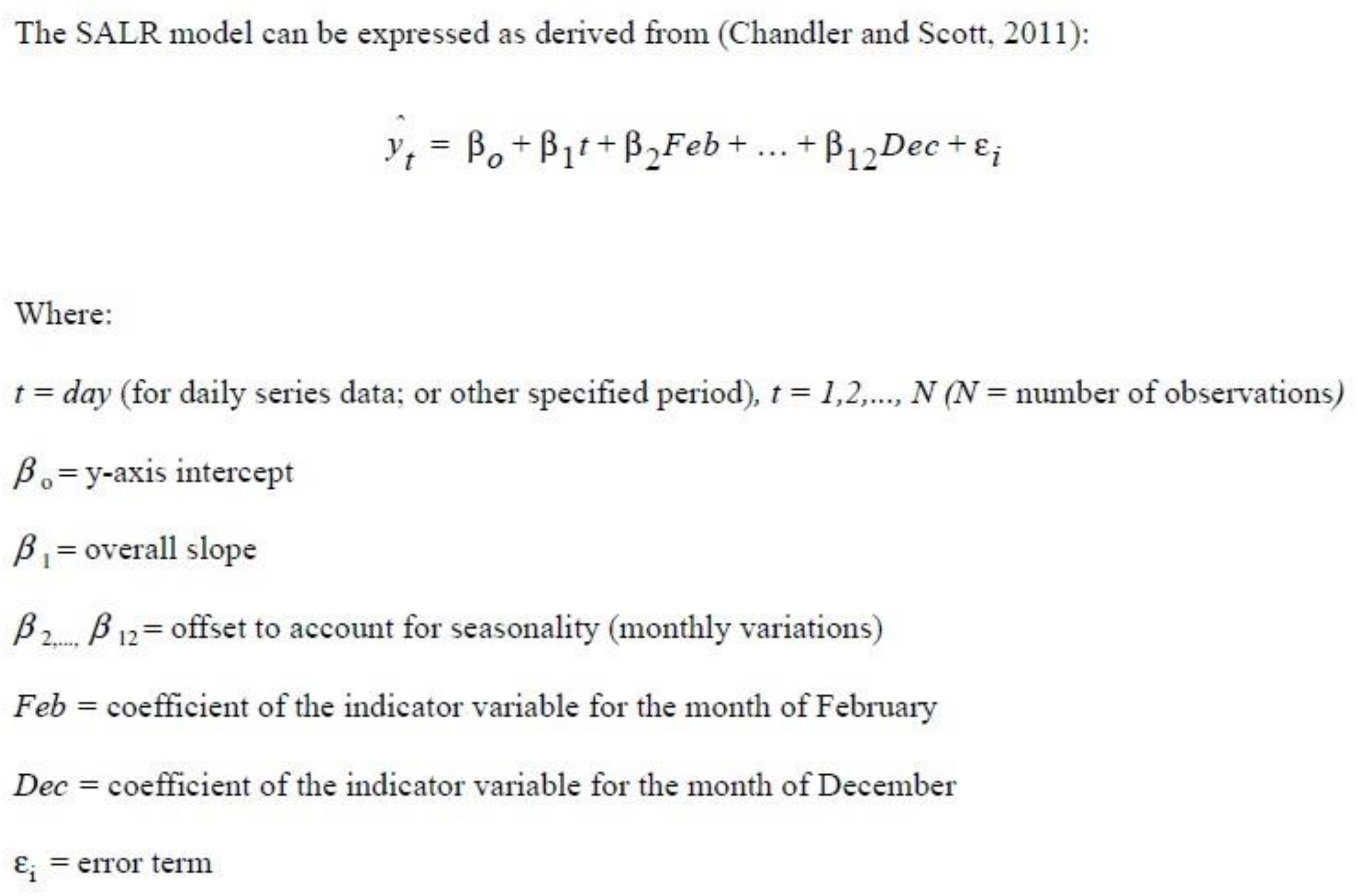
A.1.3 Seasonally Adjusted Linear Regression Method

The seasonally adjusted linear regression (SALR) method is used to establish a trigger based upon the behavior of the baseline dataset. A linear regression is a method that can be used to construct a model to fit time-series data (Chandler and Scott, 2011). The method for fitting a regression line used here is the method of ordinary least-squares, which calculates a best-fit line for the observed data by minimizing the sum of the squares of the vertical deviations from each data point to the line. "Linear least squares regression is by far the most widely used modeling method. It is what most people mean when they say they have used "regression", "linear regression" or "least squares" to fit a model to their data."(NIST/SEMATECH, 2017)

Evaluating hydrologic time-series data using a linear regression model provides the ability to assess the trend of groundwater elevation or surface-water flow over a period of time and captures the aggregate effects of the natural and human induced processes on the baseline measurement data. For example, an observed trend at a hydrologic monitoring site may reflect the aggregate effects of climate variability, consumptive use of nearby phreatophytes or groundwater production unrelated to the SNWA GDP.

The baseline data will likely exhibit aggregate, seasonal trends related to natural hydrologic processes, (runoff from snow-melt or groundwater recharge), atmospheric conditions (barometric pressure), and gravitational oscillations (earth tides), as well as, recurring human induced affects (groundwater pumping during a growing season). The application of ordinary least squares in the SALR model uses a discrete variable approach to evaluate the statistical significance of monthly variability, making it a suitable method to evaluate seasonal trends.

SNWA Exh 507, p A-3



The SALR model can be expressed as derived from (Chandler and Scott, 2011):

$$\hat{y}_t = \beta_o + \beta_1 t + \beta_2 Feb + \ldots + \beta_{12} Dec + \varepsilon_i$$

Where:

t = *day* (for daily series data; or other specified period), $t = 1,2,\ldots, N$ (N = number of observations)

β_o = y-axis intercept

β_1 = overall slope

$\beta_{2,\ldots,}\ \beta_{12}$ = offset to account for seasonality (monthly variations)

Feb = coefficient of the indicator variable for the month of February

Dec = coefficient of the indicator variable for the month of December

ε_i = error term

SNWA Exh 507, p A-4

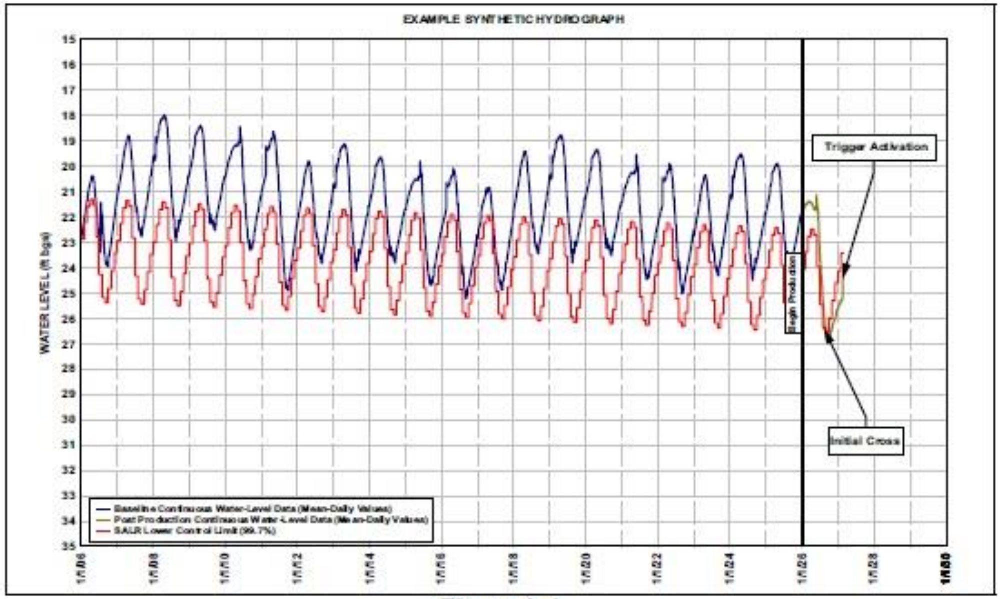


Figure A-1
Example of Trigger Activation - Strong Seasonality

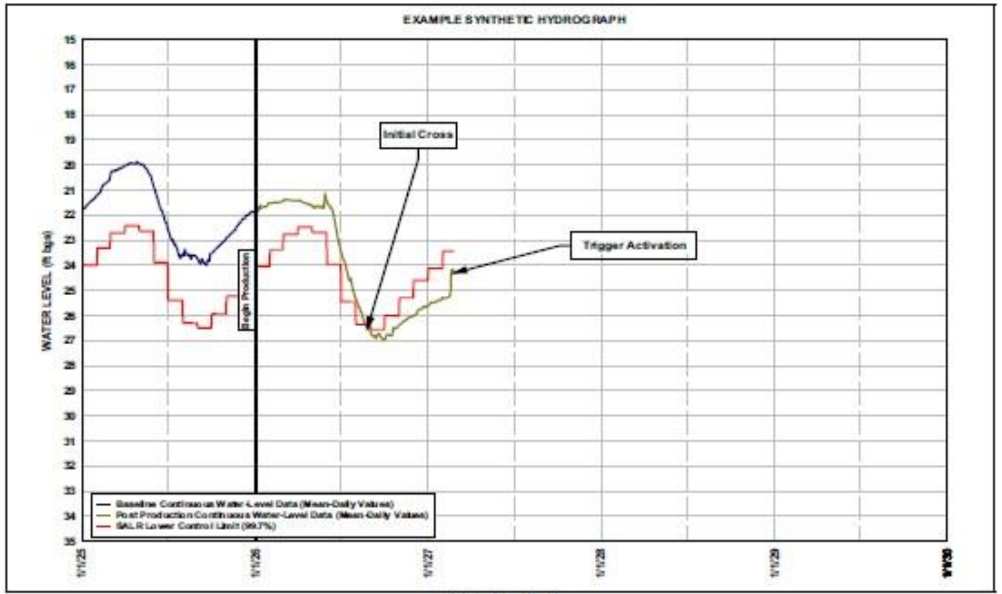


Figure A-2
Example of Trigger Activation Close up of Figure A-3

SNWA Exh 507, p A-7

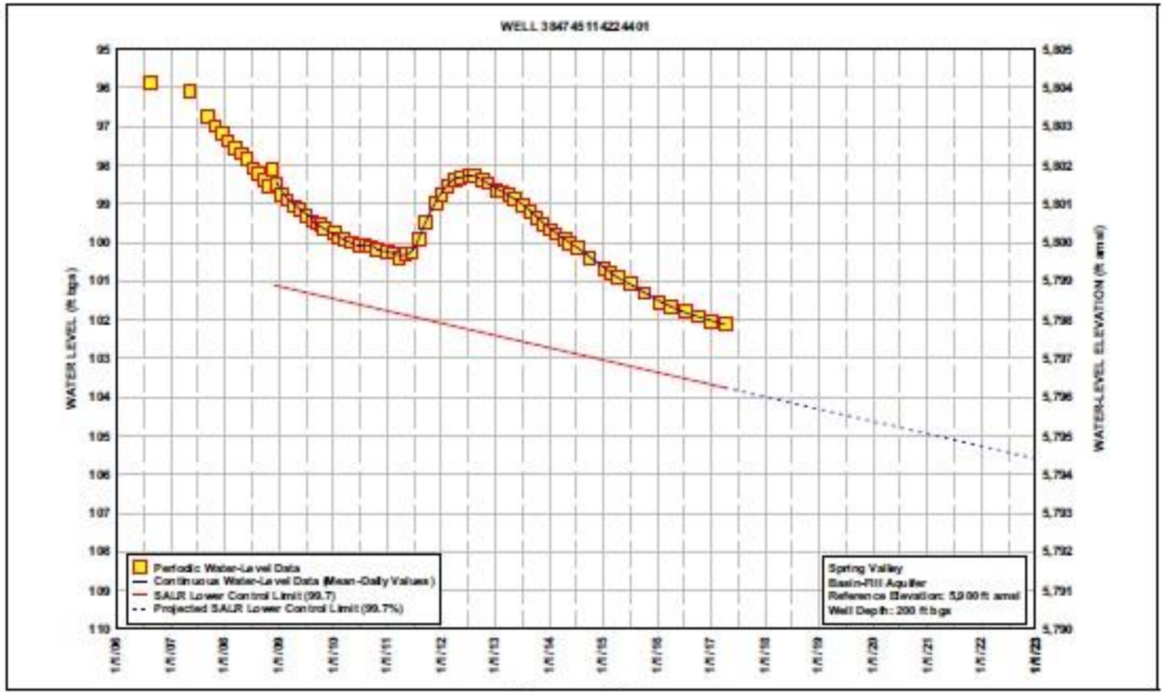


Figure C-9
Trigger, Well 384745114224401, Spring Valley Block 1

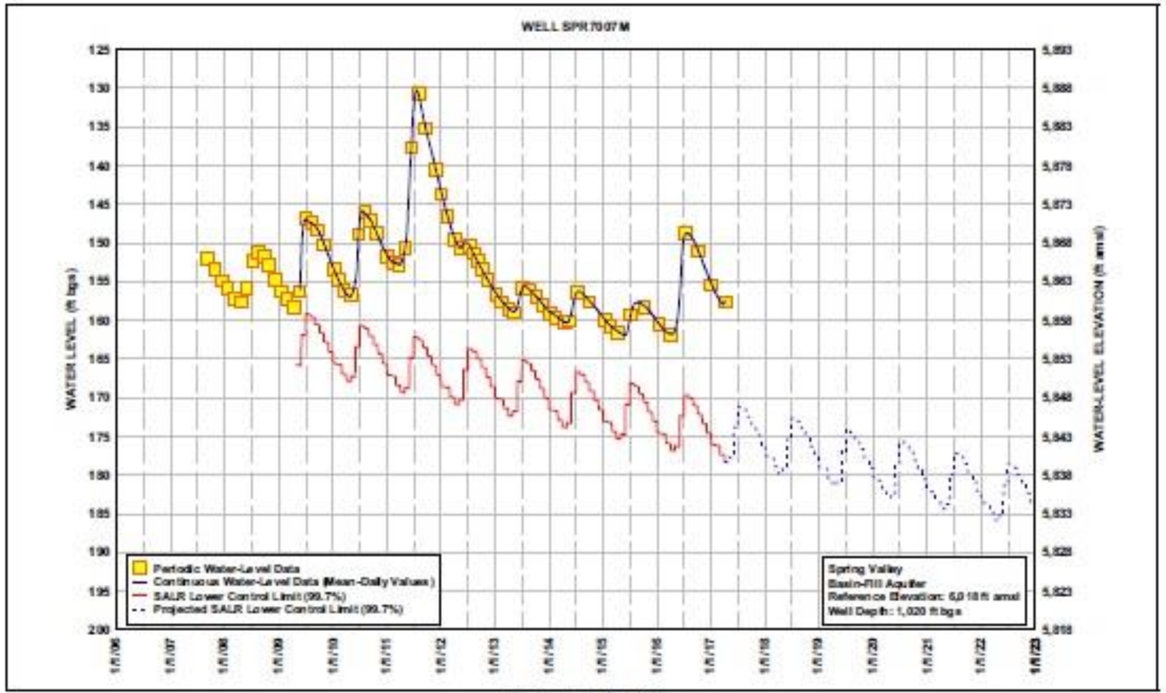
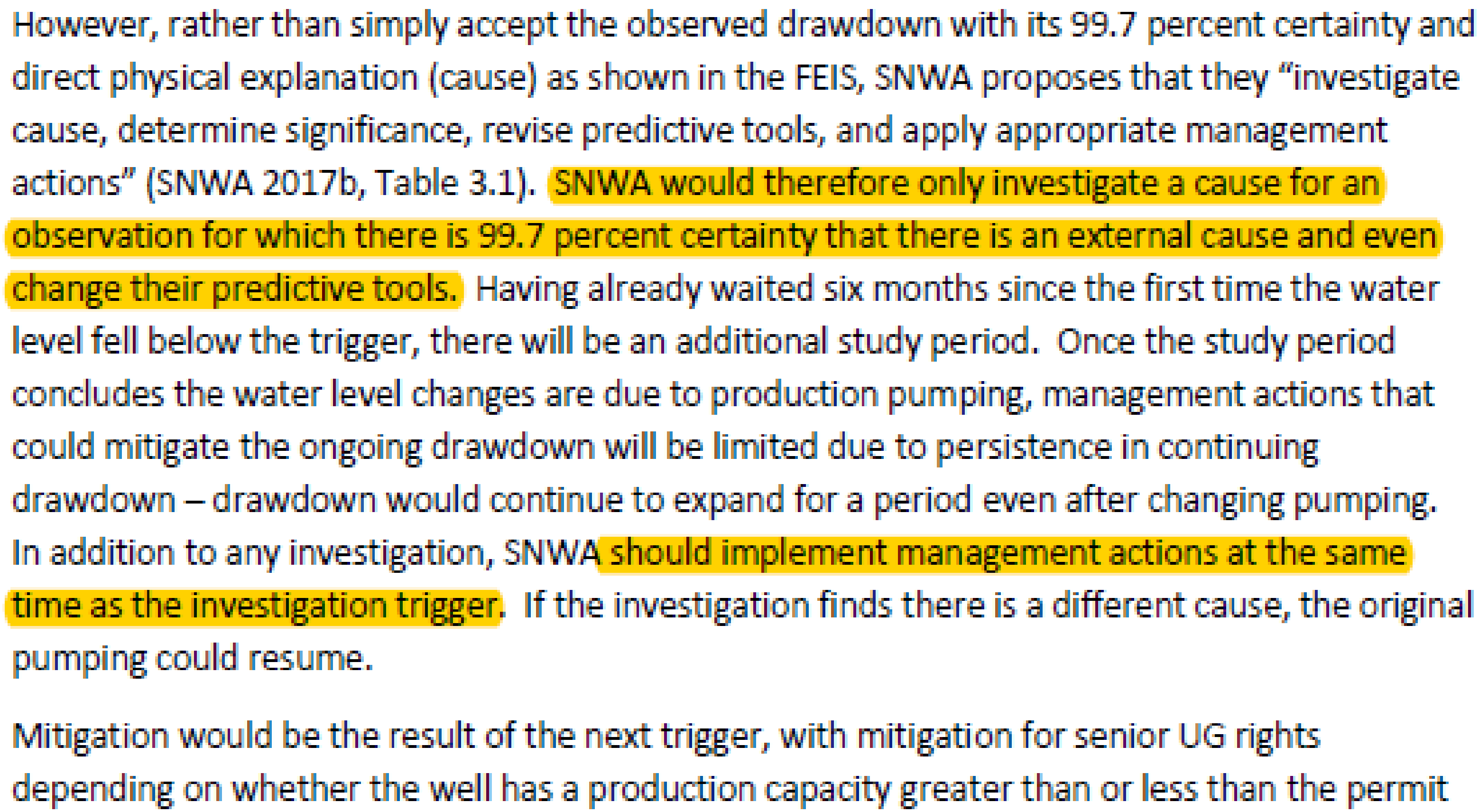


Figure C-17
Trigger, Well SPR7007M, Spring Valley Block 1

SNWA Exh 507, p C-7, C-11



However, rather than simply accept the observed drawdown with its 99.7 percent certainty and direct physical explanation (cause) as shown in the FEIS, SNWA proposes that they "investigate cause, determine significance, revise predictive tools, and apply appropriate management actions" (SNWA 2017b, Table 3.1). SNWA would therefore only investigate a cause for an observation for which there is 99.7 percent certainty that there is an external cause and even change their predictive tools. Having already waited six months since the first time the water level fell below the trigger, there will be an additional study period. Once the study period concludes the water level changes are due to production pumping, management actions that could mitigate the ongoing drawdown will be limited due to persistence in continuing drawdown – drawdown would continue to expand for a period even after changing pumping. In addition to any investigation, SNWA should implement management actions at the same time as the investigation trigger. If the investigation finds there is a different cause, the original pumping could resume.

Mitigation would be the result of the next trigger, with mitigation for senior UG rights depending on whether the well has a production capacity greater than or less than the permit

GBWN Exh_297, p 43

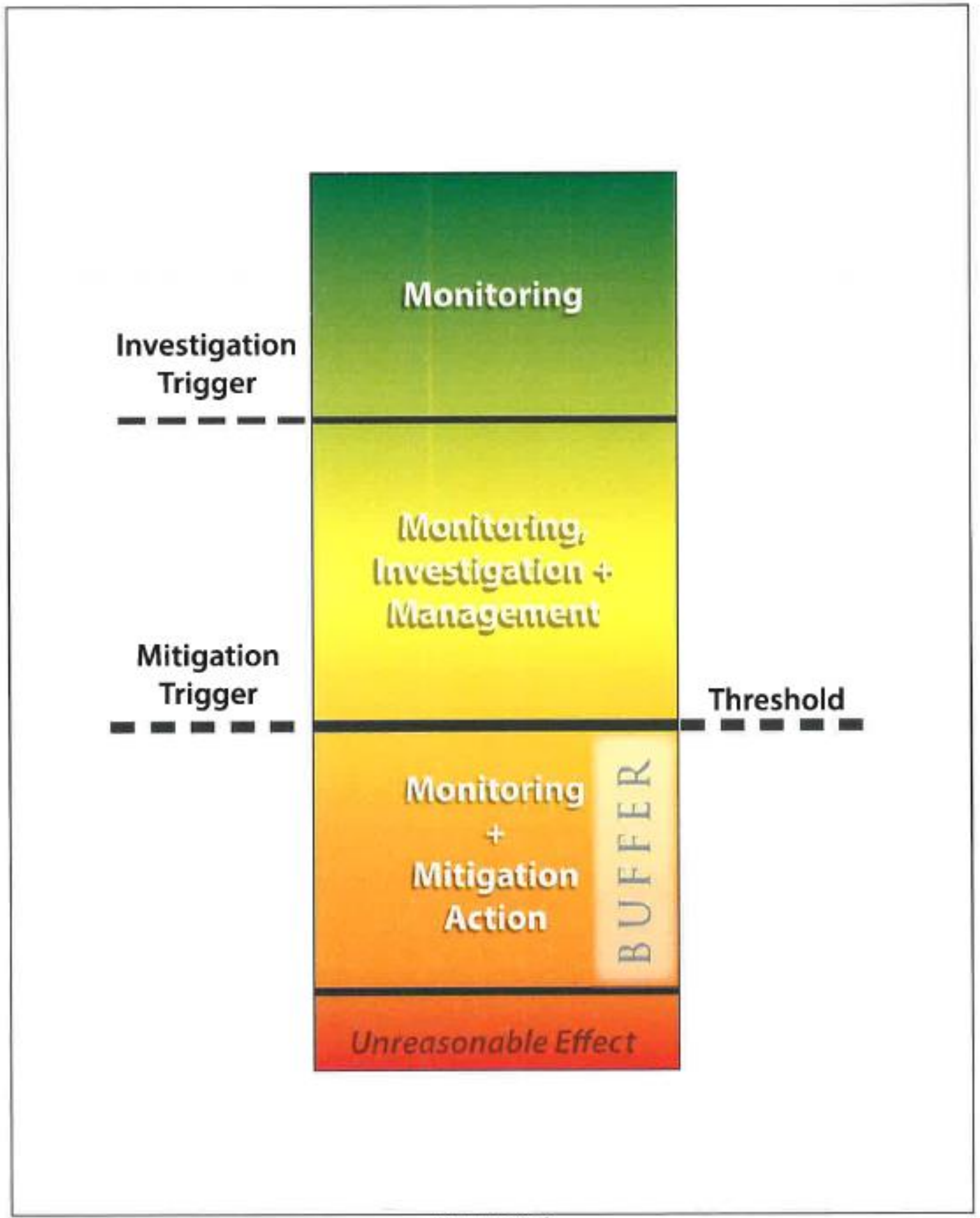
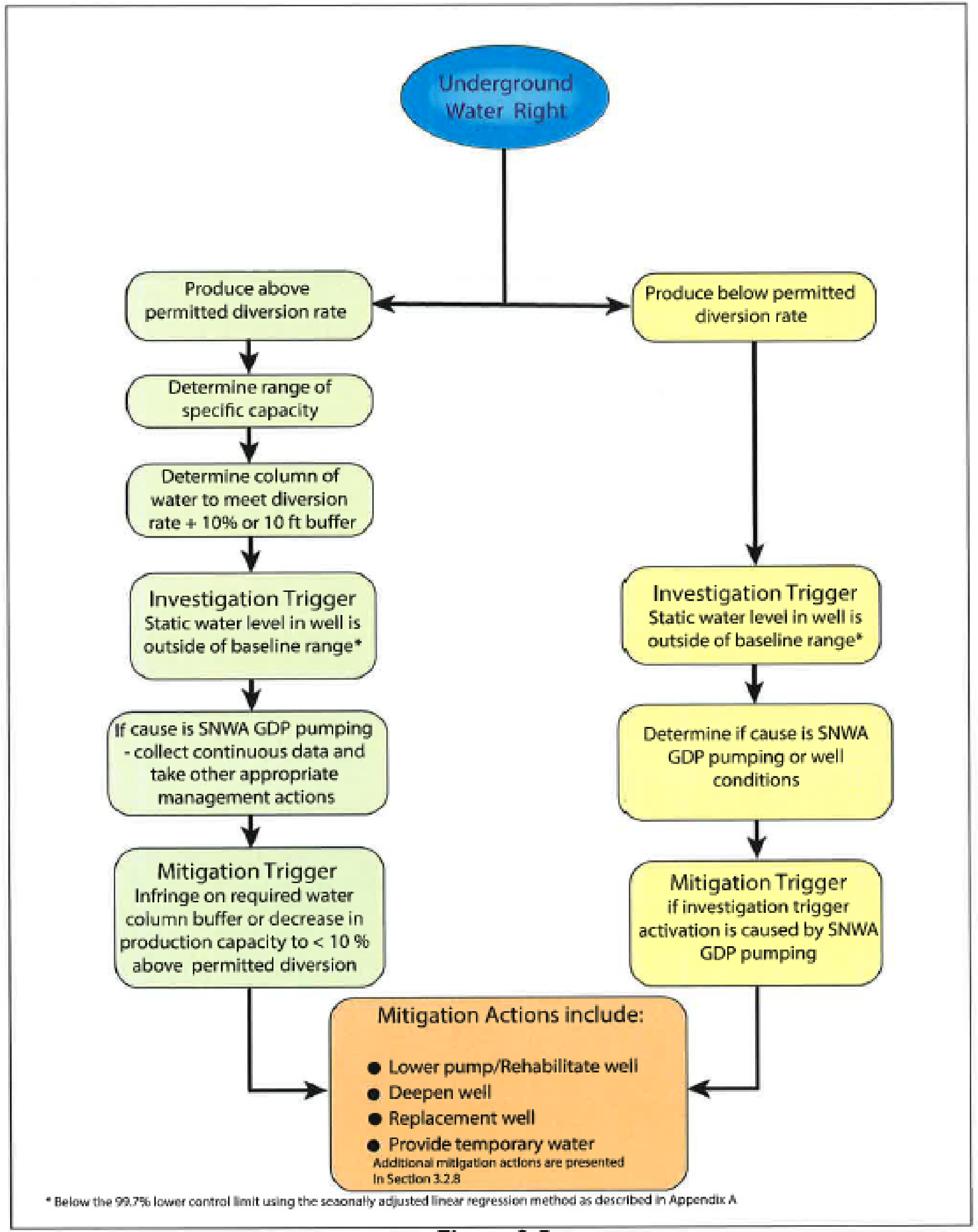


Figure 3-1
Threshold, Trigger, and Monitoring, Management, and Mitigation Approach

SNWA Exh 507, p 5-3

SNWA Exh_507, p 3-22


Underground Water Right

Produce above permitted diversion rate

Determine range of specific capacity

Determine column of water to meet diversion rate + 10% or 10 ft buffer

Investigation Trigger
Static water level in well is outside of baseline range*

If cause is SNWA GDP pumping - collect continuous data and take other appropriate management actions

Mitigation Trigger
Infringe on required water column buffer or decrease in production capacity to < 10 % above permitted diversion

Produce below permitted diversion rate

Investigation Trigger
Static water level in well is outside of baseline range*

Determine if cause is SNWA GDP pumping or well conditions

Mitigation Trigger
if investigation trigger activation is caused by SNWA GDP pumping

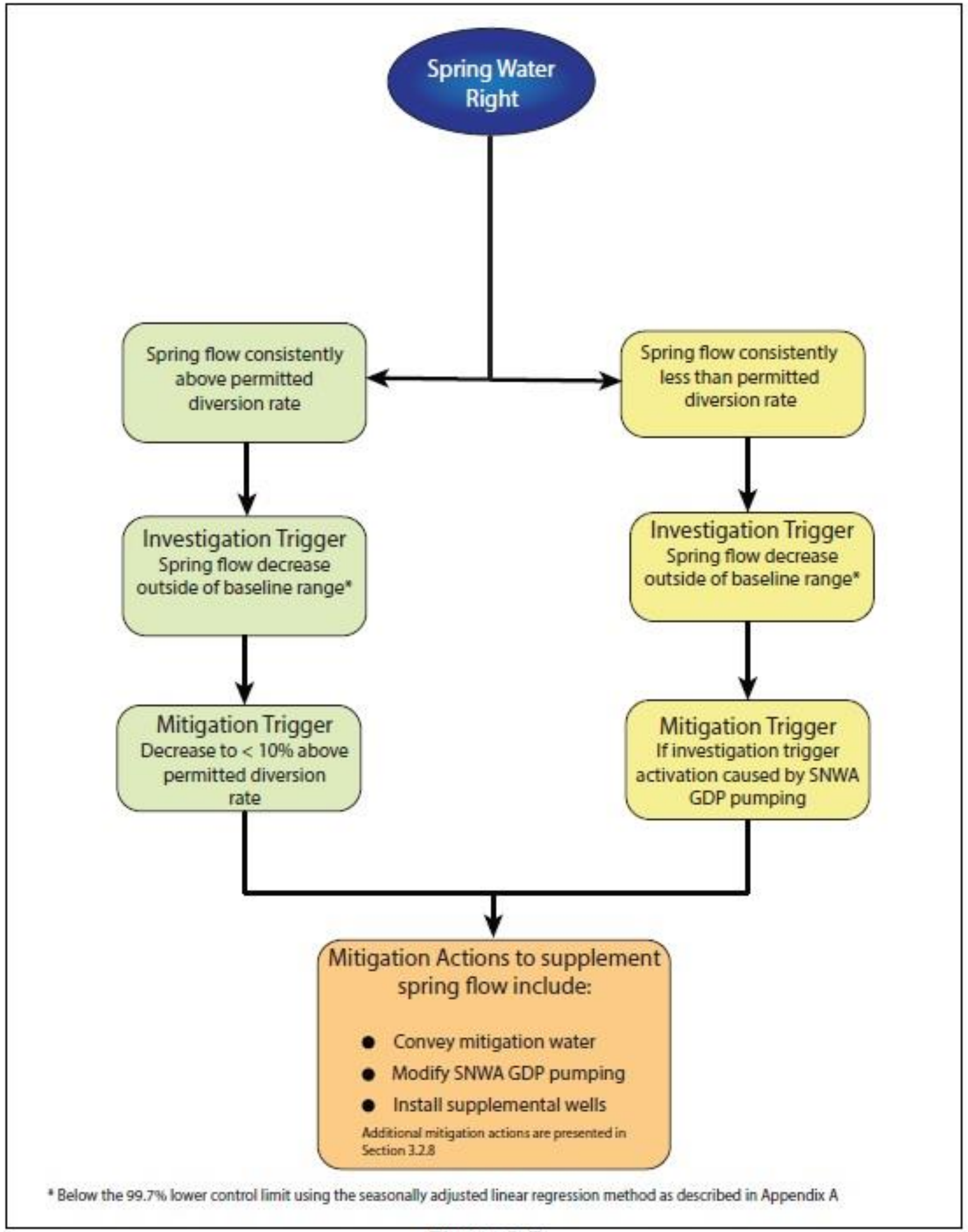
Mitigation Actions include:

- Lower pump/Rehabilitate well
- Deepen well
- Replacement well
- Provide temporary water

Additional mitigation actions are presented in Section 3.2.8

* Below the 99.7% lower control limit using the seasonally adjusted linear regression method as described in Appendix A

Figure 3-5
Management and Mitigation Flow Chart for Senior Underground Water Right

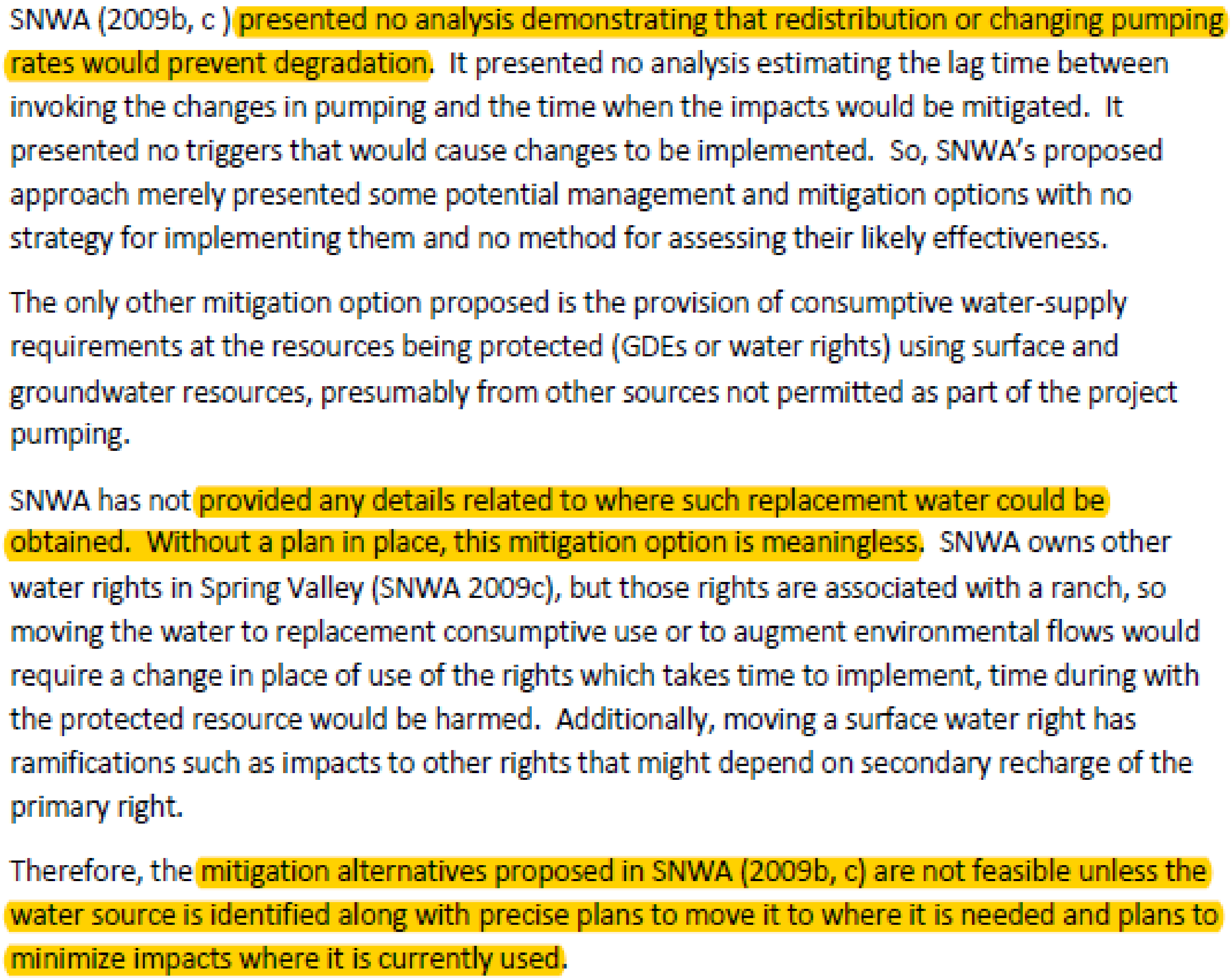


* Below the 99.7% lower control limit using the seasonally adjusted linear regression method as described in Appendix A

Figure 3-7
Management and Mitigation Flow Chart for Senior Spring or Stream Water Right

SNWA Exh_507, p 3-26

GBWN Exh_281, p 79



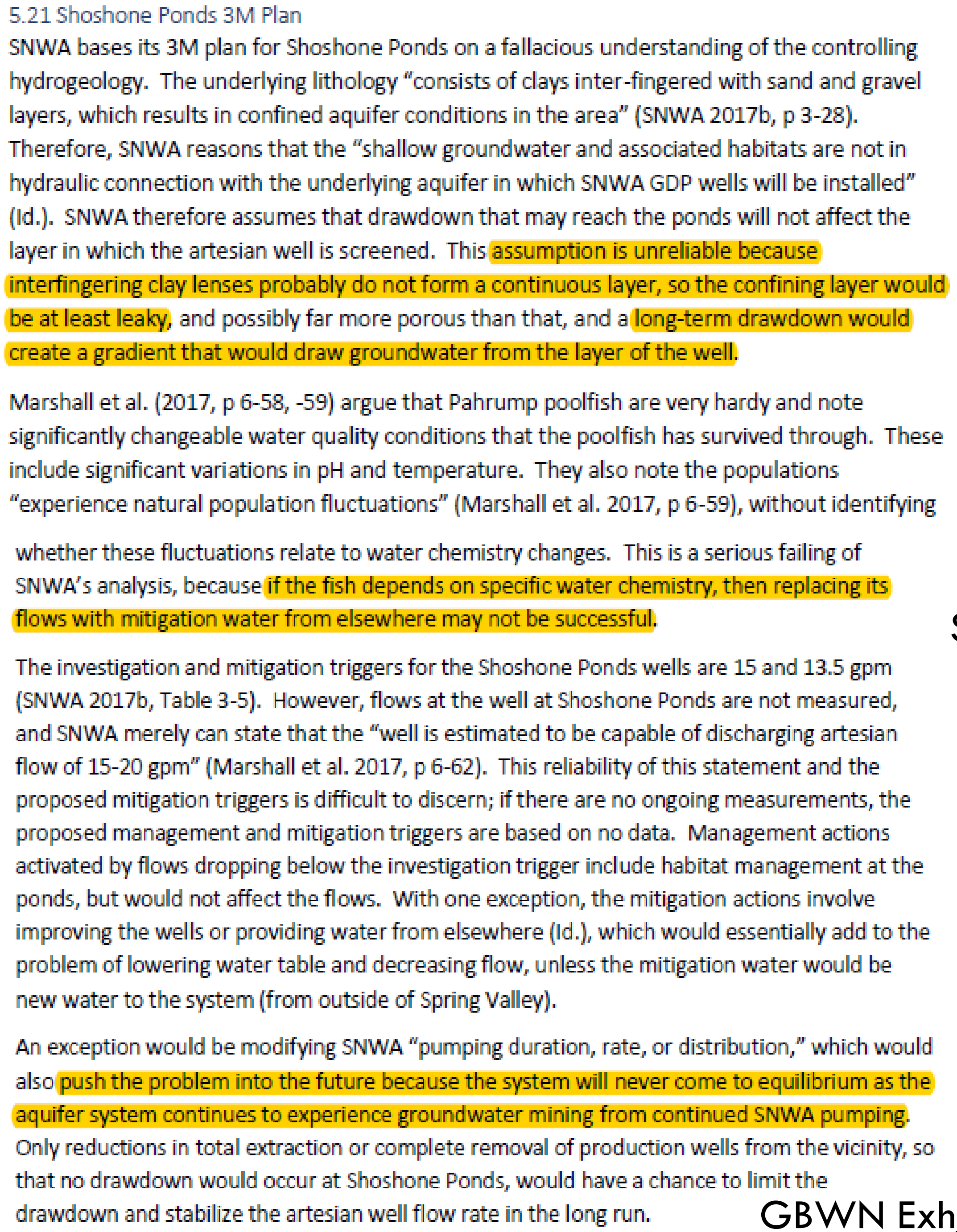
SNWA (2009b, c) presented no analysis demonstrating that redistribution or changing pumping rates would prevent degradation. It presented no analysis estimating the lag time between invoking the changes in pumping and the time when the impacts would be mitigated. It presented no triggers that would cause changes to be implemented. So, SNWA's proposed approach merely presented some potential management and mitigation options with no strategy for implementing them and no method for assessing their likely effectiveness.

The only other mitigation option proposed is the provision of consumptive water-supply requirements at the resources being protected (GDEs or water rights) using surface and groundwater resources, presumably from other sources not permitted as part of the project pumping.

SNWA has not provided any details related to where such replacement water could be obtained. Without a plan in place, this mitigation option is meaningless. SNWA owns other water rights in Spring Valley (SNWA 2009c), but those rights are associated with a ranch, so moving the water to replacement consumptive use or to augment environmental flows would require a change in place of use of the rights which takes time to implement, time during with the protected resource would be harmed. Additionally, moving a surface water right has ramifications such as impacts to other rights that might depend on secondary recharge of the primary right.

Therefore, the mitigation alternatives proposed in SNWA (2009b, c) are not feasible unless the water source is identified along with precise plans to move it to where it is needed and plans to minimize impacts where it is currently used.

SNWA_507



5.21 Shoshone Ponds 3M Plan

SNWA bases its 3M plan for Shoshone Ponds on a fallacious understanding of the controlling hydrogeology. The underlying lithology "consists of clays inter-fingered with sand and gravel layers, which results in confined aquifer conditions in the area" (SNWA 2017b, p 3-28). Therefore, SNWA reasons that the "shallow groundwater and associated habitats are not in hydraulic connection with the underlying aquifer in which SNWA GDP wells will be installed" (Id.). SNWA therefore assumes that drawdown that may reach the ponds will not affect the layer in which the artesian well is screened. This assumption is unreliable because interfingering clay lenses probably do not form a continuous layer, so the confining layer would be at least leaky, and possibly far more porous than that, and a long-term drawdown would create a gradient that would draw groundwater from the layer of the well.

Marshall et al. (2017, p 6-58, -59) argue that Pahrump poolfish are very hardy and note significantly changeable water quality conditions that the poolfish has survived through. These include significant variations in pH and temperature. They also note the populations "experience natural population fluctuations" (Marshall et al. 2017, p 6-59), without identifying

whether these fluctuations relate to water chemistry changes. This is a serious failing of SNWA's analysis, because if the fish depends on specific water chemistry, then replacing its flows with mitigation water from elsewhere may not be successful.

The investigation and mitigation triggers for the Shoshone Ponds wells are 15 and 13.5 gpm (SNWA 2017b, Table 3-5). However, flows at the well at Shoshone Ponds are not measured, and SNWA merely can state that the "well is estimated to be capable of discharging artesian flow of 15-20 gpm" (Marshall et al. 2017, p 6-62). This reliability of this statement and the proposed mitigation triggers is difficult to discern; if there are no ongoing measurements, the proposed management and mitigation triggers are based on no data. Management actions activated by flows dropping below the investigation trigger include habitat management at the ponds, but would not affect the flows. With one exception, the mitigation actions involve improving the wells or providing water from elsewhere (Id.), which would essentially add to the problem of lowering water table and decreasing flow, unless the mitigation water would be new water to the system (from outside of Spring Valley).

An exception would be modifying SNWA "pumping duration, rate, or distribution," which would also push the problem into the future because the system will never come to equilibrium as the aquifer system continues to experience groundwater mining from continued SNWA pumping. Only reductions in total extraction or complete removal of production wells from the vicinity, so that no drawdown would occur at Shoshone Ponds, would have a chance to limit the drawdown and stabilize the artesian well flow rate in the long run.

GBWN Exh_297, p 46, 47

SNWA Exh_507, p 6-78

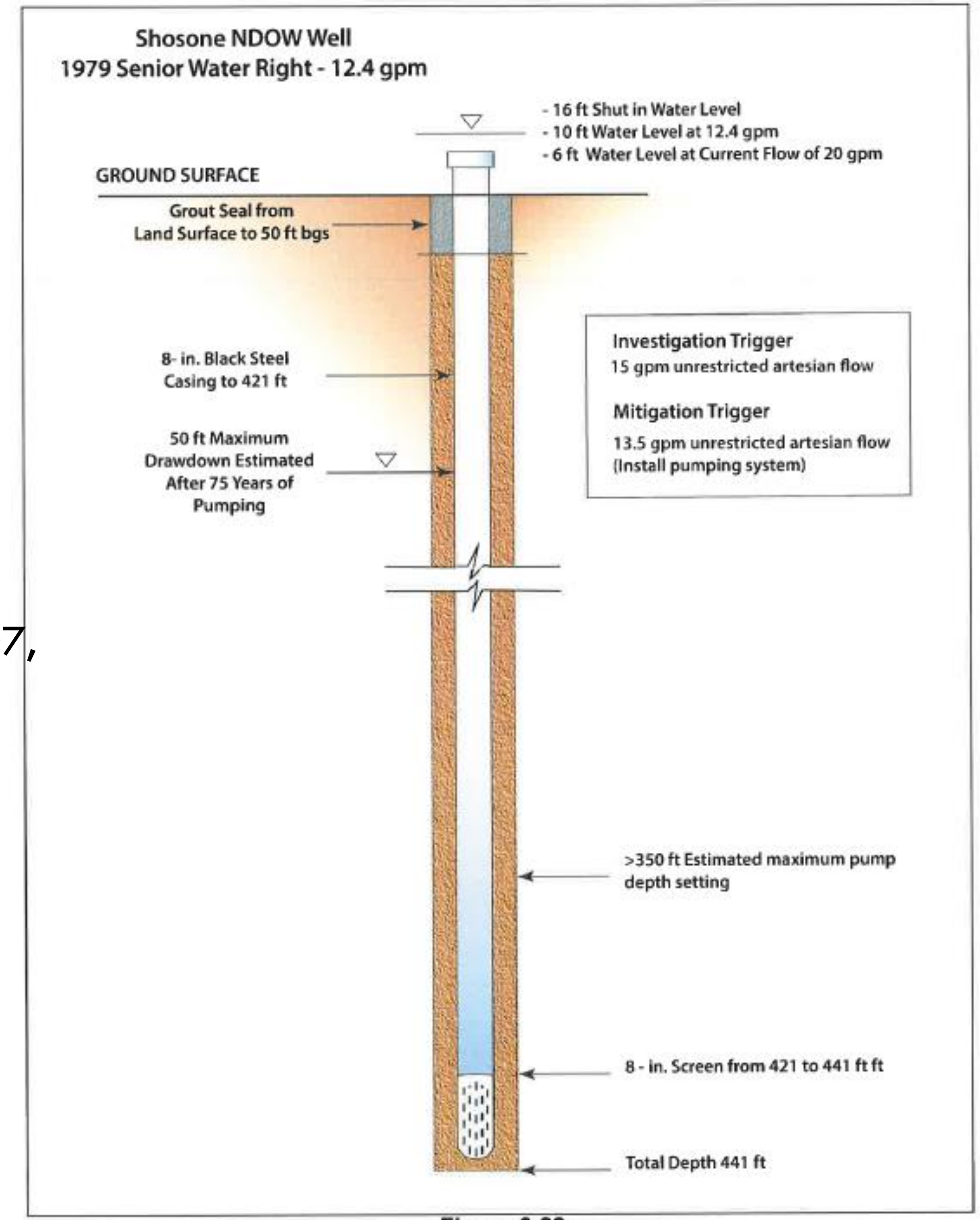
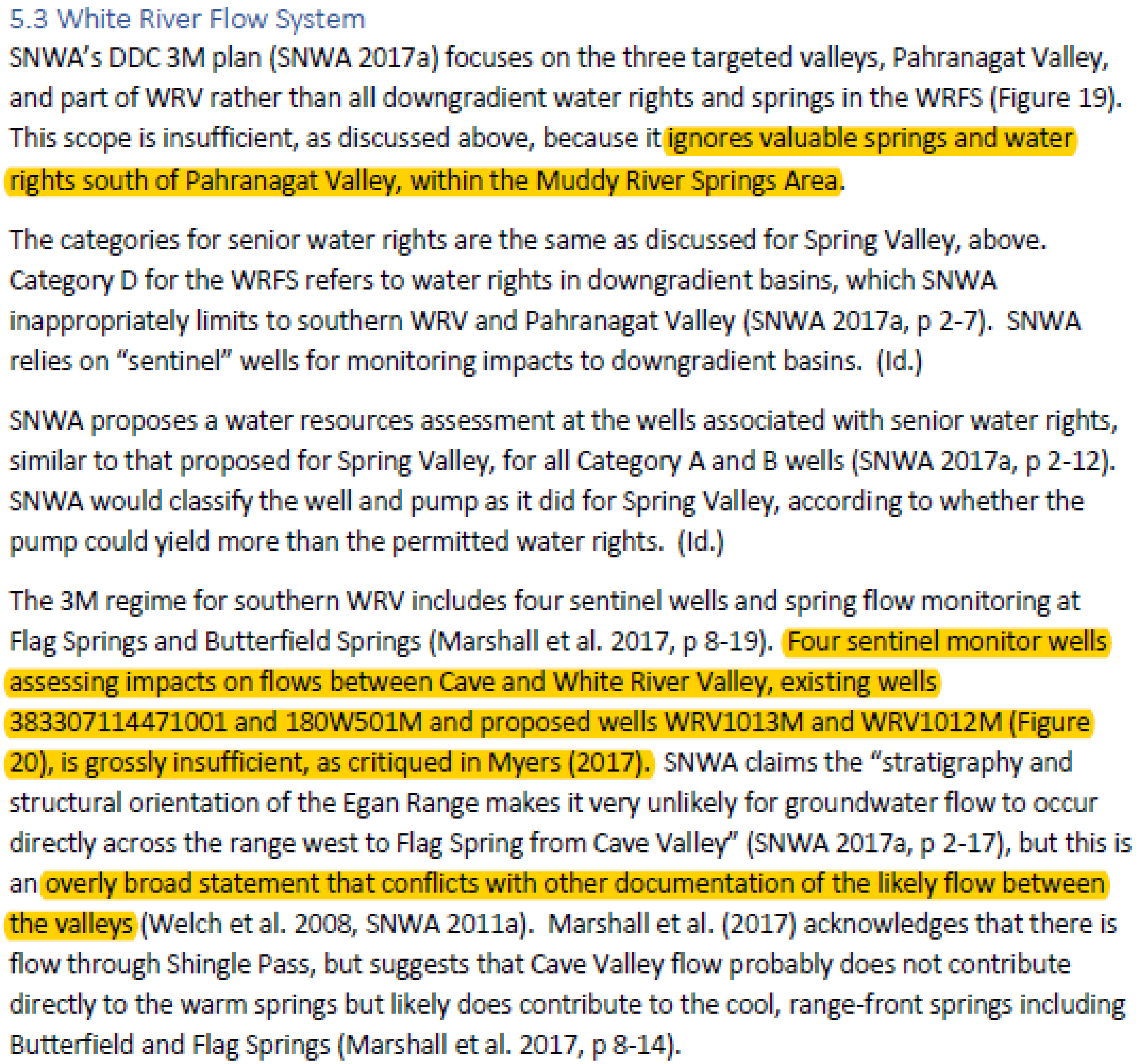


Figure 6-39
Shoshone NDOW Well Construction Schematic and Management Plan



5.3 White River Flow System

SNWA's DDC 3M plan (SNWA 2017a) focuses on the three targeted valleys, Pahranagat Valley, and part of WRV rather than all downgradient water rights and springs in the WRFS (Figure 19). This scope is insufficient, as discussed above, because it ignores valuable springs and water rights south of Pahranagat Valley, within the Muddy River Springs Area.

The categories for senior water rights are the same as discussed for Spring Valley, above. Category D for the WRFS refers to water rights in downgradient basins, which SNWA inappropriately limits to southern WRV and Pahranagat Valley (SNWA 2017a, p 2-7). SNWA relies on "sentinel" wells for monitoring impacts to downgradient basins. (Id.)

SNWA proposes a water resources assessment at the wells associated with senior water rights, similar to that proposed for Spring Valley, for all Category A and B wells (SNWA 2017a, p 2-12). SNWA would classify the well and pump as it did for Spring Valley, according to whether the pump could yield more than the permitted water rights. (Id.)

The 3M regime for southern WRV includes four sentinel wells and spring flow monitoring at Flag Springs and Butterfield Springs (Marshall et al. 2017, p 8-19). Four sentinel monitor wells assessing impacts on flows between Cave and White River Valley, existing wells 383307114471001 and 180W501M and proposed wells WRV1013M and WRV1012M (Figure 20), is grossly insufficient, as critiqued in Myers (2017). SNWA claims the "stratigraphy and structural orientation of the Egan Range makes it very unlikely for groundwater flow to occur directly across the range west to Flag Spring from Cave Valley" (SNWA 2017a, p 2-17), but this is an overly broad statement that conflicts with other documentation of the likely flow between the valleys (Welch et al. 2008, SNWA 2011a). Marshall et al. (2017) acknowledges that there is flow through Shingle Pass, but suggests that Cave Valley flow probably does not contribute directly to the warm springs but likely does contribute to the cool, range-front springs including Butterfield and Flag Springs (Marshall et al. 2017, p 8-14).

GBWN Exh_297, p 49

GBWN Exh_297, p 53

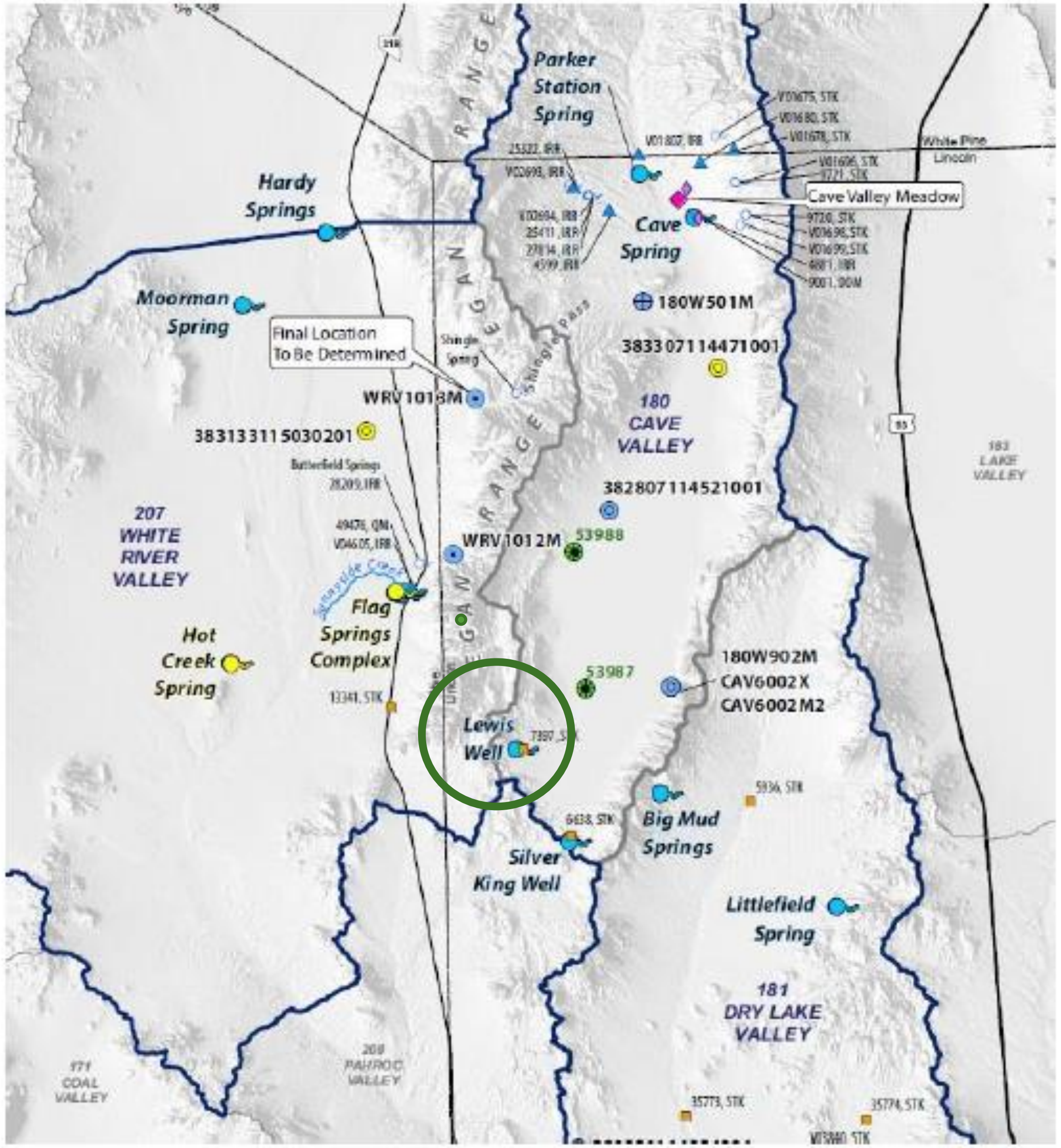
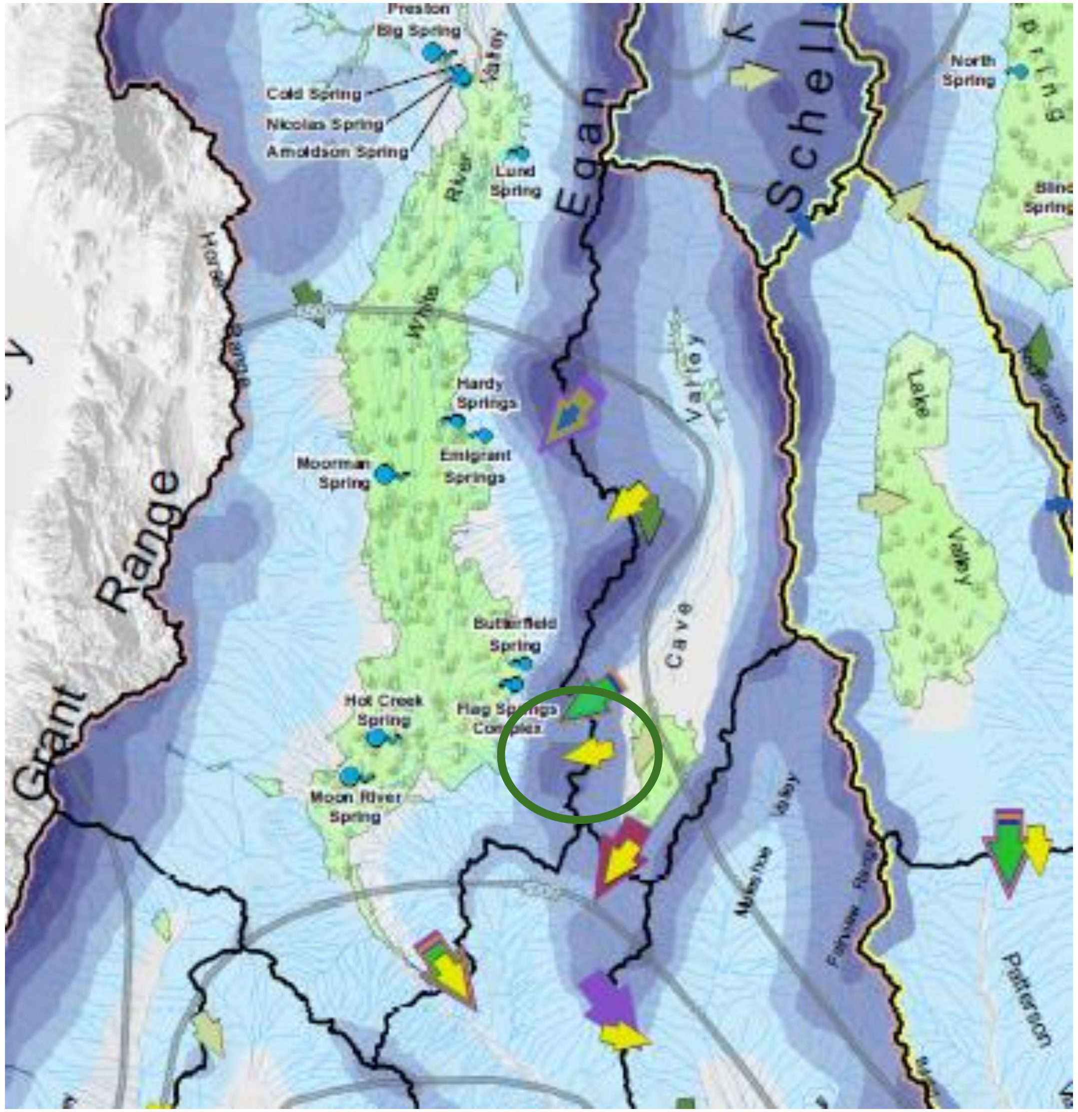
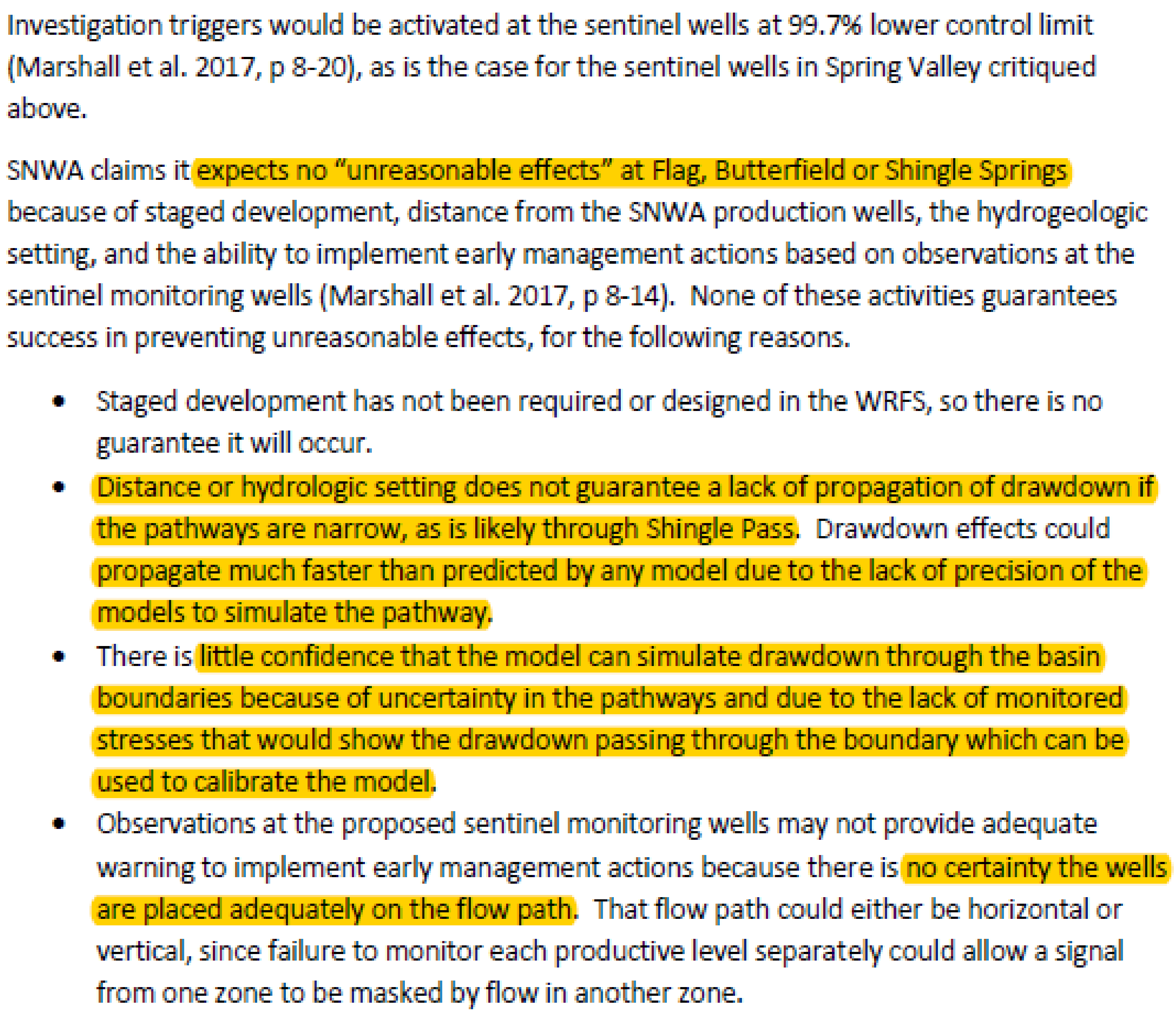


Figure 20: Portion of SNWA (2017a) Figure 2-4 showing springs, monitoring points, and points of diversion in White River Valley, Cave Valley, and Dry Lake Valley.

GBWN Exh_281, portion Figure 16, p 28





Investigation triggers would be activated at the sentinel wells at 99.7% lower control limit (Marshall et al. 2017, p 8-20), as is the case for the sentinel wells in Spring Valley critiqued above.

SNWA claims it expects no "unreasonable effects" at Flag, Butterfield or Shingle Springs because of staged development, distance from the SNWA production wells, the hydrogeologic setting, and the ability to implement early management actions based on observations at the sentinel monitoring wells (Marshall et al. 2017, p 8-14). None of these activities guarantees success in preventing unreasonable effects, for the following reasons.

- Staged development has not been required or designed in the WRFS, so there is no guarantee it will occur.
- Distance or hydrologic setting does not guarantee a lack of propagation of drawdown if the pathways are narrow, as is likely through Shingle Pass. Drawdown effects could propagate much faster than predicted by any model due to the lack of precision of the models to simulate the pathway.
- There is little confidence that the model can simulate drawdown through the basin boundaries because of uncertainty in the pathways and due to the lack of monitored stresses that would show the drawdown passing through the boundary which can be used to calibrate the model.
- Observations at the proposed sentinel monitoring wells may not provide adequate warning to implement early management actions because there is no certainty the wells are placed adequately on the flow path. That flow path could either be horizontal or vertical, since failure to monitor each productive level separately could allow a signal from one zone to be masked by flow in another zone.

GBWN Exh_297, p 51

SNWA Exh 507, p 9-16

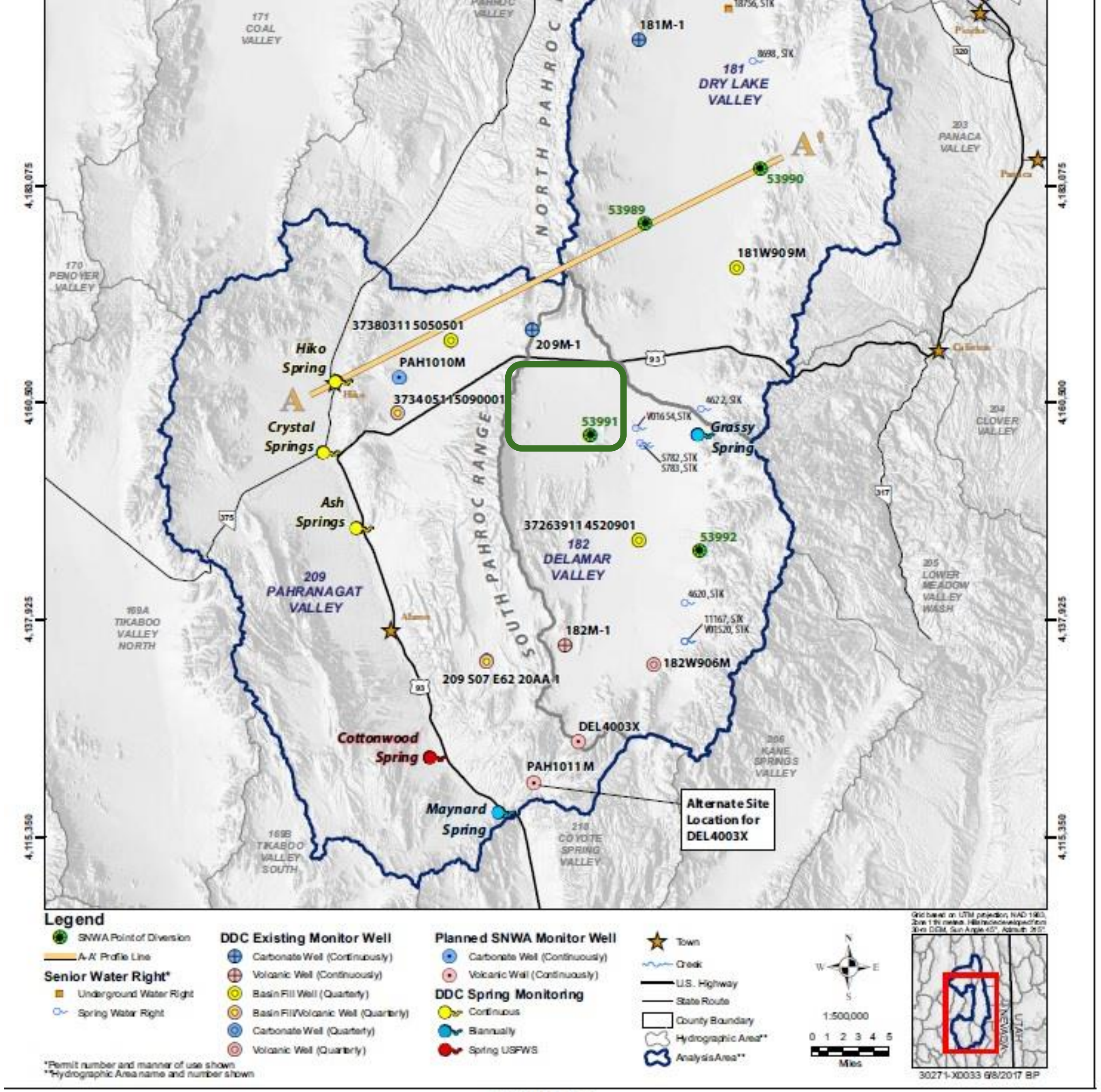


Figure 9-3
Geologic and Monitor Well Profile Location

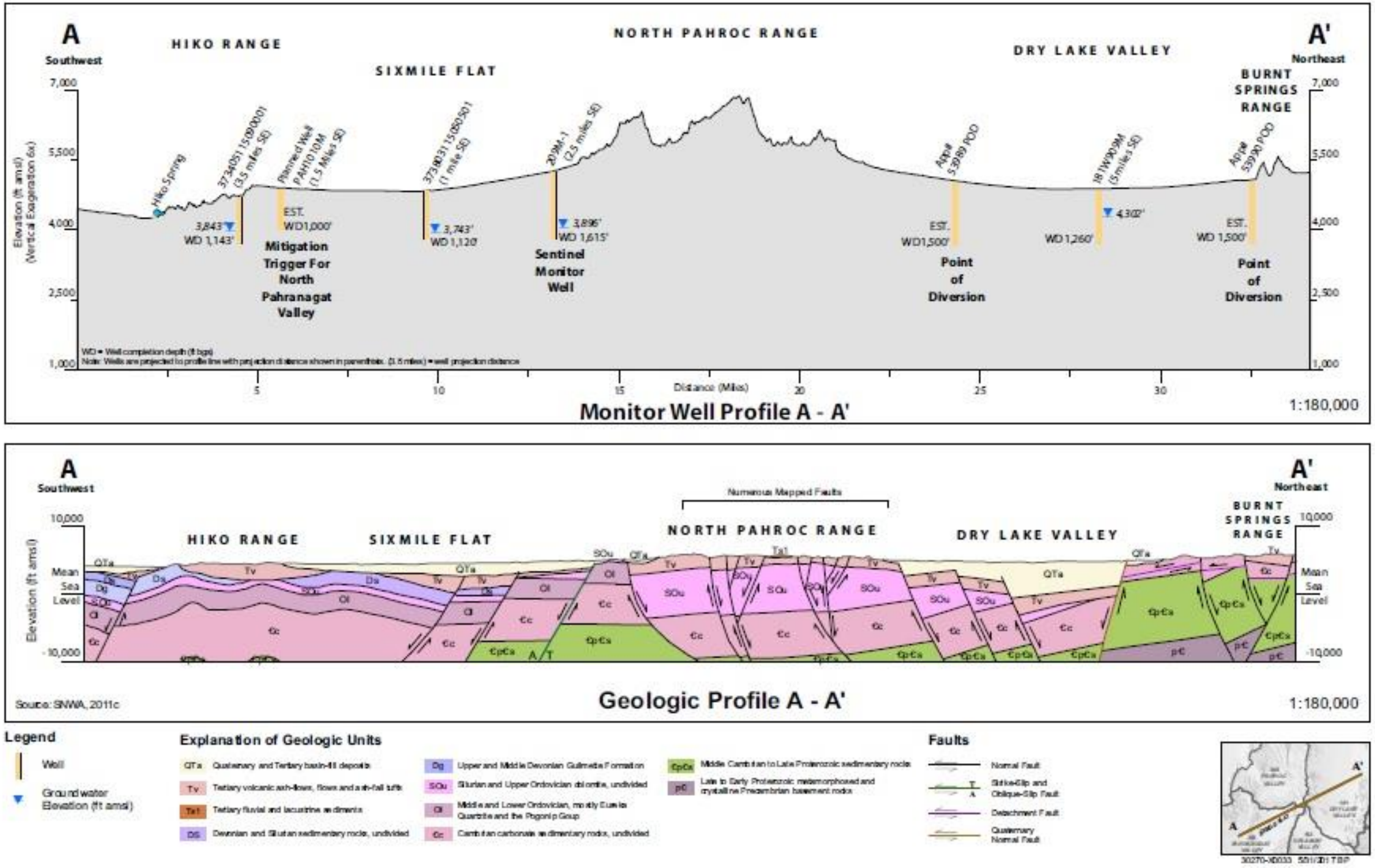


Figure 9-4
Geologic and Monitor Well Profile - Dry Lake PODs to Hiko Spring

SNWA Exhibit 507, p 9-17

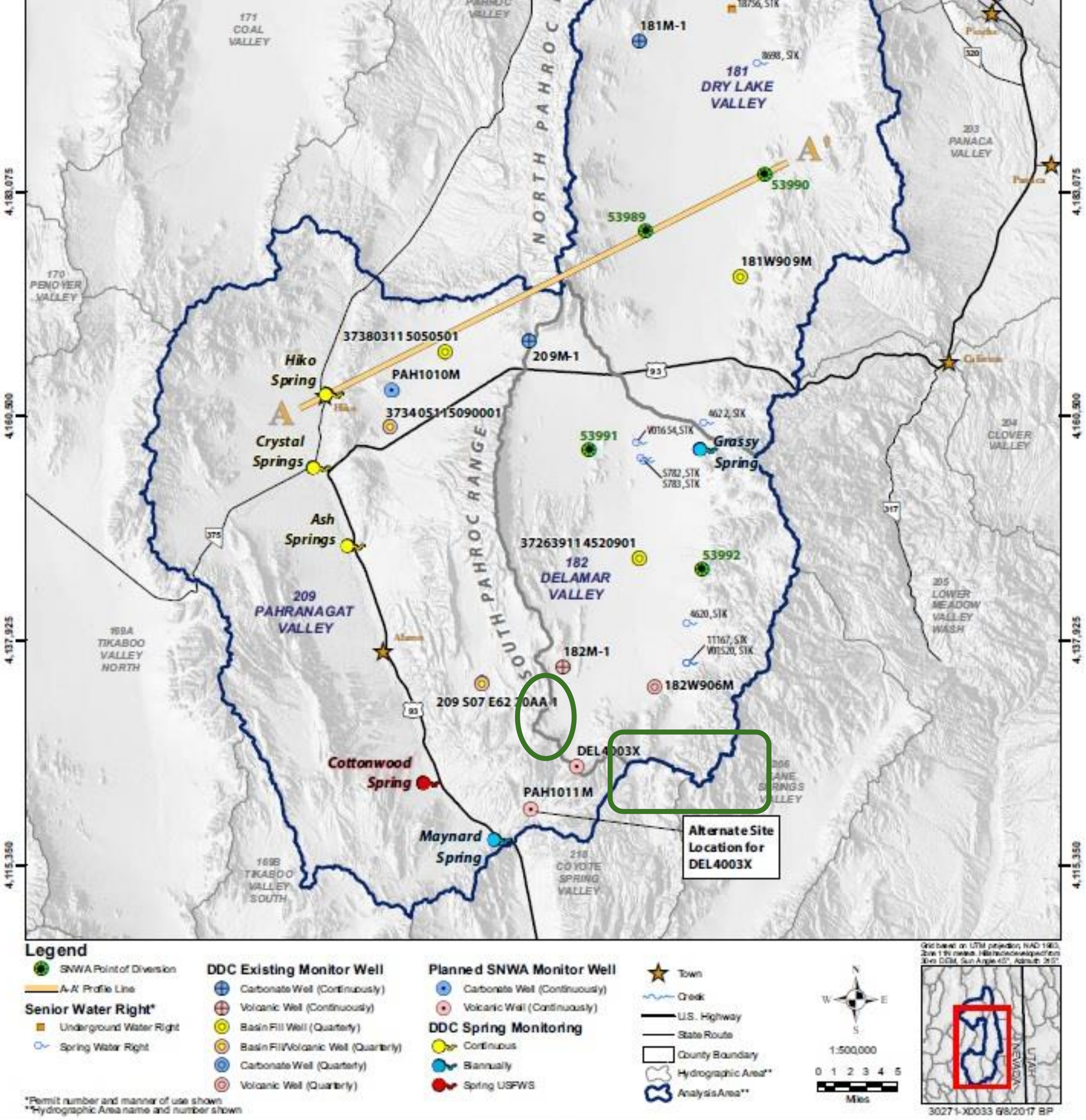
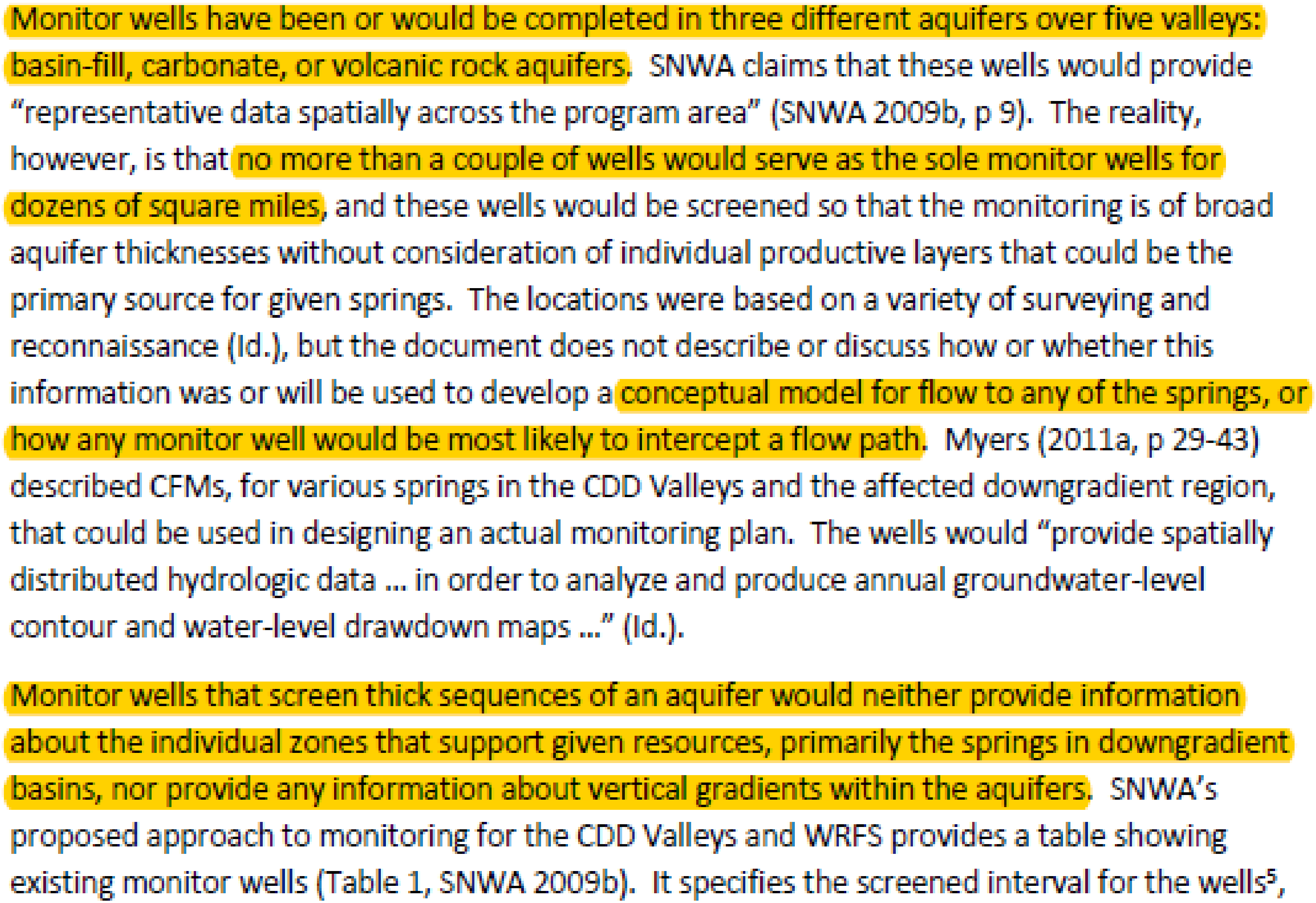


Figure 9-3
Geologic and Monitor Well Profile Location

SNWA Exh 507, p 9-16

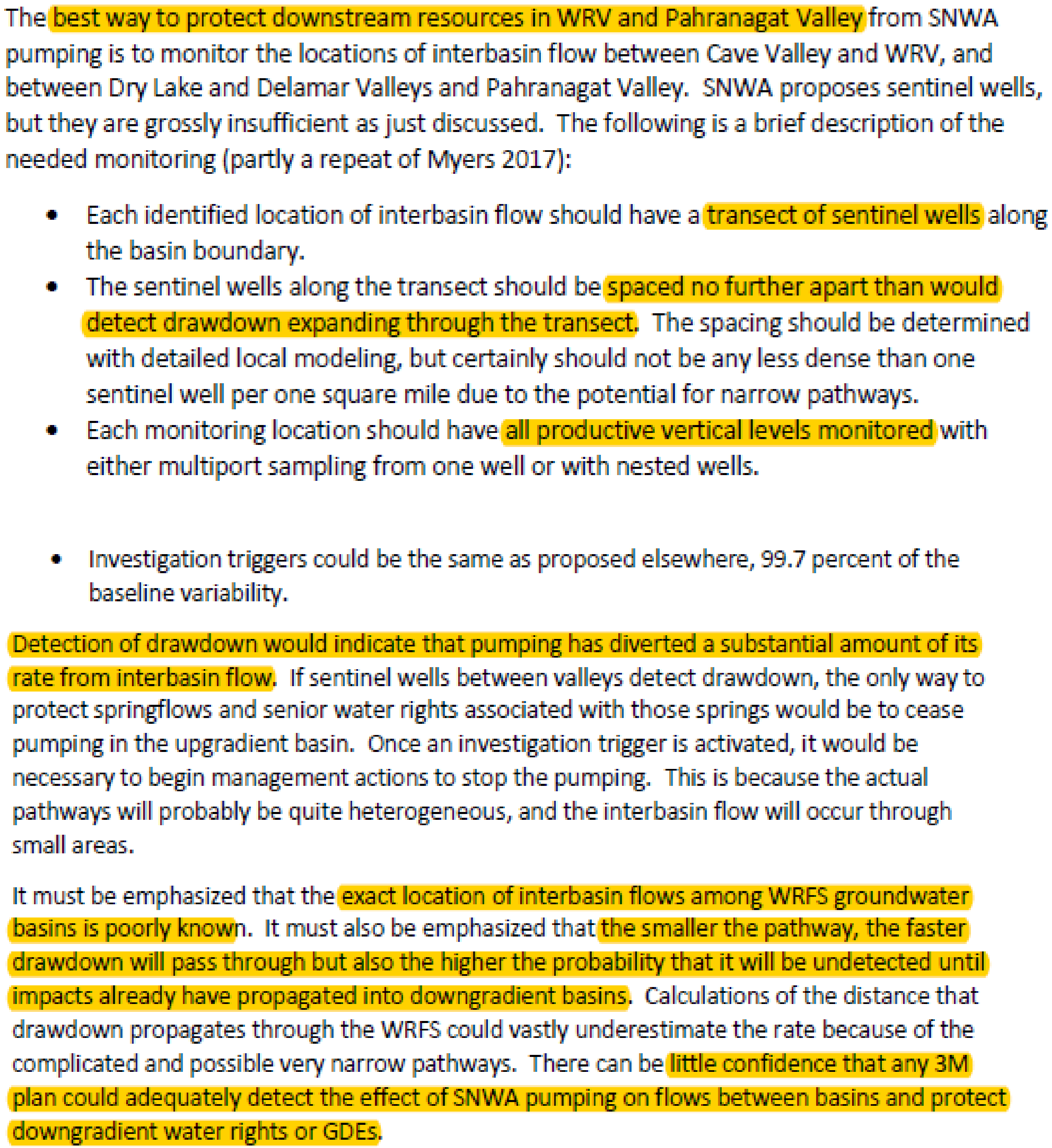
SNWA Exh 507



Monitor wells have been or would be completed in three different aquifers over five valleys: basin-fill, carbonate, or volcanic rock aquifers. SNWA claims that these wells would provide "representative data spatially across the program area" (SNWA 2009b, p 9). The reality, however, is that no more than a couple of wells would serve as the sole monitor wells for dozens of square miles, and these wells would be screened so that the monitoring is of broad aquifer thicknesses without consideration of individual productive layers that could be the primary source for given springs. The locations were based on a variety of surveying and reconnaissance (Id.), but the document does not describe or discuss how or whether this information was or will be used to develop a conceptual model for flow to any of the springs, or how any monitor well would be most likely to intercept a flow path. Myers (2011a, p 29-43) described CFMs, for various springs in the CDD Valleys and the affected downgradient region, that could be used in designing an actual monitoring plan. The wells would "provide spatially distributed hydrologic data … in order to analyze and produce annual groundwater-level contour and water-level drawdown maps …" (Id.).

Monitor wells that screen thick sequences of an aquifer would neither provide information about the individual zones that support given resources, primarily the springs in downgradient basins, nor provide any information about vertical gradients within the aquifers. SNWA's proposed approach to monitoring for the CDD Valleys and WRFS provides a table showing existing monitor wells (Table 1, SNWA 2009b). It specifies the screened interval for the wells[5],

GBWN Exh_281, p 76



The best way to protect downstream resources in WRV and Pahranagat Valley from SNWA pumping is to monitor the locations of interbasin flow between Cave Valley and WRV, and between Dry Lake and Delamar Valleys and Pahranagat Valley. SNWA proposes sentinel wells, but they are grossly insufficient as just discussed. The following is a brief description of the needed monitoring (partly a repeat of Myers 2017):

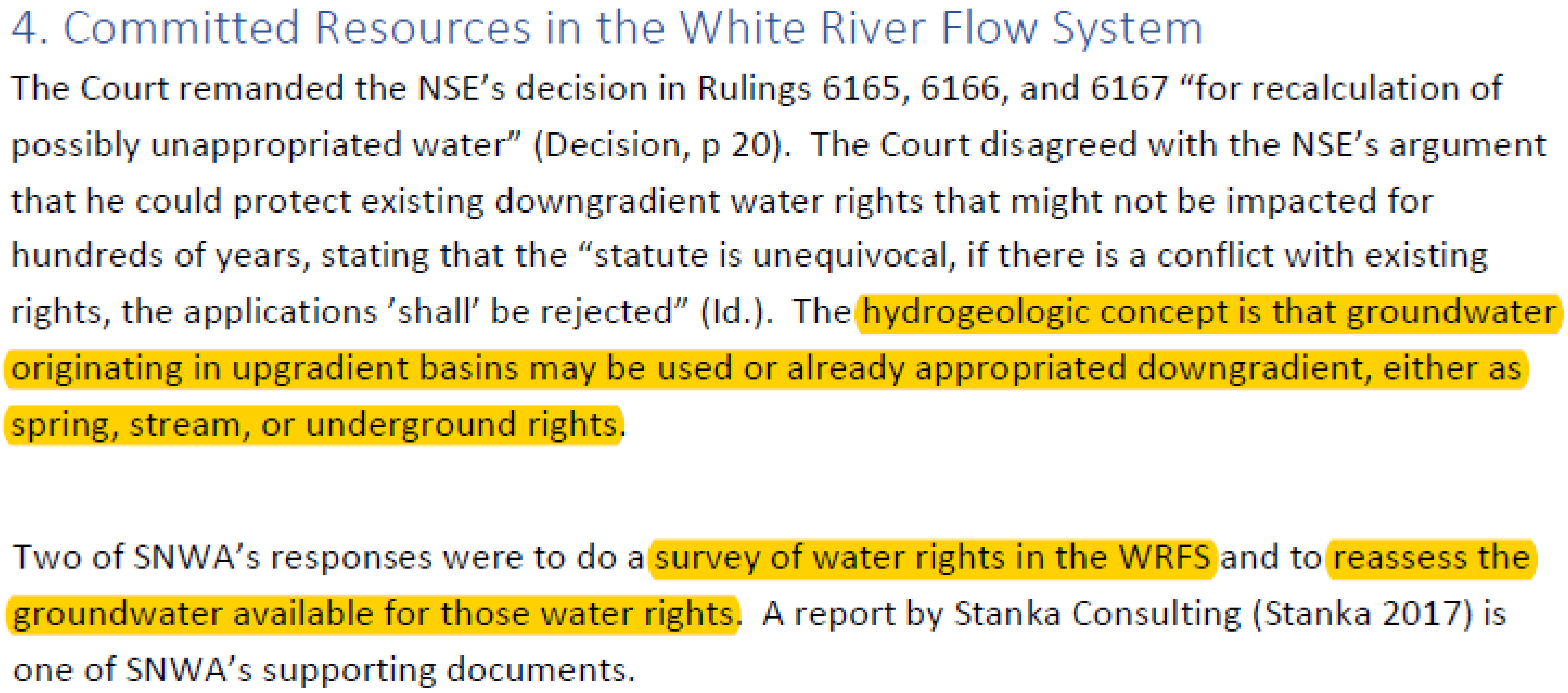
- Each identified location of interbasin flow should have a transect of sentinel wells along the basin boundary.
- The sentinel wells along the transect should be spaced no further apart than would detect drawdown expanding through the transect. The spacing should be determined with detailed local modeling, but certainly should not be any less dense than one sentinel well per one square mile due to the potential for narrow pathways.
- Each monitoring location should have all productive vertical levels monitored with either multiport sampling from one well or with nested wells.

- Investigation triggers could be the same as proposed elsewhere, 99.7 percent of the baseline variability.

Detection of drawdown would indicate that pumping has diverted a substantial amount of its rate from interbasin flow. If sentinel wells between valleys detect drawdown, the only way to protect springflows and senior water rights associated with those springs would be to cease pumping in the upgradient basin. Once an investigation trigger is activated, it would be necessary to begin management actions to stop the pumping. This is because the actual pathways will probably be quite heterogeneous, and the interbasin flow will occur through small areas.

It must be emphasized that the exact location of interbasin flows among WRFS groundwater basins is poorly known. It must also be emphasized that the smaller the pathway, the faster drawdown will pass through but also the higher the probability that it will be undetected until impacts already have propagated into downgradient basins. Calculations of the distance that drawdown propagates through the WRFS could vastly underestimate the rate because of the complicated and possible very narrow pathways. There can be little confidence that any 3M plan could adequately detect the effect of SNWA pumping on flows between basins and protect downgradient water rights or GDEs.

GBWN Exh_297, p 51, 52

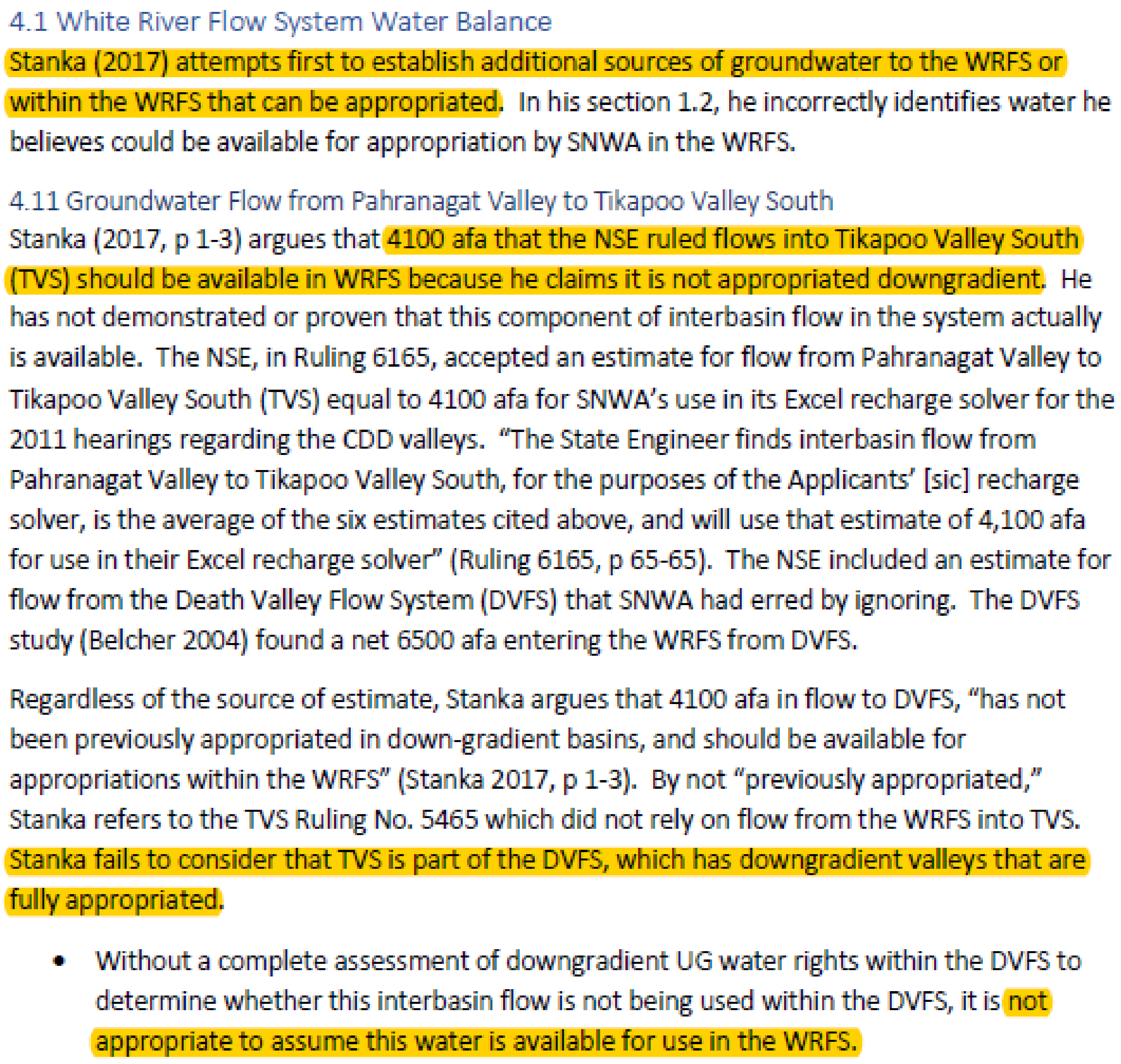


4. Committed Resources in the White River Flow System

The Court remanded the NSE's decision in Rulings 6165, 6166, and 6167 "for recalculation of possibly unappropriated water" (Decision, p 20). The Court disagreed with the NSE's argument that he could protect existing downgradient water rights that might not be impacted for hundreds of years, stating that the "statute is unequivocal, if there is a conflict with existing rights, the applications 'shall' be rejected" (Id.). The hydrogeologic concept is that groundwater originating in upgradient basins may be used or already appropriated downgradient, either as spring, stream, or underground rights.

Two of SNWA's responses were to do a survey of water rights in the WRFS and to reassess the groundwater available for those water rights. A report by Stanka Consulting (Stanka 2017) is one of SNWA's supporting documents.

GBWN Exh_297, p 13, 14



4.1 White River Flow System Water Balance

Stanka (2017) attempts first to establish additional sources of groundwater to the WRFS or within the WRFS that can be appropriated. In his section 1.2, he incorrectly identifies water he believes could be available for appropriation by SNWA in the WRFS.

4.11 Groundwater Flow from Pahranagat Valley to Tikapoo Valley South

Stanka (2017, p 1-3) argues that 4100 afa that the NSE ruled flows into Tikapoo Valley South (TVS) should be available in WRFS because he claims it is not appropriated downgradient. He has not demonstrated or proven that this component of interbasin flow in the system actually is available. The NSE, in Ruling 6165, accepted an estimate for flow from Pahranagat Valley to Tikapoo Valley South (TVS) equal to 4100 afa for SNWA's use in its Excel recharge solver for the 2011 hearings regarding the CDD valleys. "The State Engineer finds interbasin flow from Pahranagat Valley to Tikapoo Valley South, for the purposes of the Applicants' [sic] recharge solver, is the average of the six estimates cited above, and will use that estimate of 4,100 afa for use in their Excel recharge solver" (Ruling 6165, p 65-65). The NSE included an estimate for flow from the Death Valley Flow System (DVFS) that SNWA had erred by ignoring. The DVFS study (Belcher 2004) found a net 6500 afa entering the WRFS from DVFS.

Regardless of the source of estimate, Stanka argues that 4100 afa in flow to DVFS, "has not been previously appropriated in down-gradient basins, and should be available for appropriations within the WRFS" (Stanka 2017, p 1-3). By not "previously appropriated," Stanka refers to the TVS Ruling No. 5465 which did not rely on flow from the WRFS into TVS. Stanka fails to consider that TVS is part of the DVFS, which has downgradient valleys that are fully appropriated.

- Without a complete assessment of downgradient UG water rights within the DVFS to determine whether this interbasin flow is not being used within the DVFS, it is not appropriate to assume this water is available for use in the WRFS.

GBWN Exh_297, p 14

SNWA Exh 483, p 1-8

Committed Groundwater Resources within The White River Flow System

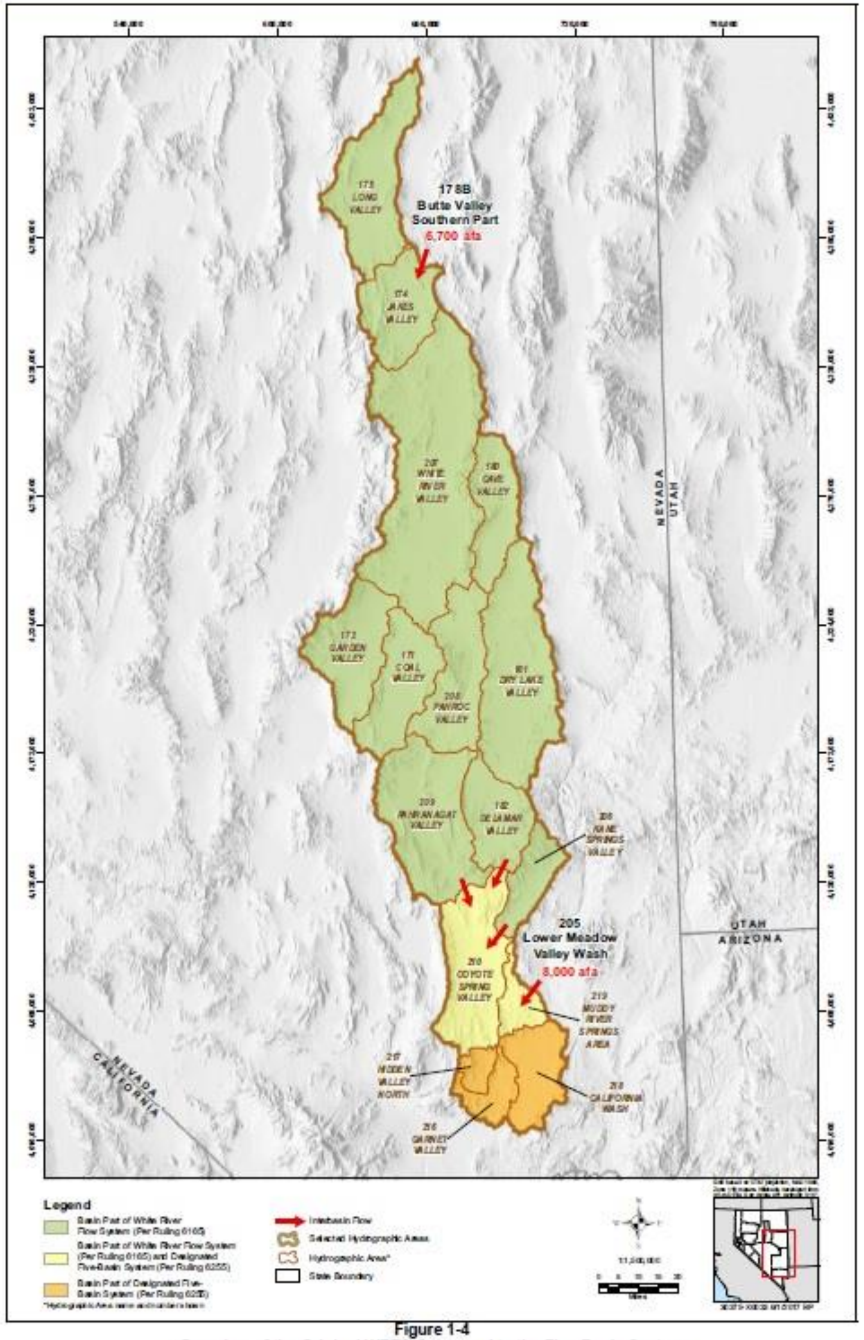
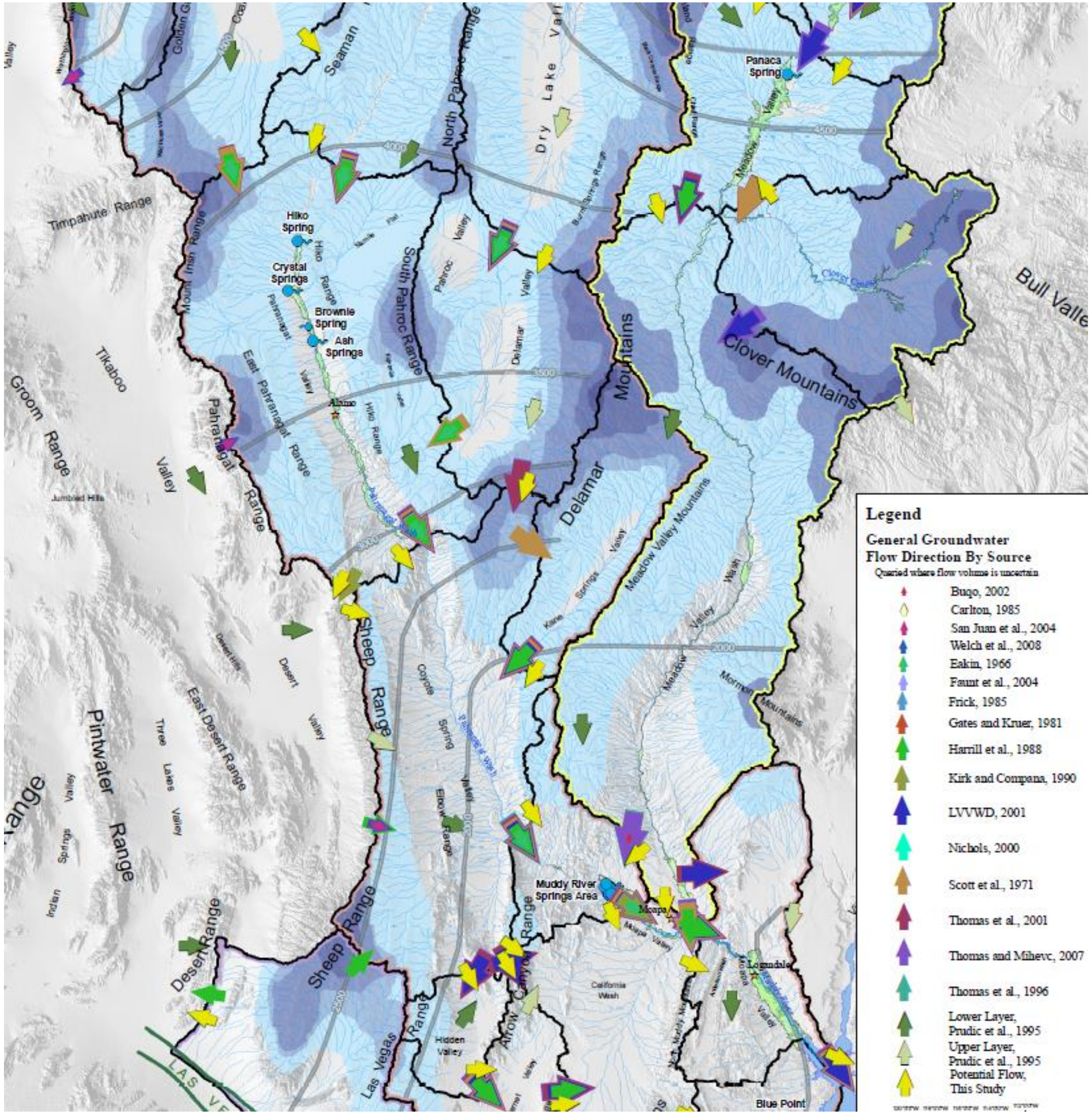
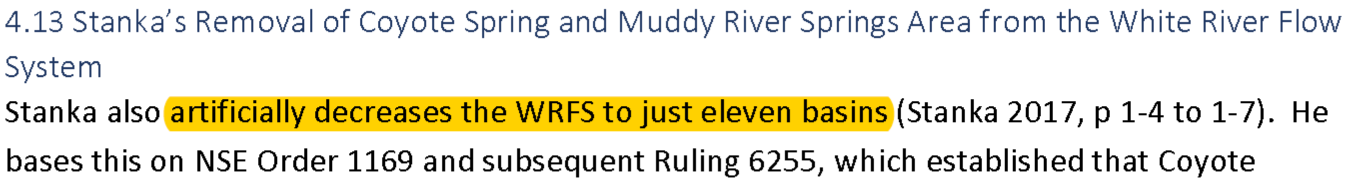


Figure 1-4
Overview of the Original WRFS Compared to the Five-Basin System

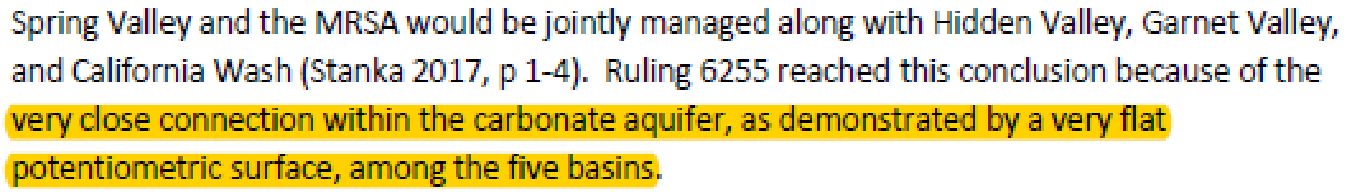


GBWN Exh_281, portion Figure 16, p 28 and portion of Figure 13, p 24



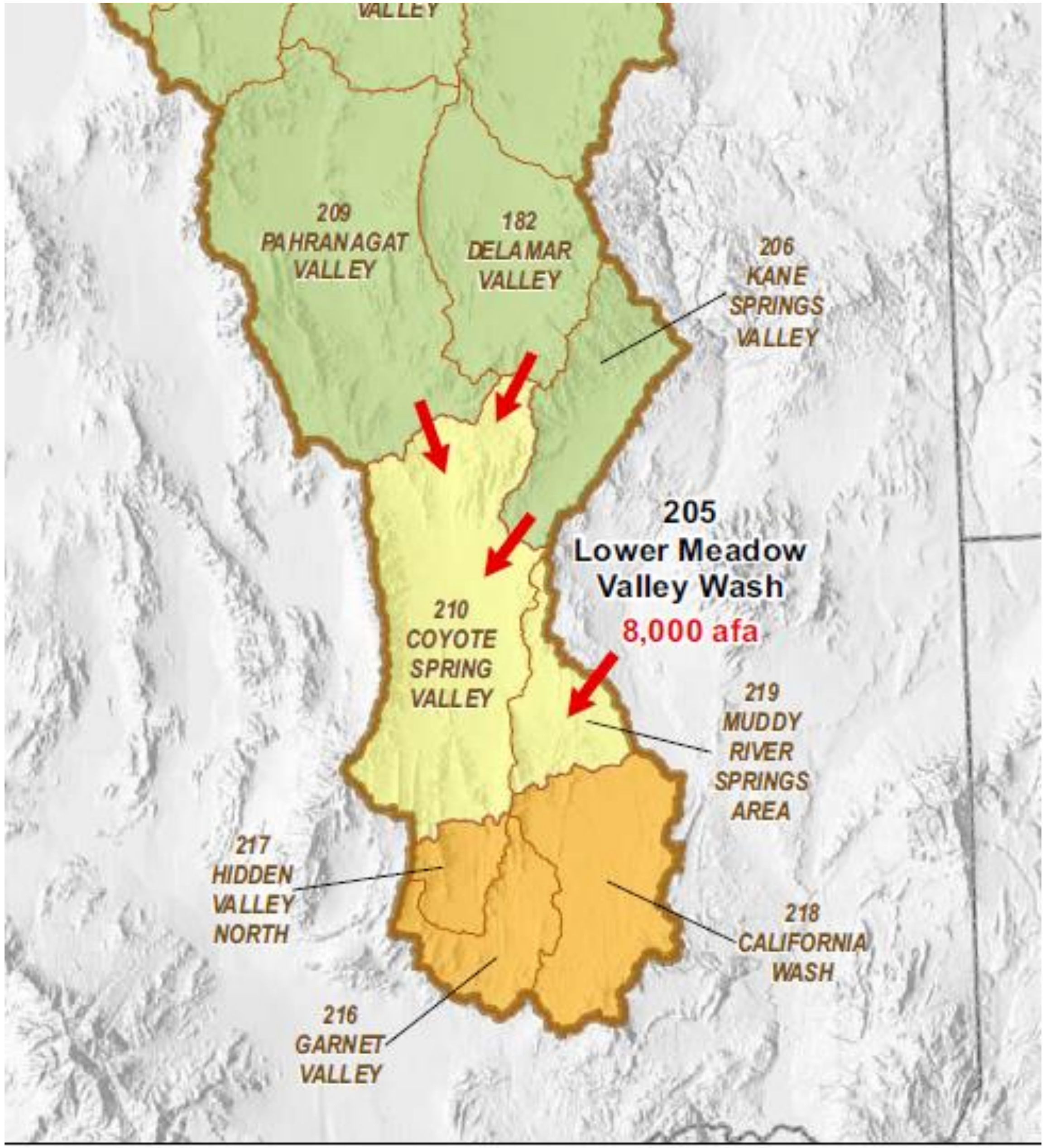
4.13 Stanka's Removal of Coyote Spring and Muddy River Springs Area from the White River Flow System

Stanka also artificially decreases the WRFS to just eleven basins (Stanka 2017, p 1-4 to 1-7). He bases this on NSE Order 1169 and subsequent Ruling 6255, which established that Coyote

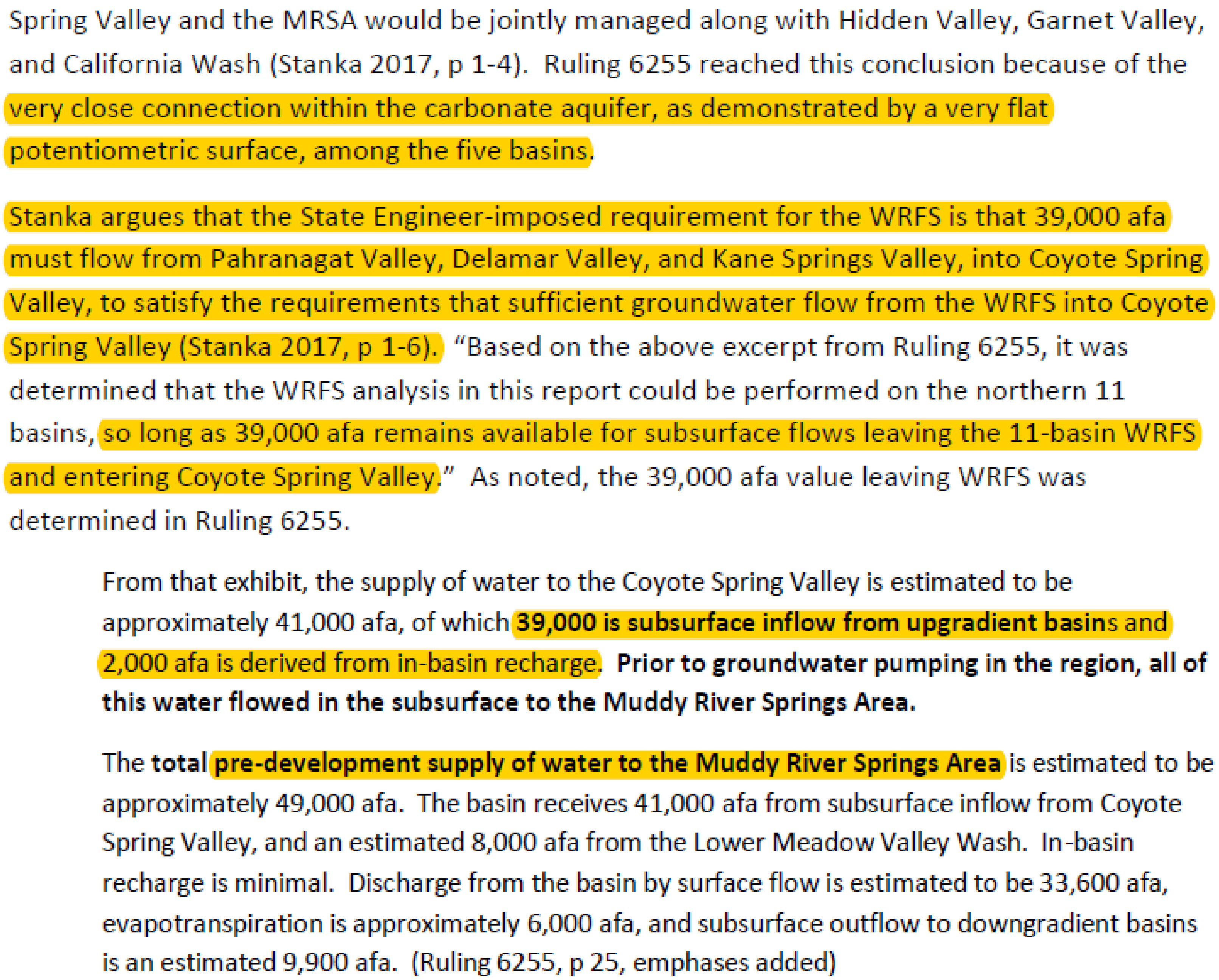


Spring Valley and the MRSA would be jointly managed along with Hidden Valley, Garnet Valley, and California Wash (Stanka 2017, p 1-4). Ruling 6255 reached this conclusion because of the very close connection within the carbonate aquifer, as demonstrated by a very flat potentiometric surface, among the five basins.

GBWN Exh_297, p 15, 16



SNWA Exh 483, portion Figure 1-4, p 1-8

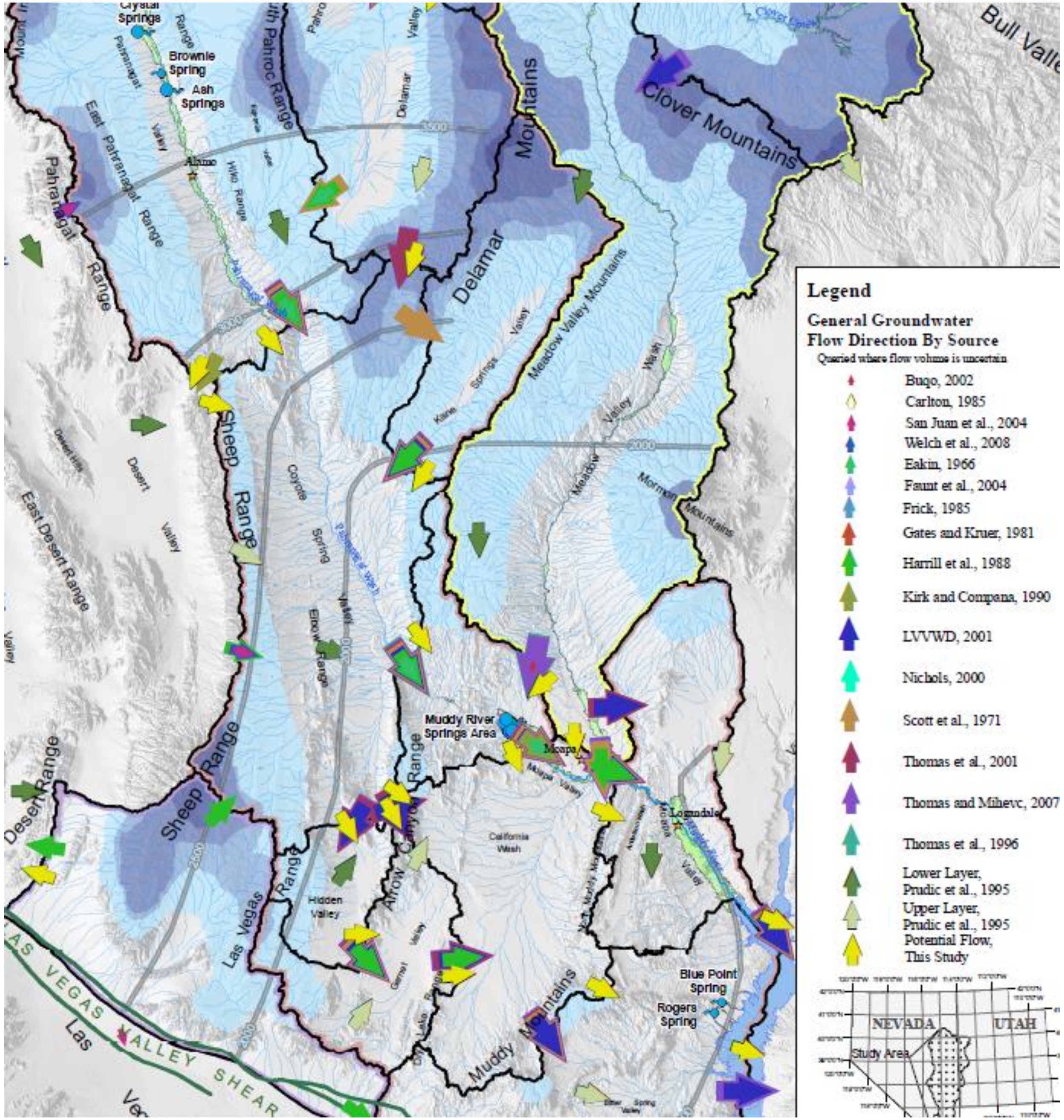


Spring Valley and the MRSA would be jointly managed along with Hidden Valley, Garnet Valley, and California Wash (Stanka 2017, p 1-4). Ruling 6255 reached this conclusion because of the very close connection within the carbonate aquifer, as demonstrated by a very flat potentiometric surface, among the five basins.

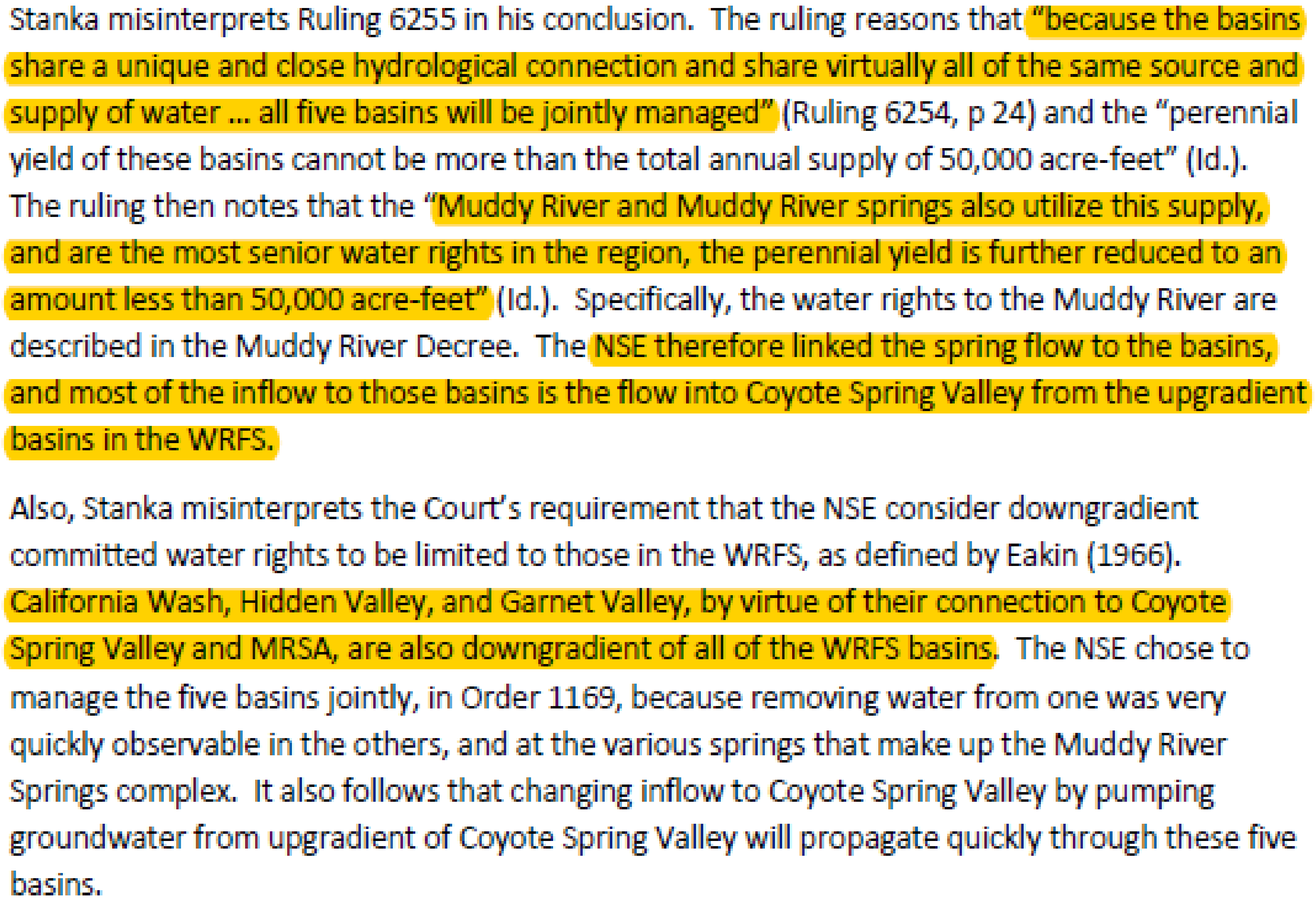
Stanka argues that the State Engineer-imposed requirement for the WRFS is that 39,000 afa must flow from Pahranagat Valley, Delamar Valley, and Kane Springs Valley, into Coyote Spring Valley, to satisfy the requirements that sufficient groundwater flow from the WRFS into Coyote Spring Valley (Stanka 2017, p 1-6). "Based on the above excerpt from Ruling 6255, it was determined that the WRFS analysis in this report could be performed on the northern 11 basins, so long as 39,000 afa remains available for subsurface flows leaving the 11-basin WRFS and entering Coyote Spring Valley." As noted, the 39,000 afa value leaving WRFS was determined in Ruling 6255.

> From that exhibit, the supply of water to the Coyote Spring Valley is estimated to be approximately 41,000 afa, of which **39,000 is subsurface inflow from upgradient basin**s and 2,000 afa is derived from in-basin recharge. **Prior to groundwater pumping in the region, all of this water flowed in the subsurface to the Muddy River Springs Area.**
>
> The **total pre-development supply of water to the Muddy River Springs Area** is estimated to be approximately 49,000 afa. The basin receives 41,000 afa from subsurface inflow from Coyote Spring Valley, and an estimated 8,000 afa from the Lower Meadow Valley Wash. In-basin recharge is minimal. Discharge from the basin by surface flow is estimated to be 33,600 afa, evapotranspiration is approximately 6,000 afa, and subsurface outflow to downgradient basins is an estimated 9,900 afa. (Ruling 6255, p 25, emphases added)

GBWN Exh_297, p 16



Portion of Plate 1, SNWA Exh 88

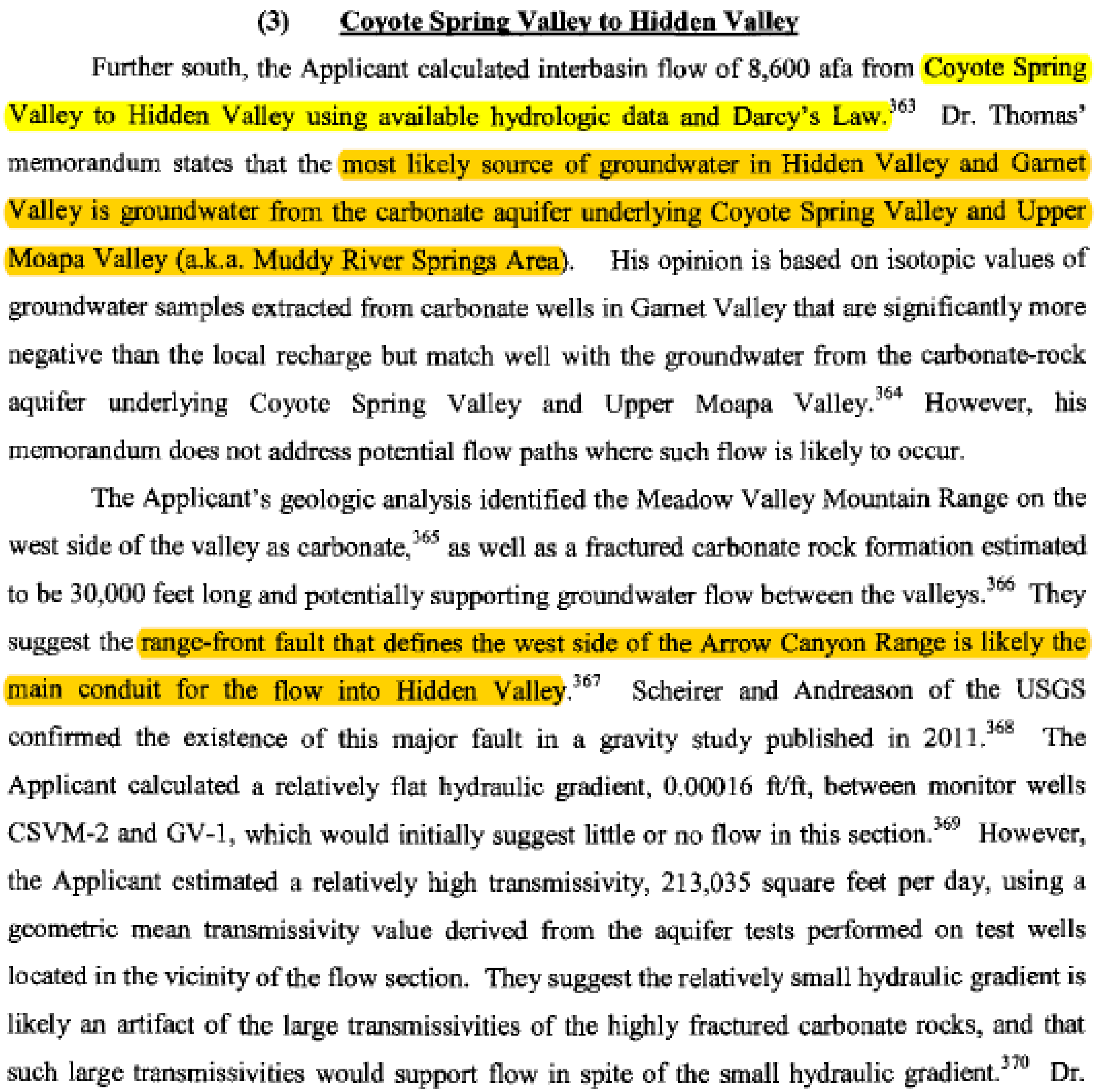


Stanka misinterprets Ruling 6255 in his conclusion. The ruling reasons that "because the basins share a unique and close hydrological connection and share virtually all of the same source and supply of water … all five basins will be jointly managed" (Ruling 6254, p 24) and the "perennial yield of these basins cannot be more than the total annual supply of 50,000 acre-feet" (Id.). The ruling then notes that the "Muddy River and Muddy River springs also utilize this supply, and are the most senior water rights in the region, the perennial yield is further reduced to an amount less than 50,000 acre-feet" (Id.). Specifically, the water rights to the Muddy River are described in the Muddy River Decree. The NSE therefore linked the spring flow to the basins, and most of the inflow to those basins is the flow into Coyote Spring Valley from the upgradient basins in the WRFS.

Also, Stanka misinterprets the Court's requirement that the NSE consider downgradient committed water rights to be limited to those in the WRFS, as defined by Eakin (1966). California Wash, Hidden Valley, and Garnet Valley, by virtue of their connection to Coyote Spring Valley and MRSA, are also downgradient of all of the WRFS basins. The NSE chose to manage the five basins jointly, in Order 1169, because removing water from one was very quickly observable in the others, and at the various springs that make up the Muddy River Springs complex. It also follows that changing inflow to Coyote Spring Valley by pumping groundwater from upgradient of Coyote Spring Valley will propagate quickly through these five basins.

GBWN Exh_297, p 18

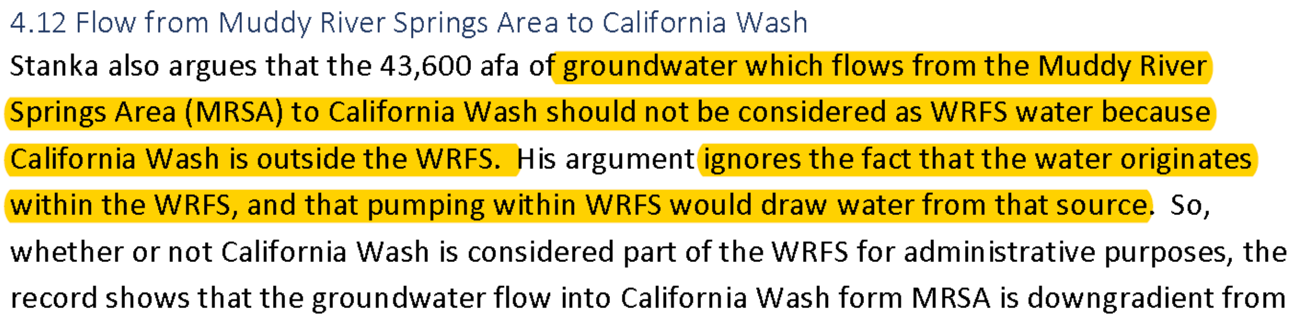
Ruling 6165, p 66



(3) Coyote Spring Valley to Hidden Valley

Further south, the Applicant calculated interbasin flow of 8,600 afa from Coyote Spring Valley to Hidden Valley using available hydrologic data and Darcy's Law.[363] Dr. Thomas' memorandum states that the most likely source of groundwater in Hidden Valley and Garnet Valley is groundwater from the carbonate aquifer underlying Coyote Spring Valley and Upper Moapa Valley (a.k.a. Muddy River Springs Area). His opinion is based on isotopic values of groundwater samples extracted from carbonate wells in Garnet Valley that are significantly more negative than the local recharge but match well with the groundwater from the carbonate-rock aquifer underlying Coyote Spring Valley and Upper Moapa Valley.[364] However, his memorandum does not address potential flow paths where such flow is likely to occur.

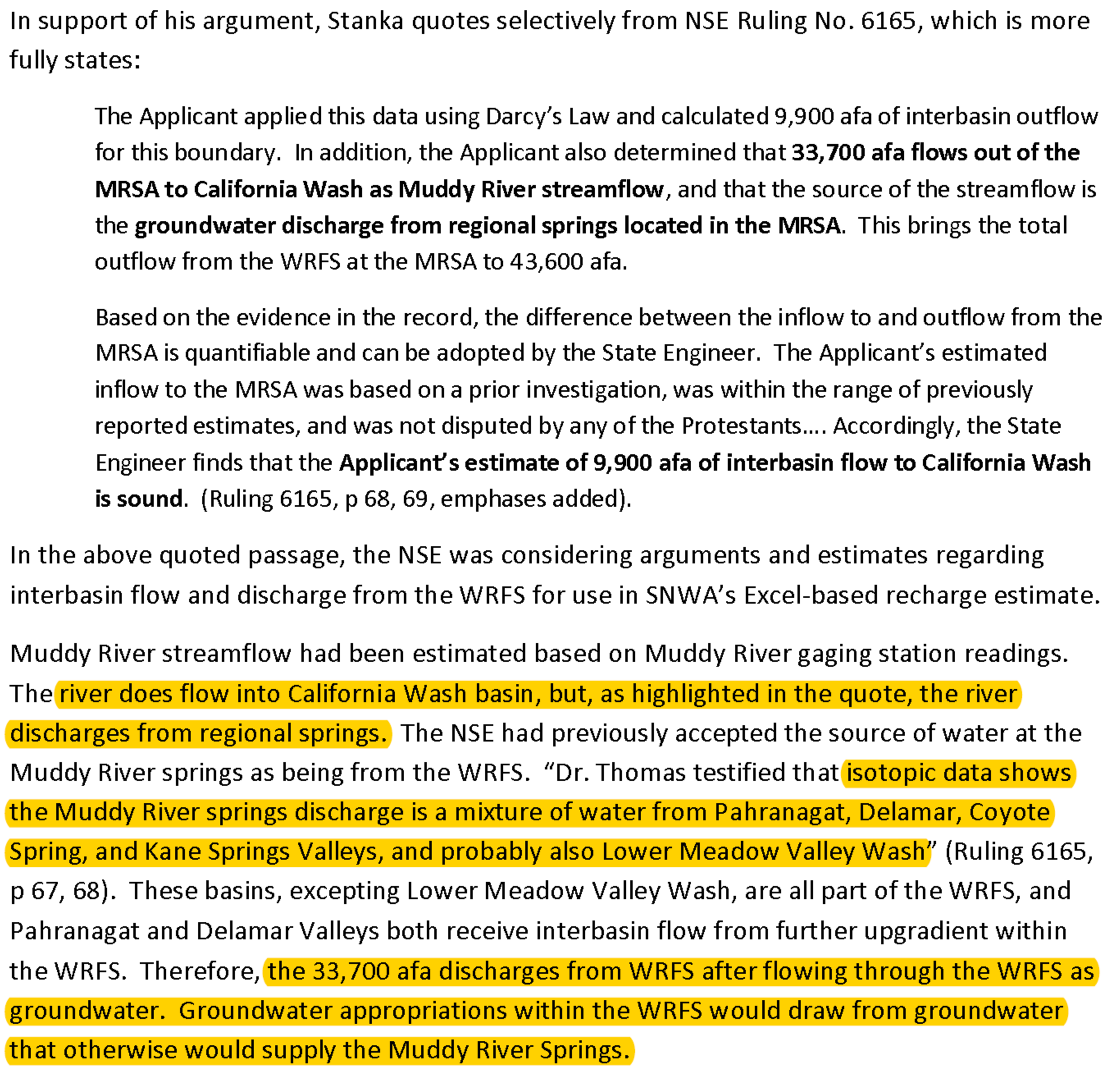
The Applicant's geologic analysis identified the Meadow Valley Mountain Range on the west side of the valley as carbonate,[365] as well as a fractured carbonate rock formation estimated to be 30,000 feet long and potentially supporting groundwater flow between the valleys.[366] They suggest the range-front fault that defines the west side of the Arrow Canyon Range is likely the main conduit for the flow into Hidden Valley.[367] Scheirer and Andreason of the USGS confirmed the existence of this major fault in a gravity study published in 2011.[368] The Applicant calculated a relatively flat hydraulic gradient, 0.00016 ft/ft, between monitor wells CSVM-2 and GV-1, which would initially suggest little or no flow in this section.[369] However, the Applicant estimated a relatively high transmissivity, 213,035 square feet per day, using a geometric mean transmissivity value derived from the aquifer tests performed on test wells located in the vicinity of the flow section. They suggest the relatively small hydraulic gradient is likely an artifact of the large transmissivities of the highly fractured carbonate rocks, and that such large transmissivities would support flow in spite of the small hydraulic gradient.[370] Dr.



4.12 Flow from Muddy River Springs Area to California Wash

Stanka also argues that the 43,600 afa of groundwater which flows from the Muddy River Springs Area (MRSA) to California Wash should not be considered as WRFS water because California Wash is outside the WRFS. His argument ignores the fact that the water originates within the WRFS, and that pumping within WRFS would draw water from that source. So, whether or not California Wash is considered part of the WRFS for administrative purposes, the record shows that the groundwater flow into California Wash form MRSA is downgradient from

GBWN Exh_297, p 14, 15

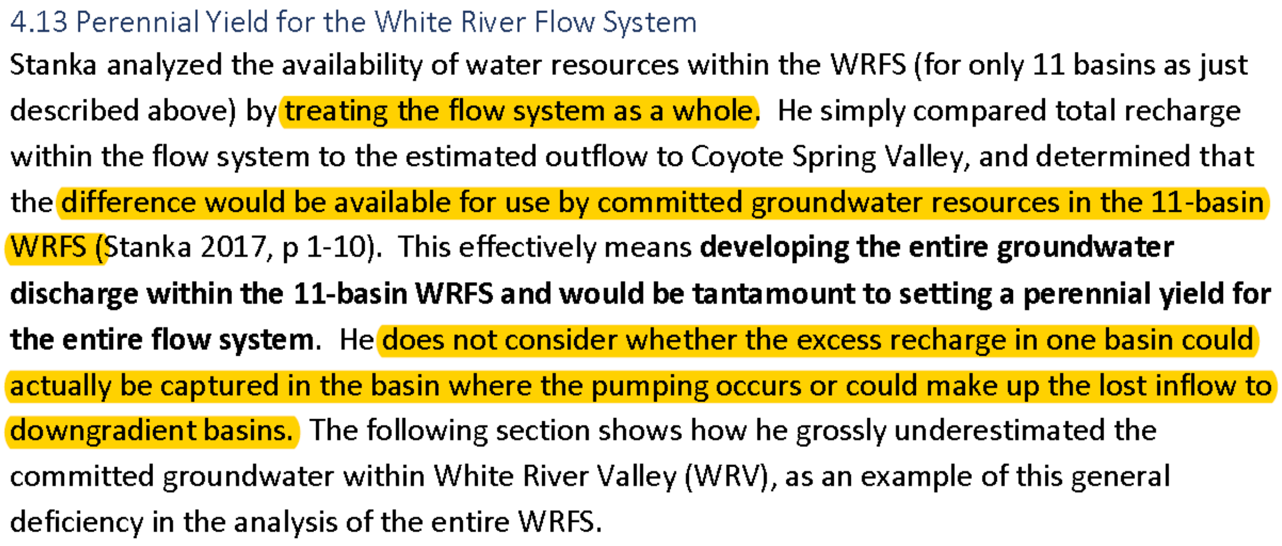


In support of his argument, Stanka quotes selectively from NSE Ruling No. 6165, which is more fully states:

> The Applicant applied this data using Darcy's Law and calculated 9,900 afa of interbasin outflow for this boundary. In addition, the Applicant also determined that **33,700 afa flows out of the MRSA to California Wash as Muddy River streamflow**, and that the source of the streamflow is the **groundwater discharge from regional springs located in the MRSA**. This brings the total outflow from the WRFS at the MRSA to 43,600 afa.
>
> Based on the evidence in the record, the difference between the inflow to and outflow from the MRSA is quantifiable and can be adopted by the State Engineer. The Applicant's estimated inflow to the MRSA was based on a prior investigation, was within the range of previously reported estimates, and was not disputed by any of the Protestants…. Accordingly, the State Engineer finds that the **Applicant's estimate of 9,900 afa of interbasin flow to California Wash is sound**. (Ruling 6165, p 68, 69, emphases added).

In the above quoted passage, the NSE was considering arguments and estimates regarding interbasin flow and discharge from the WRFS for use in SNWA's Excel-based recharge estimate.

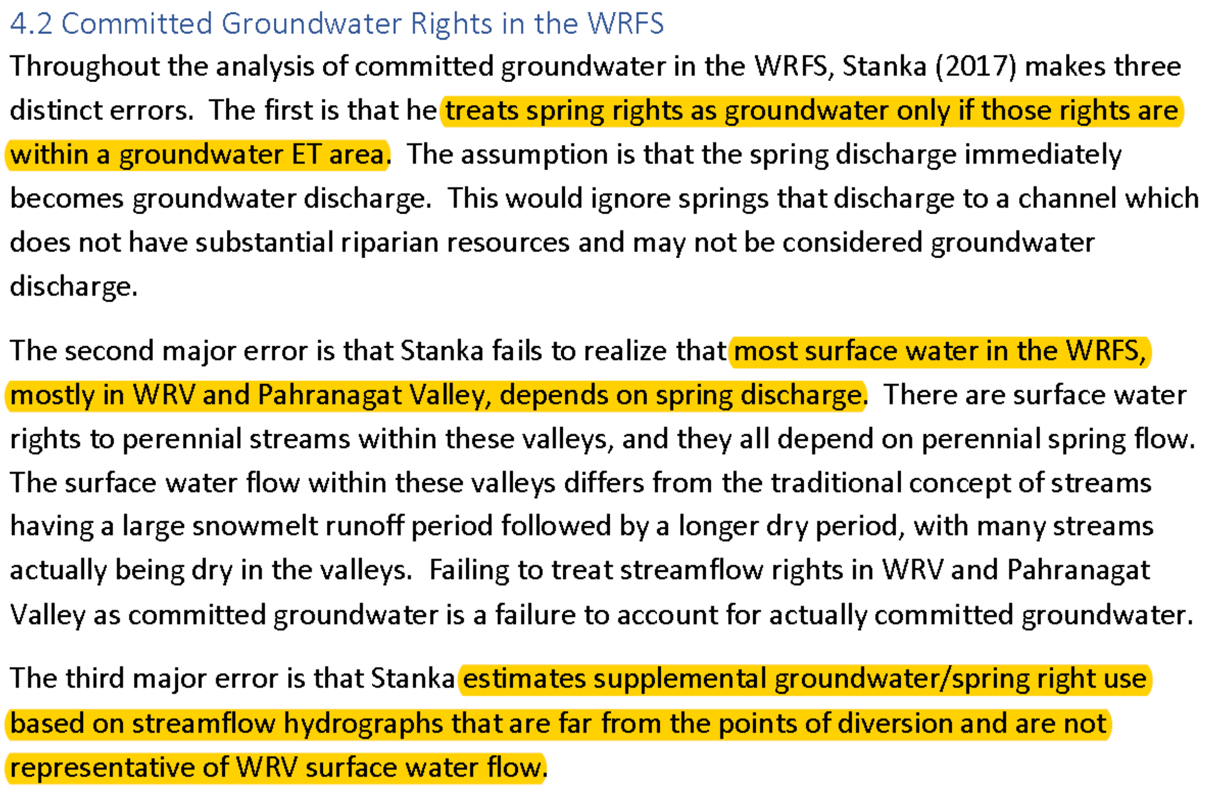
Muddy River streamflow had been estimated based on Muddy River gaging station readings. The river does flow into California Wash basin, but, as highlighted in the quote, the river discharges from regional springs. The NSE had previously accepted the source of water at the Muddy River springs as being from the WRFS. "Dr. Thomas testified that isotopic data shows the Muddy River springs discharge is a mixture of water from Pahranagat, Delamar, Coyote Spring, and Kane Springs Valleys, and probably also Lower Meadow Valley Wash" (Ruling 6165, p 67, 68). These basins, excepting Lower Meadow Valley Wash, are all part of the WRFS, and Pahranagat and Delamar Valleys both receive interbasin flow from further upgradient within the WRFS. Therefore, the 33,700 afa discharges from WRFS after flowing through the WRFS as groundwater. Groundwater appropriations within the WRFS would draw from groundwater that otherwise would supply the Muddy River Springs.



4.13 Perennial Yield for the White River Flow System

Stanka analyzed the availability of water resources within the WRFS (for only 11 basins as just described above) by treating the flow system as a whole. He simply compared total recharge within the flow system to the estimated outflow to Coyote Spring Valley, and determined that the difference would be available for use by committed groundwater resources in the 11-basin WRFS (Stanka 2017, p 1-10). This effectively means **developing the entire groundwater discharge within the 11-basin WRFS and would be tantamount to setting a perennial yield for the entire flow system**. He does not consider whether the excess recharge in one basin could actually be captured in the basin where the pumping occurs or could make up the lost inflow to downgradient basins. The following section shows how he grossly underestimated the committed groundwater within White River Valley (WRV), as an example of this general deficiency in the analysis of the entire WRFS.

GBWN Exh_297, p 18



4.2 Committed Groundwater Rights in the WRFS

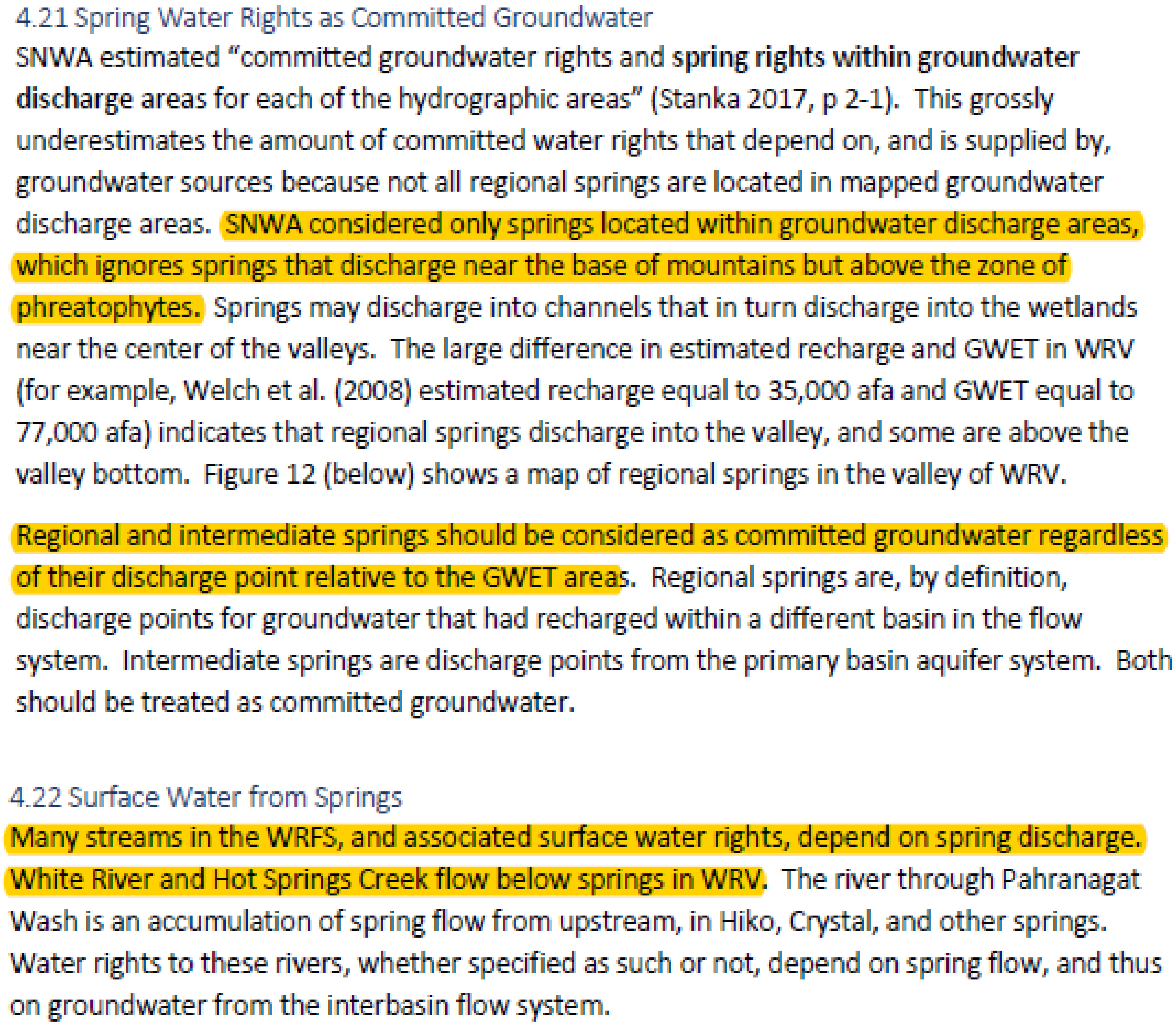
Throughout the analysis of committed groundwater in the WRFS, Stanka (2017) makes three distinct errors. The first is that he treats spring rights as groundwater only if those rights are within a groundwater ET area. The assumption is that the spring discharge immediately becomes groundwater discharge. This would ignore springs that discharge to a channel which does not have substantial riparian resources and may not be considered groundwater discharge.

The second major error is that Stanka fails to realize that most surface water in the WRFS, mostly in WRV and Pahranagat Valley, depends on spring discharge. There are surface water rights to perennial streams within these valleys, and they all depend on perennial spring flow. The surface water flow within these valleys differs from the traditional concept of streams having a large snowmelt runoff period followed by a longer dry period, with many streams actually being dry in the valleys. Failing to treat streamflow rights in WRV and Pahranagat Valley as committed groundwater is a failure to account for actually committed groundwater.

The third major error is that Stanka estimates supplemental groundwater/spring right use based on streamflow hydrographs that are far from the points of diversion and are not representative of WRV surface water flow.

GBWN Exh_297, p 19

GBWN Exh_297, p 19, 20



4.21 Spring Water Rights as Committed Groundwater

SNWA estimated “committed groundwater rights and **spring rights within groundwater discharge areas** for each of the hydrographic areas” (Stanka 2017, p 2-1). This grossly underestimates the amount of committed water rights that depend on, and is supplied by, groundwater sources because not all regional springs are located in mapped groundwater discharge areas. SNWA considered only springs located within groundwater discharge areas, which ignores springs that discharge near the base of mountains but above the zone of phreatophytes. Springs may discharge into channels that in turn discharge into the wetlands near the center of the valleys. The large difference in estimated recharge and GWET in WRV (for example, Welch et al. (2008) estimated recharge equal to 35,000 afa and GWET equal to 77,000 afa) indicates that regional springs discharge into the valley, and some are above the valley bottom. Figure 12 (below) shows a map of regional springs in the valley of WRV.

Regional and intermediate springs should be considered as committed groundwater regardless of their discharge point relative to the GWET areas. Regional springs are, by definition, discharge points for groundwater that had recharged within a different basin in the flow system. Intermediate springs are discharge points from the primary basin aquifer system. Both should be treated as committed groundwater.

4.22 Surface Water from Springs

Many streams in the WRFS, and associated surface water rights, depend on spring discharge. White River and Hot Springs Creek flow below springs in WRV. The river through Pahranagat Wash is an accumulation of spring flow from upstream, in Hiko, Crystal, and other springs. Water rights to these rivers, whether specified as such or not, depend on spring flow, and thus on groundwater from the interbasin flow system.

4.32 Spring Rights as Committed Groundwater

Stanka treated spring water rights as discharging from groundwater only if the springs discharged from a GWET discharge zone (Figure 12). As noted, this ignores the larger springs that discharge at the base of the mountains or on the fans. He states there are 47 irrigation rights with a spring source, and three additional White River decreed rights, presumably spring sourced, that are not in the database, and a single stream right with a POD from a spring. He then stated that 40 of these rights are within groundwater discharge areas, and "will be considered to be groundwater commitments for accounting purposes" (Stanka 2017, p 5-20). These are not listed, so it is not possible to cross-check them.[2] My list verifies the 47 irrigation rights, and I've cross-checked them with Stanka Appendix 5-32, the Place of Use of Spring Irrigation Rights (Un-sorted). Stanka lists these rights as the "40 irrigation spring rights" (Stanka 2017, p 5-21) referring to the 40 within groundwater discharge areas. Appendix 5-32 was the start of Stanka's supplemental rights calculation. Of the 47 irrigation rights in my list, 36 were in Stanka Appendix 5-32; the appendix also lists three White River Decree rights. Stanka stated there is one stream right sourced to springs, but he does not list it in Appendix 5-32 (where the rights are all identified as having spring source). Stanka's (2017) Table 5-10 lists 19,853 afa of water rights associated with springs and adjusted for supplemental rights. Stanka's primary error is that he has ignored additional springs that should be considered as committed groundwater and stream rights that are also groundwater which causes an underestimate of committed groundwater rights.

I selected the spring rights shown in Figure 9 within the valley bottom Qal, Qflv, and the Qas for alluvial slope. This added application #s 699, 2420, 4163, 5336, 5337, 69363, V001166, V01170, V01167, V01171, and V01169 to the list of spring rights using groundwater. Including these water rights would add 1787 afa to the total. However, several of the vested water rights probably have a duty listed in the White River Decree, so my estimated amount still would be low.

GBWN Exh_297, p 25, 26

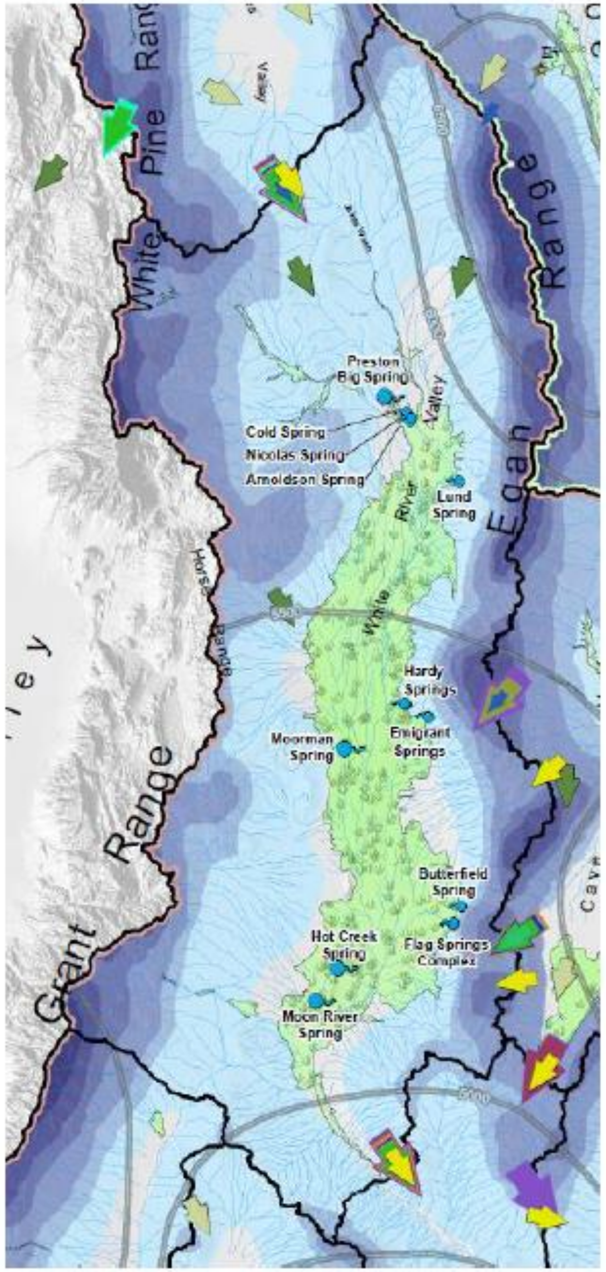
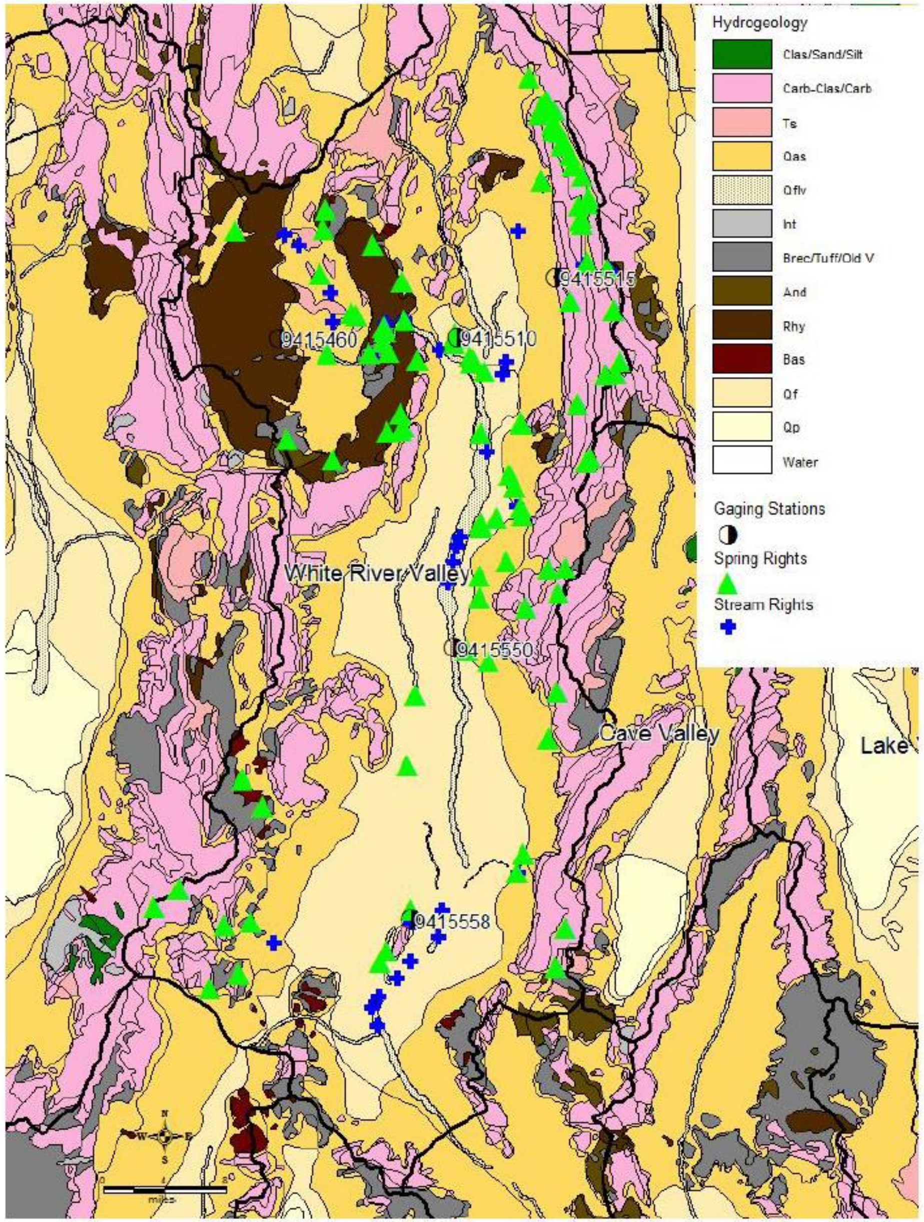


Figure 12: White River Valley portion of Plate 1, SNWA (2009a), showing springs and groundwater discharge area.

GBWN Exh_297, P 23, 17



igure 9: Map showing the location of stream and spring water rights points of diversion as tabulated n the hydrologic abstract obtained from the NSE website.

4.33 Stream Rights as Committed Groundwater

Most WRV surface water depends on spring flow, not runoff. The surface flows would be much more consistent, as may be seen in the hydrograph (Figure 10) for Hot Creek near Sunnyside gage (gage 9415558 on Figure 9). This site is downstream from various springs which in combination created the consistent streamflow seen in Figure 10. Considering the number of large regional springs in WRV (Figure 12), most surface water in the valley bottom would be a sum of spring flow. If surface water depends on spring discharge, as it does in the WRV, stream rights should be considered dependent on groundwater.

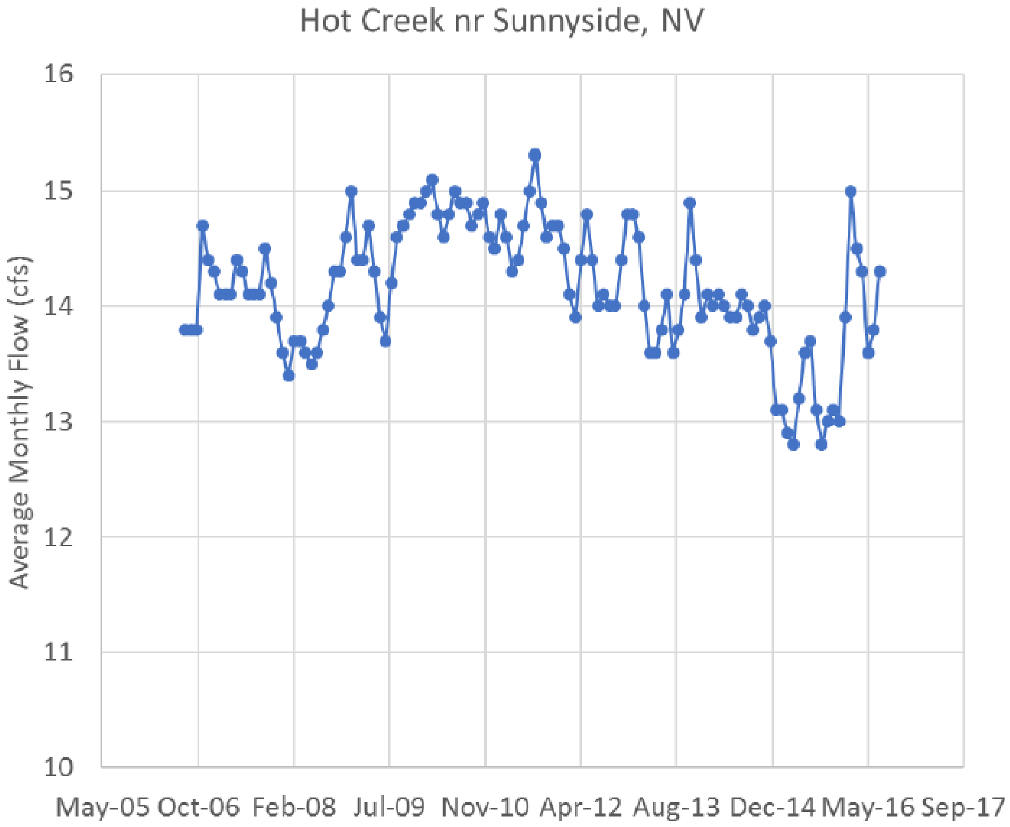


Figure 10: Monthly flow rate at the USGS gage 94155588, Hot Creek near Sunnyside, NV

The total duty for WRV water rights listed as stream with status listed as certificated, permitted, or vested, is 38,837 afa before supplemental adjustment and 32,017 afa if all stream rights listed as supplemental are removed[3]. Assuming that stream rights are preferentially used, then removing all rights listed as supplemental would provide the most conservative estimate. Most stream rights are in the WRV valley bottom (Figure 9). Figure 11 shows the detailed location of five stream water rights in southern WRV, which have a total 4710 afa duty. Rights 38205 and 23623 are wildlife rights, noted in Appendix 5-11 (Stanka 2017). The other wildlife right, 20466, is just northeast of the map in Figure 11. As noted above, most runoff would have percolated before reaching the valley floor, so the river in the valley would only flow if there are springs supporting it.

To assess the amount of stream water rights likely discharging from groundwater, I selected the stream water rights that are within the Qas or Qflv hydrogeology units, shown on Figure 9. These are listed in Table A1. The total duty, unadjusted for supplemental rights, is 29,138 afa. Removing the supplemental surface water rights from the total results in 26,181 afa of water

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[3] This sum is derived from the White River Valley water rights abstract, which I downloaded from the NSE website.

GBWN Exh_297, p 26, 28

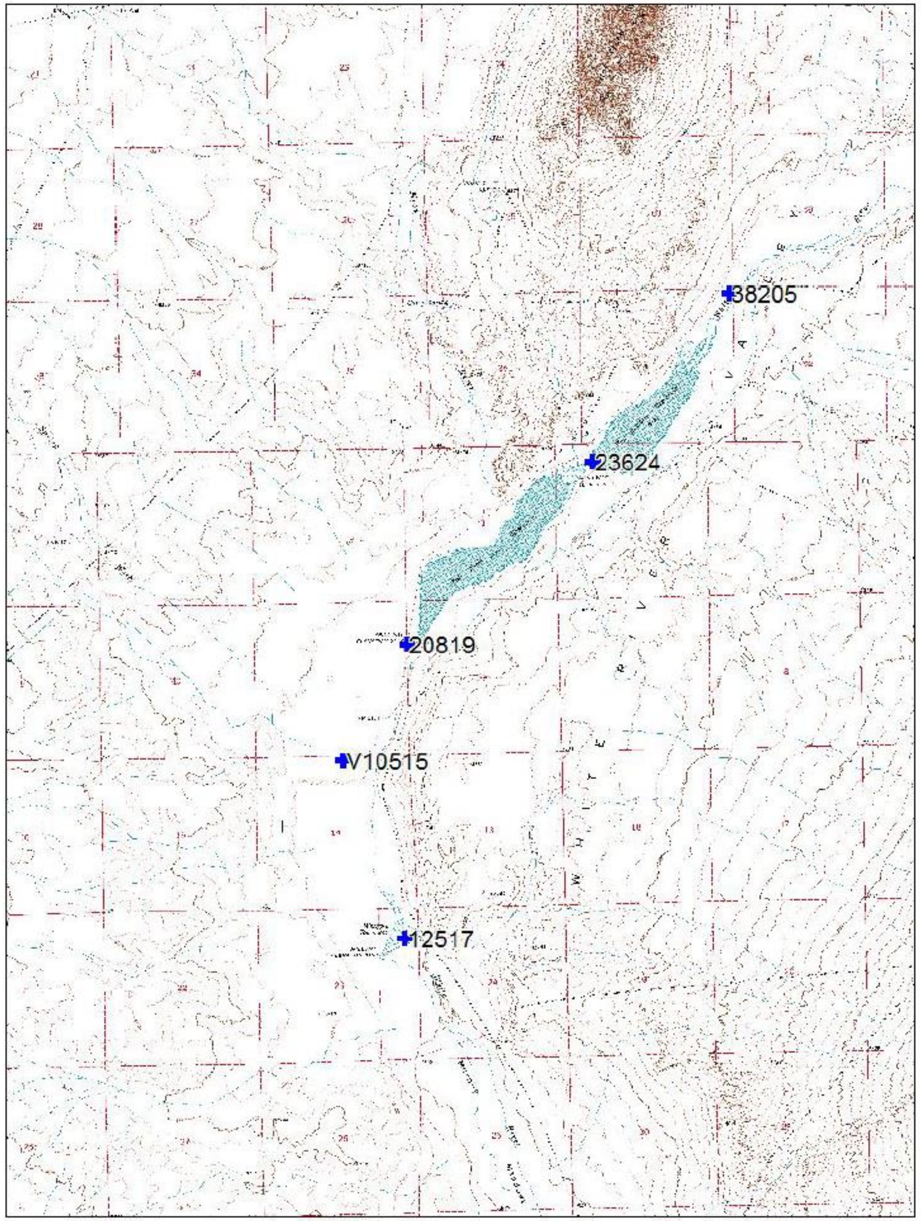

Figure 11: Location of stream water rights in southern White River Valley. Base map is Hot Creek Butte USGS 1:24000 scale map.

rights, predating 1989, that probably depend on spring flow. The difference between the duty for the stream rights that probably depend on springs and the total stream rights for WRV is 9699 afa, not accounting for supplemental rights, which indicates that a substantial amount of stream rights, up to 26,181 afa, depends on groundwater flow. Stream rights on the alluvial fans could also be spring discharge, as discussed above, but they are not included because it is more likely that stream rights on the alluvial fans would be runoff. It is also more likely that streams discharging from a spring in this area would be considered a spring right because the POD would be near the spring discharge point. Ignoring potential stream rights on the alluvial fans being groundwater yields a conservative estimate of committed groundwater as stream rights.

SNWA has therefore underestimated committed groundwater for the WRV by as much as 26,181 afa, ignoring the rights considered to be supplemental. This is because Stanka (2017) did not consider streamflow downstream from springs as committed groundwater.

GBWN Exh_297, p 29, 30

SNWA Exh_613

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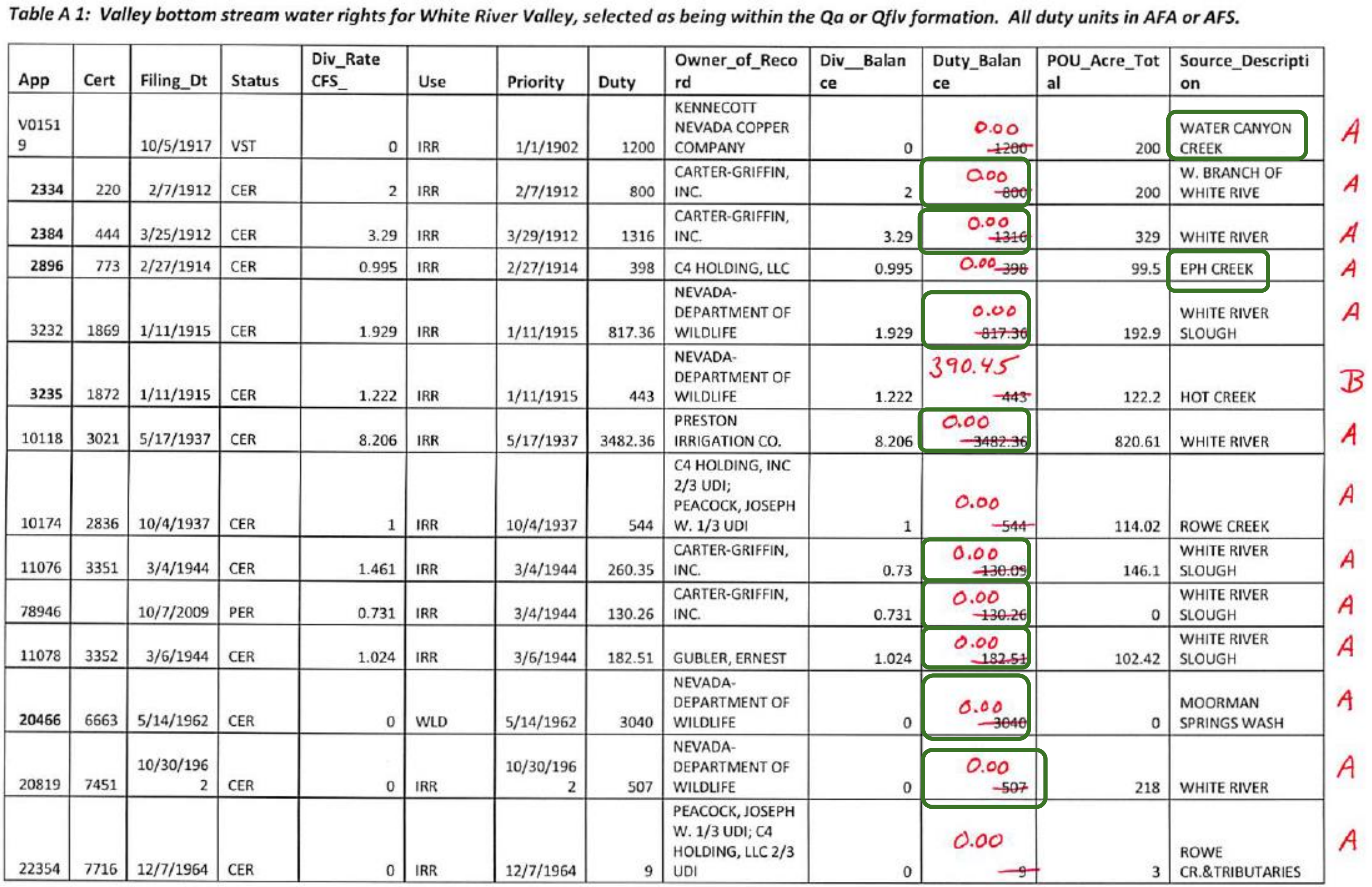

Table A 1: Valley bottom stream water rights for White River Valley, selected as being within the Qa or Qflv formation. All duty units in AFA or AFS.

App	Cert	Filing_Dt	Status	Div_Rate CFS_	Use	Priority	Duty	Owner_of_Record	Div__Balance	Duty_Balance	POU_Acre_Total	Source_Description	
V01519		10/5/1917	VST	0	IRR	1/1/1902	1200	KENNECOTT NEVADA COPPER COMPANY	0	0.00 ~~1200~~	200	WATER CANYON CREEK	A
2334	220	2/7/1912	CER	2	IRR	2/7/1912	800	CARTER-GRIFFIN, INC.	2	0.00 ~~800~~	200	W. BRANCH OF WHITE RIVE	A
2384	444	3/25/1912	CER	3.29	IRR	3/29/1912	1316	CARTER-GRIFFIN, INC.	3.29	0.00 ~~1316~~	329	WHITE RIVER	A
2896	773	2/27/1914	CER	0.995	IRR	2/27/1914	398	C4 HOLDING, LLC	0.995	0.00 ~~398~~	99.5	EPH CREEK	A
3232	1869	1/11/1915	CER	1.929	IRR	1/11/1915	817.36	NEVADA-DEPARTMENT OF WILDLIFE	1.929	0.00 ~~817.36~~	192.9	WHITE RIVER SLOUGH	A
3235	1872	1/11/1915	CER	1.222	IRR	1/11/1915	443	NEVADA-DEPARTMENT OF WILDLIFE	1.222	390.45 ~~443~~	122.2	HOT CREEK	B
10118	3021	5/17/1937	CER	8.206	IRR	5/17/1937	3482.36	PRESTON IRRIGATION CO.	8.206	0.00 ~~3482.36~~	820.61	WHITE RIVER	A
10174	2836	10/4/1937	CER	1	IRR	10/4/1937	544	C4 HOLDING, INC 2/3 UDI; PEACOCK, JOSEPH W. 1/3 UDI	1	0.00 ~~544~~	114.02	ROWE CREEK	A
11076	3351	3/4/1944	CER	1.461	IRR	3/4/1944	260.35	CARTER-GRIFFIN, INC.	0.73	0.00 ~~130.09~~	146.1	WHITE RIVER SLOUGH	A
78946		10/7/2009	PER	0.731	IRR	3/4/1944	130.26	CARTER-GRIFFIN, INC.	0.731	0.00 ~~130.26~~	0	WHITE RIVER SLOUGH	A
11078	3352	3/6/1944	CER	1.024	IRR	3/6/1944	182.51	GUBLER, ERNEST	1.024	0.00 ~~182.51~~	102.42	WHITE RIVER SLOUGH	A
20466	6663	5/14/1962	CER	0	WLD	5/14/1962	3040	NEVADA-DEPARTMENT OF WILDLIFE	0	0.00 ~~3040~~	0	MOORMAN SPRINGS WASH	A
20819	7451	10/30/1962	CER	0	IRR	10/30/1962	507	NEVADA-DEPARTMENT OF WILDLIFE	0	0.00 ~~507~~	218	WHITE RIVER	A
22354	7716	12/7/1964	CER	0	IRR	12/7/1964	9	PEACOCK, JOSEPH W. 1/3 UDI; C4 HOLDING, LLC 2/3 UDI	0	0.00 ~~9~~	3	ROWE CR.&TRIBUTARIES	A

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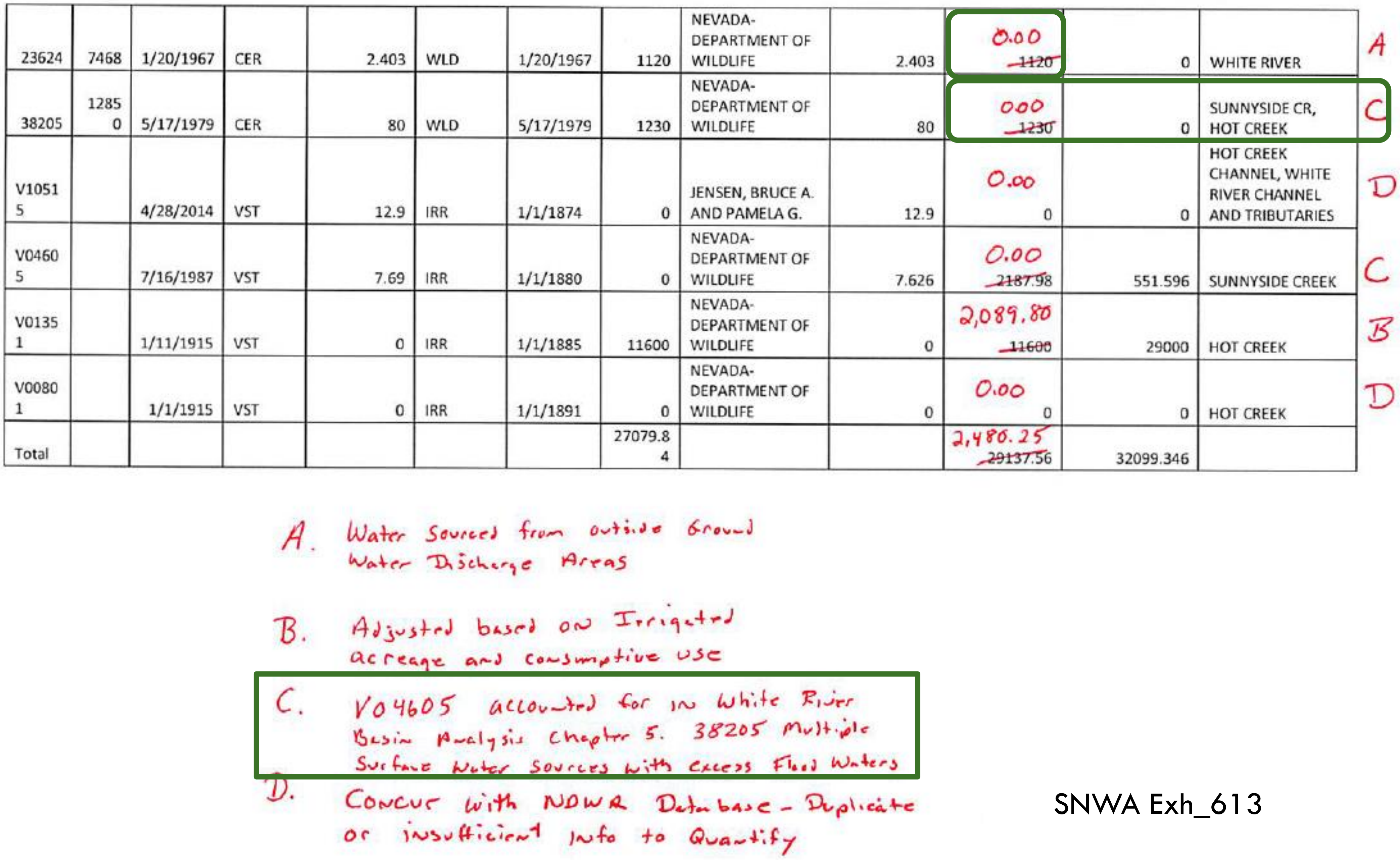

23624	7468	1/20/1967	CER	2.403	WLD	1/20/1967	1120	NEVADA-DEPARTMENT OF WILDLIFE	2.403	0.00 ~~1120~~	0	WHITE RIVER	A
38205	12850	5/17/1979	CER	80	WLD	5/17/1979	1230	NEVADA-DEPARTMENT OF WILDLIFE	80	0.00 ~~1230~~	0	SUNNYSIDE CR, HOT CREEK	C
V10515		4/28/2014	VST	12.9	IRR	1/1/1874	0	JENSEN, BRUCE A. AND PAMELA G.	12.9	0.00 0	0	HOT CREEK CHANNEL, WHITE RIVER CHANNEL AND TRIBUTARIES	D
V04605		7/16/1987	VST	7.69	IRR	1/1/1880	0	NEVADA-DEPARTMENT OF WILDLIFE	7.626	0.00 ~~2187.98~~	551.596	SUNNYSIDE CREEK	C
V01351		1/11/1915	VST	0	IRR	1/1/1885	11600	NEVADA-DEPARTMENT OF WILDLIFE	0	2,089.80 ~~11600~~	29000	HOT CREEK	B
V00801		1/1/1915	VST	0	IRR	1/1/1891	0	NEVADA-DEPARTMENT OF WILDLIFE	0	0.00 0	0	HOT CREEK	D
Total							27079.84			2,480.25 ~~29137.56~~	32099.346		

A. Water Sourced from outside Ground Water Discharge Areas

B. Adjusted based on Irrigated acreage and consumptive use

C. V04605 accounted for in White River Basin Analysis Chapter 5. 38205 Multiple Surface Water Sources with excess Flood Waters

D. Concur with NDWR Database - Duplicate or insufficient Info to Quantify

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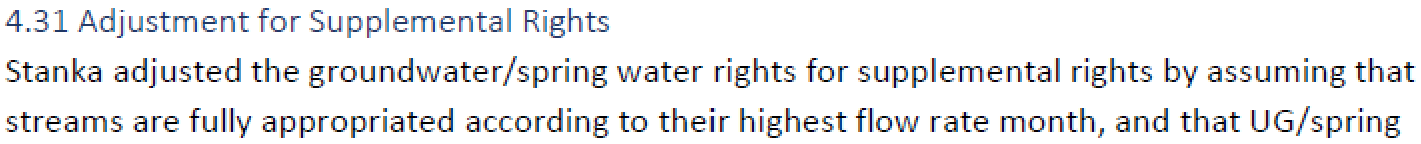
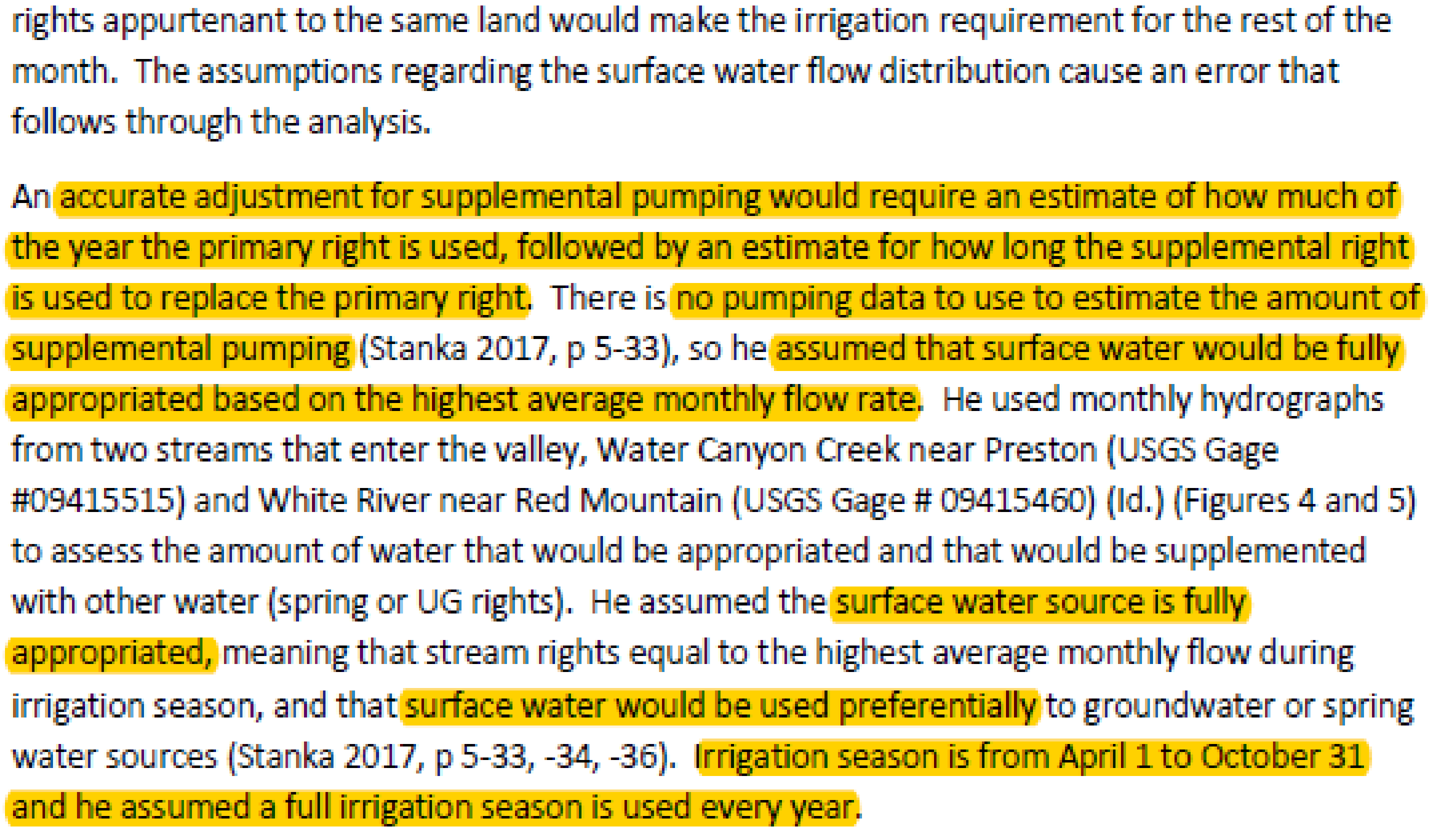


4.31 Adjustment for Supplemental Rights

Stanka adjusted the groundwater/spring water rights for supplemental rights by assuming that streams are fully appropriated according to their highest flow rate month, and that UG/spring



rights appurtenant to the same land would make the irrigation requirement for the rest of the month. The assumptions regarding the surface water flow distribution cause an error that follows through the analysis.

An accurate adjustment for supplemental pumping would require an estimate of how much of the year the primary right is used, followed by an estimate for how long the supplemental right is used to replace the primary right. There is no pumping data to use to estimate the amount of supplemental pumping (Stanka 2017, p 5-33), so he assumed that surface water would be fully appropriated based on the highest average monthly flow rate. He used monthly hydrographs from two streams that enter the valley, Water Canyon Creek near Preston (USGS Gage #09415515) and White River near Red Mountain (USGS Gage # 09415460) (Id.) (Figures 4 and 5) to assess the amount of water that would be appropriated and that would be supplemented with other water (spring or UG rights). He assumed the surface water source is fully appropriated, meaning that stream rights equal to the highest average monthly flow during irrigation season, and that surface water would be used preferentially to groundwater or spring water sources (Stanka 2017, p 5-33, -34, -36). Irrigation season is from April 1 to October 31 and he assumed a full irrigation season is used every year.

GBWN Exh_297, p 20, 21

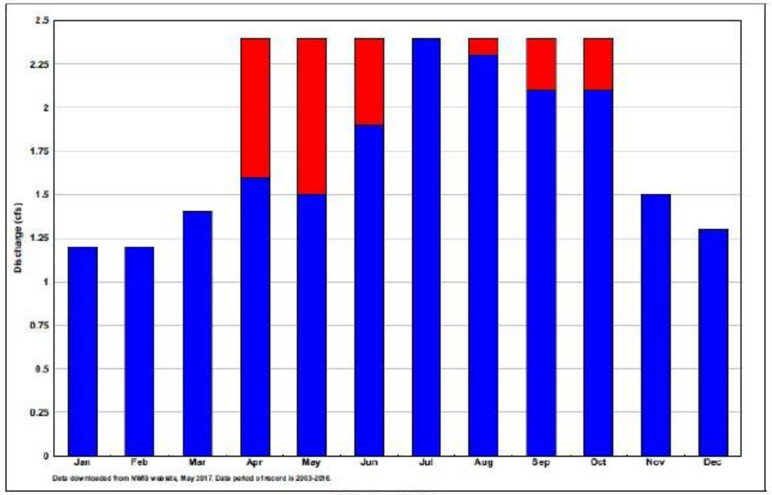


Figure 5-11
Water Canyon Creek Hydrograph with Supplemental Groundwater

igure 4: Figure 5-11 from Stanka (2017) showing an example of supplemental pumping for Water anyon Creek. See text for a discussion.

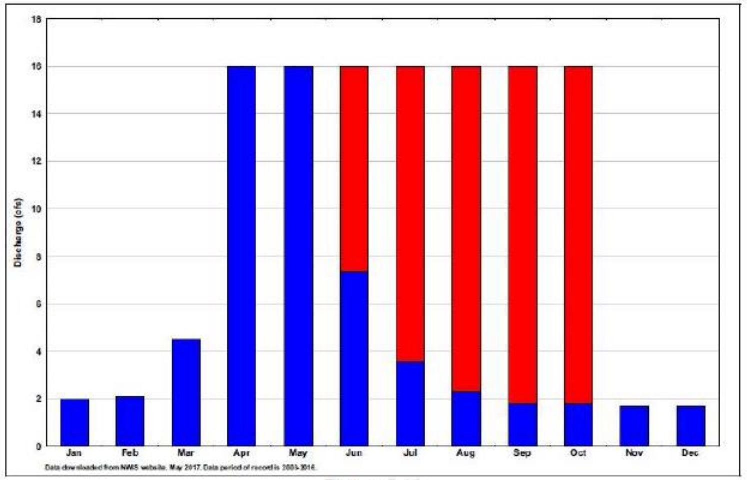


Figure 5-13
White River Hydrograph with Supplemental Groundwater/Springs

Figure 5: Figure 5-13 from Stanka (2017) showing an example of supplemental pumping for White River. See text for a discussion.

Stanka does not address whether either gage is representative of surface flows in WRV at the elevations or actual points of diversion at which they could be used for irrigation. Instead, he

GBWN Exh_297, p 22

Each gage is far above the valley bottom, meaning that diversions that could occur at the gage would be far above the areas of irrigation. The gage elevation and drainage area for Water Canyon near Preston are 6400 feet amsl and 11 square miles, and for White River near Red Mountain the gage elevation and drainage area are 6800 feet amsl and 28.2 square miles. The Water Canyon gage is high on an alluvial fan northeast of any irrigation on the WRV floor (Figures 6 and 7) into which it likely percolates and becomes recharge. The White River gage is at 6800 feet in the northwest part of WRV within the Toiyabe-Humboldt National Forest (Figure 8). Capturing surface water at the point of these gages would effectively take recharge from the WRV system.

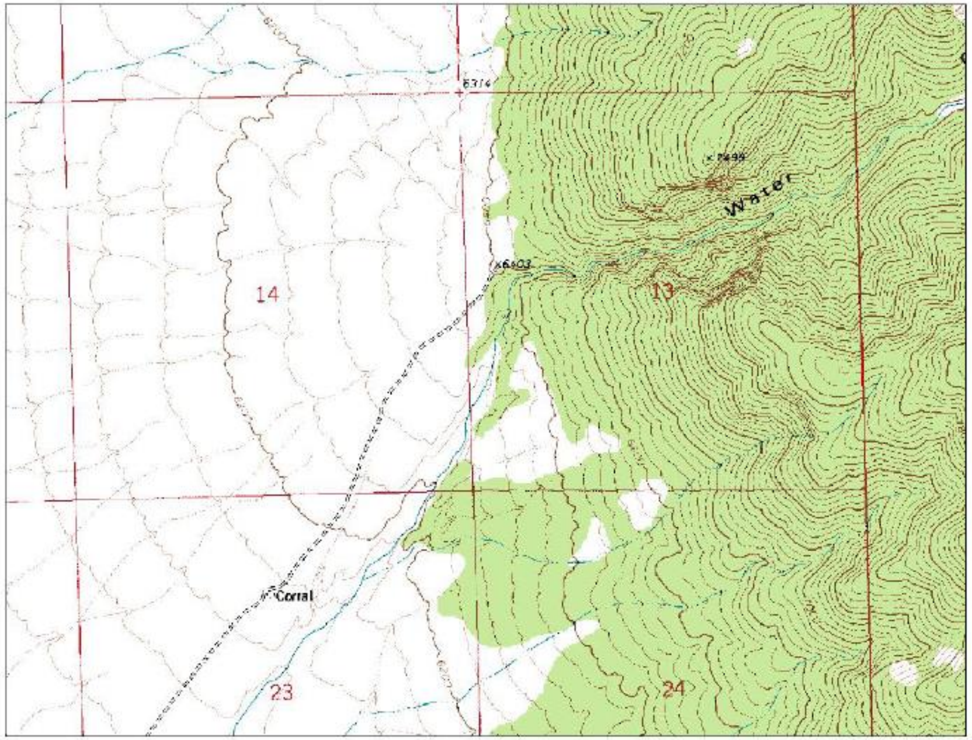


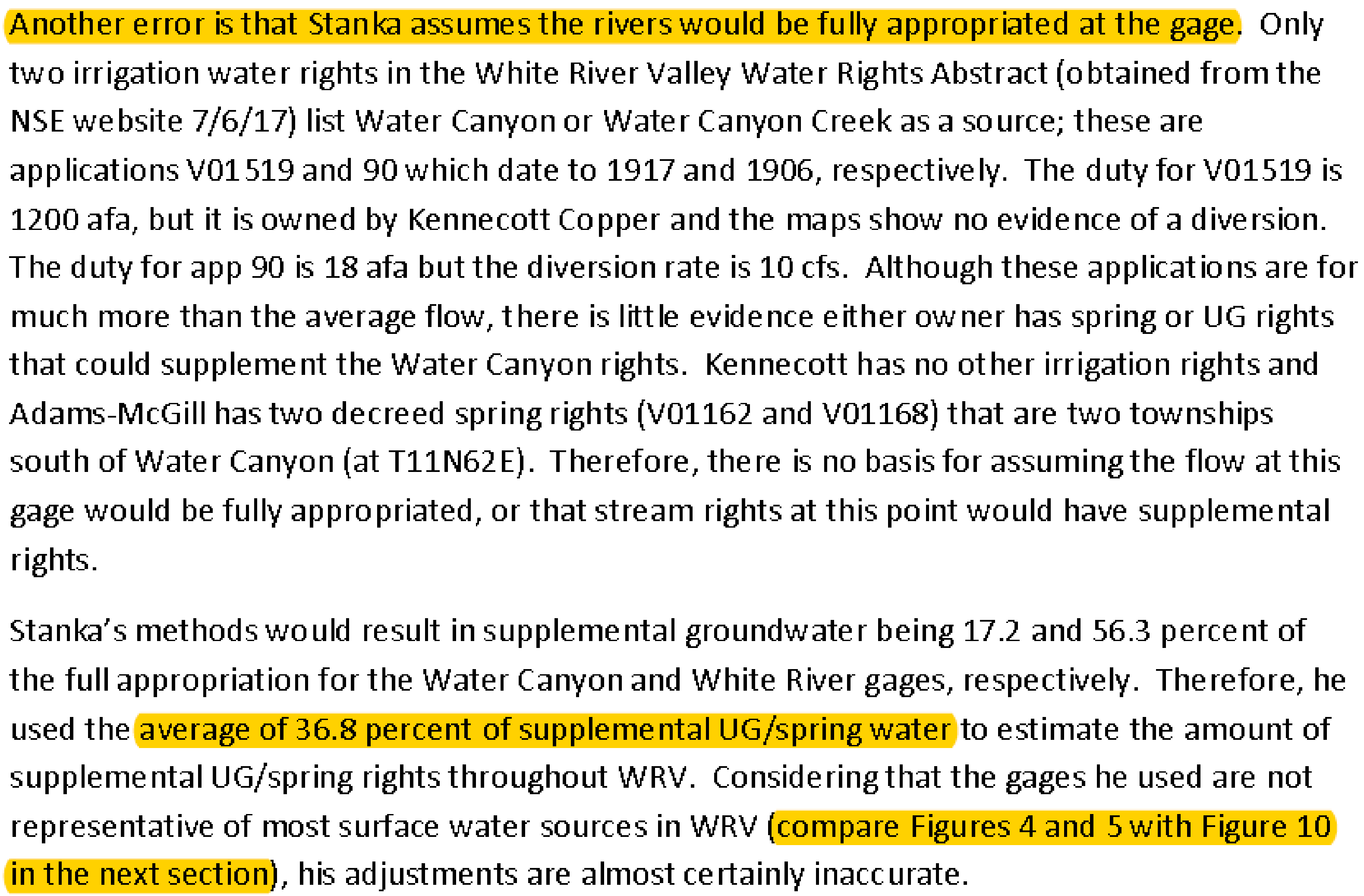
Figure 6: Portion of USGS 1:24K map, Sawmill Canyon, showing Water Canyon draining west onto an alluvial fan in the White River Valley. The gage is at the 6400' contour.

GBWN Exh_297, p 23

Figure 7: Google earth image of Water Canyon, in the middle of the picture, showing the canyon is several miles north of irrigation.

Figure 8: Portion of USGS 1:24K map, Willow Grove, showing the White River in the Humboldt-Toiyabe National Forest. The gage is at the 6800' contour.

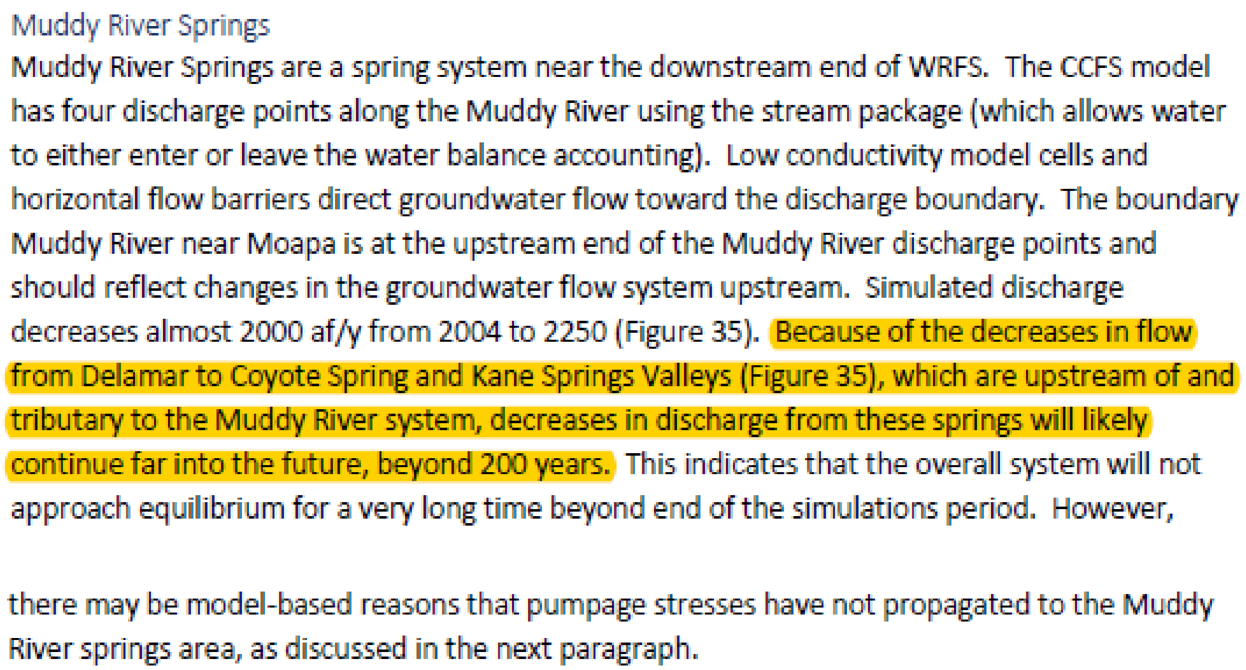
GBWN Exh_297, p 24



Another error is that Stanka assumes the rivers would be fully appropriated at the gage. Only two irrigation water rights in the White River Valley Water Rights Abstract (obtained from the NSE website 7/6/17) list Water Canyon or Water Canyon Creek as a source; these are applications V01519 and 90 which date to 1917 and 1906, respectively. The duty for V01519 is 1200 afa, but it is owned by Kennecott Copper and the maps show no evidence of a diversion. The duty for app 90 is 18 afa but the diversion rate is 10 cfs. Although these applications are for much more than the average flow, there is little evidence either owner has spring or UG rights that could supplement the Water Canyon rights. Kennecott has no other irrigation rights and Adams-McGill has two decreed spring rights (V01162 and V01168) that are two townships south of Water Canyon (at T11N62E). Therefore, there is no basis for assuming the flow at this gage would be fully appropriated, or that stream rights at this point would have supplemental rights.

Stanka's methods would result in supplemental groundwater being 17.2 and 56.3 percent of the full appropriation for the Water Canyon and White River gages, respectively. Therefore, he used the average of 36.8 percent of supplemental UG/spring water to estimate the amount of supplemental UG/spring rights throughout WRV. Considering that the gages he used are not representative of most surface water sources in WRV (compare Figures 4 and 5 with Figure 10 in the next section), his adjustments are almost certainly inaccurate.

GBWN Exh_297, p 25



Muddy River Springs

Muddy River Springs are a spring system near the downstream end of WRFS. The CCFS model has four discharge points along the Muddy River using the stream package (which allows water to either enter or leave the water balance accounting). Low conductivity model cells and horizontal flow barriers direct groundwater flow toward the discharge boundary. The boundary Muddy River near Moapa is at the upstream end of the Muddy River discharge points and should reflect changes in the groundwater flow system upstream. Simulated discharge decreases almost 2000 af/y from 2004 to 2250 (Figure 35). Because of the decreases in flow from Delamar to Coyote Spring and Kane Springs Valleys (Figure 35), which are upstream of and tributary to the Muddy River system, decreases in discharge from these springs will likely continue far into the future, beyond 200 years. This indicates that the overall system will not approach equilibrium for a very long time beyond end of the simulations period. However,

there may be model-based reasons that pumpage stresses have not propagated to the Muddy River springs area, as discussed in the next paragraph.

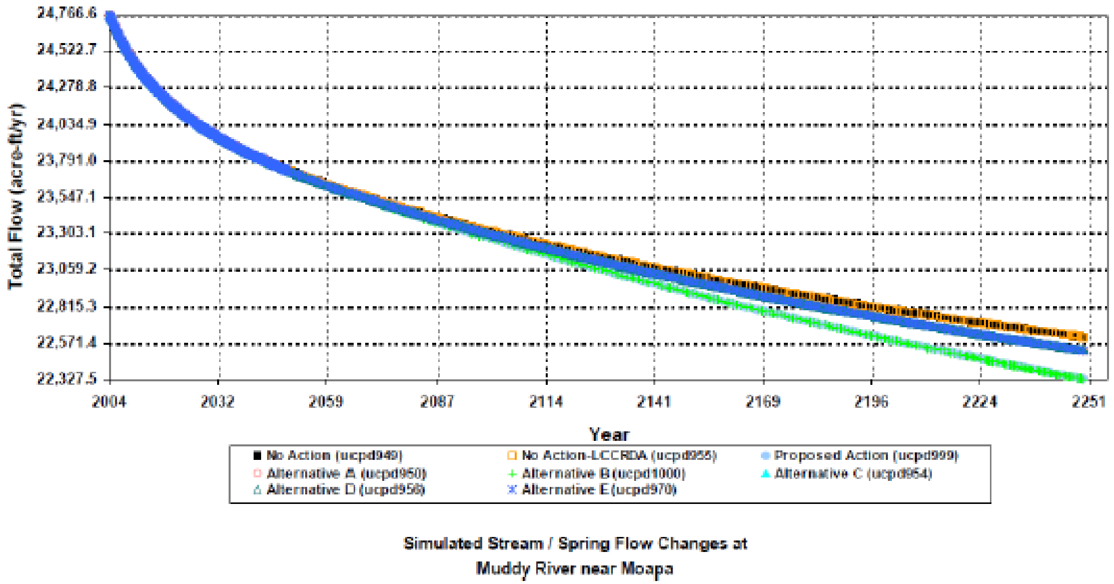


Figure 35: Snapshot of figure from file titled Springs_Hydrograph_Report_2005_2250 (BLM undated b). The graph shows flows at Muddy River Springs for various alternatives. Alternative F was not included and a file with Alternative F was not available. Because it pumps at higher rates, Muddy River Springs flow would decrease more under Alternative F than for Alternative E.

GBWN Exh_281, p 57, 58

The CCFS model simulated groundwater flow through carbonate formations and fault systems in the southern end of the White River Flow System. The model grid cells are one kilometer square. Most interbasin flow to Coyote Spring Valley emanates from Pahranagat Valley with additional flow from the northeast (Delamar and Kane Springs Valleys) and from the west (Death Valley Flow System) (Figure 16). Some of the flow from Pahranagat Valley entered that valley from Delamar Valley (Figure 16). Most of the interbasin flow, 49,200 af/y, exits Coyote Spring Valley into the Muddy River Springs area (Figure 36). Decreases in the interbasin groundwater flow that supports the spring discharge at the Muddy River near Moapa would manifest at the Muddy River near Moapa gage. However, the modeling minimizes potential flow changes because it does not accurately represent the hydrogeology of the model domain area that allows flow from upstream to reach the Muddy River Springs and that releases water from the aquifer pores spaces in response to pumping. The model cells are far too large and average too much variability in properties to accurately portray preferential flow through carbonate formations which would support the springs.

The surface formations in the southern portion of the area are generally carbonate rock with displacement faults that provide high conductivity pathways (Figure 37). The valleys are basin fill (Figure 37). North of Coyote Spring Valley there is more volcanic rock, although at depth there is some carbonate rock (Figure 37). Displacement faults provide a north-south conduit for flow, but none of the displacement faults, as simulated, connect the northern valleys such as Pahranagat with the Muddy River Springs area (Figure 37). The Pahranagat shear zone across the south end of that valley (Figure 37) causes the substantial drop in the water table across the shear zone (Figure 36). The model simulates the shear zone with horizontal flow barriers with relatively high conductivity carbonate rock.

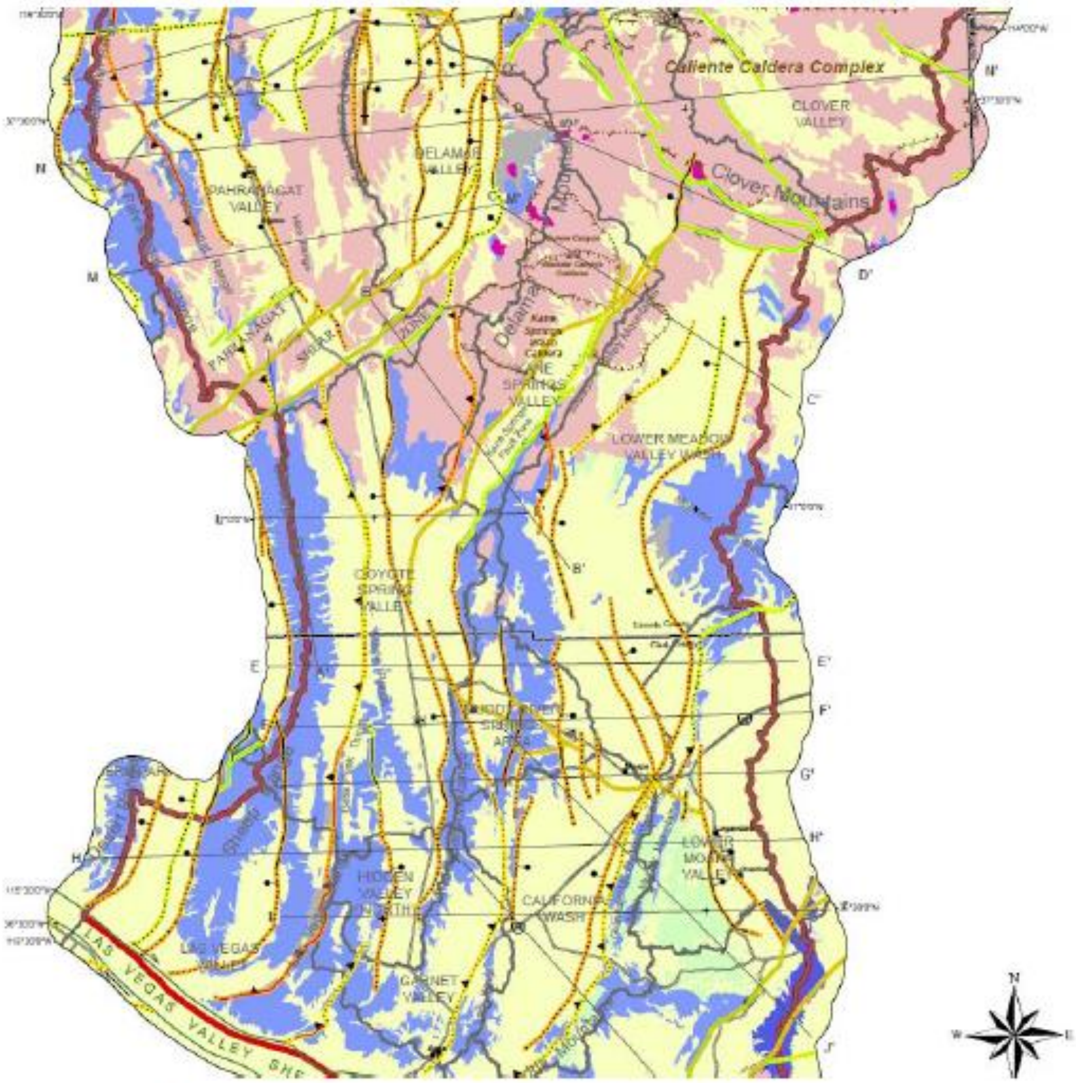


Figure 37: Snapshot of portion of Plate 2 (SNWA 2009a) showing surface geology and structure centered on Coyote Spring Valley with portions of surrounding valleys.

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Simulation of flow depends on the conductivity of the formations, with high conductivity zones along fault lines simulating flow along the fault. Parameterization for the area reflects carbonate rock hydrogeology with much higher conductivity for the fault zones, which the model simulates as 3280 feet or 1000 m wide (Figure 38). There is no evidence that faults affect flow over such a wide zone with conductivity two orders of magnitude higher than outside the fault. Caine et al (1996) describes how faults can be a barrier or a conduit, but provides nine examples of faults that are mostly less than 100 m wide, which is much less than the 1000 m wide cells in this model. SNWA (2008b), the geology study that forms the basis for the groundwater flow model, does not document the width of any faults nor show the importance of fault flow. The document notes that fault damage zones in carbonate rock may undergo dissolution to create large flow zones, but does not present any examples or references. Studies have shown that most flow through faults is concentrated in a very small portion of the fault, which would be a factor of the formation of the flow path. For example, for a geothermal fault system in the Great Basin northwest of this study area, Fairly and Hinds (2005) found that, based on detailed mapping of conductivity in an 800 by 100 m fault zone, the truly high permeability pathways conduct a very small proportion of the flow. "On the basis of our findings, we conclude that the flux transmitted by an individual fast-flow path is significantly greater than that of an average flow path, but the total flux transported in fast-flow paths is a negligible fraction of the total flux transmitted by the fault" (Fairly and Hinds 2005, abstract).

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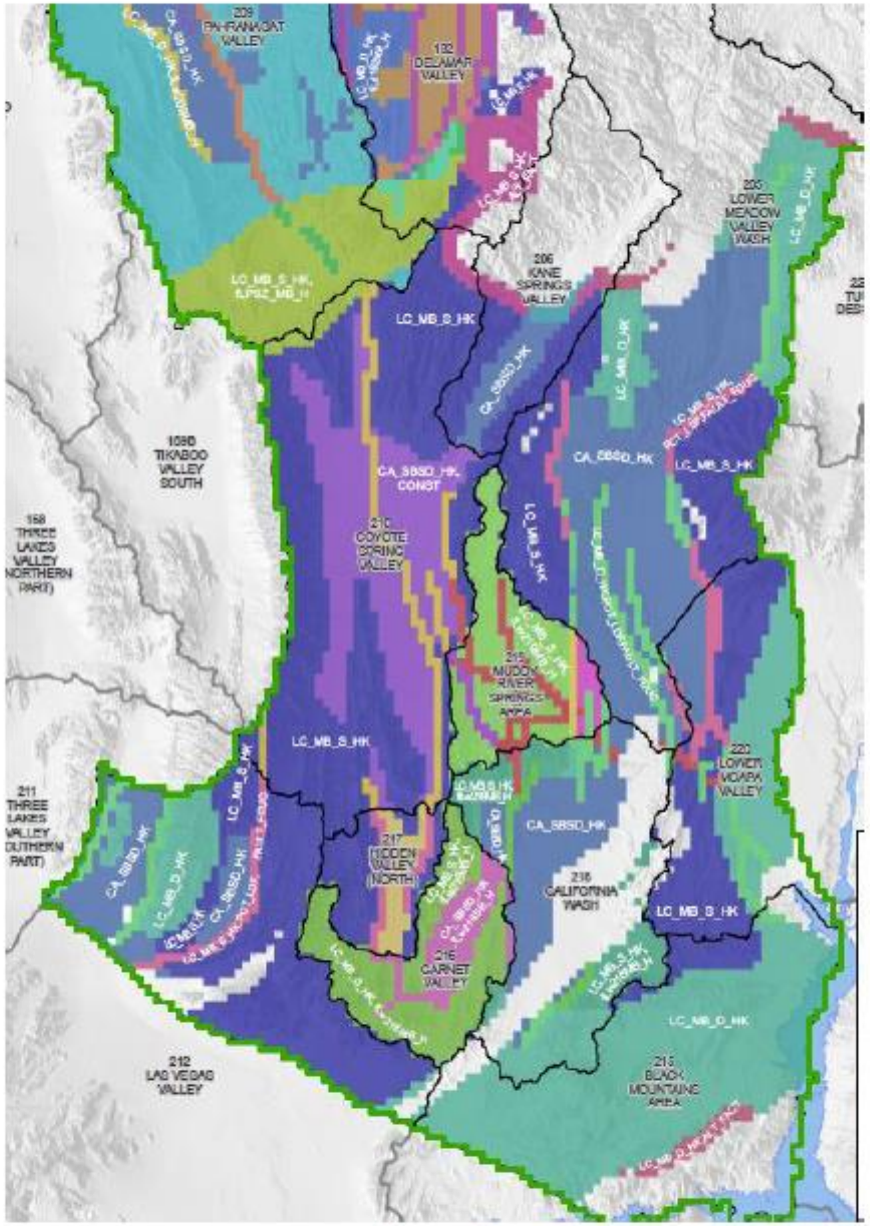


Figure 38: Snapshot of southern portion of the CCFS from Plate 1 (SNWA 2009d) showing parameter zones for carbonate rock formations.

area[3]. None of those maps describe the fault zone in a way that would indicate the zone differs from that described by Fairly and Hinds (2005) or that would justify the conductivity over a 1000 m wide cell being two orders of magnitude higher than the surrounding rock. Rowley et al (2011, p 2-11) stated that in Section 5 of the that report that "[D]etailed, high-quality geophysics, including seismic and audiomagnetotellurics (AMT) profiles and also gravity and aeromagnetic anomalies, provides even better estimates of fault widths." That section presents substantial geophysics but at no point provides width or thickness of fault zones nor does it discuss the hydrogeology of faults.

Even though a fault affects flow over a few tens of meters of width (Caine et al 1996) and significantly increases the conductivity over a much smaller proportion of the fault thickness, the CCFS model parameterizes faults over a 1-km width cell. With very high conductivity for pathways at least 1-km in width and up to 12,000 feet in thickness (up to seven model layers), the model transmits a very large flow rate to the Muddy River springs even with a very flat gradient, as described in the next paragraph.

Conductivity in the seven layers in the conduit shown in Coyote Spring Valley from layers 1 through 7 is 0.0278, 22.1, 61.4, 51.8, 40.2, 27.7, and 17.7 ft/d (Figure 39). Figure 39 does not specify layer thickness but the bottom is at -10,000 feet and the upper layer is at about 2000 feet; the upper layer with low conductivity is very thin. The average conductivity of the lower six layers is 36.8 ft/d, not weighted for layer thickness because the thicknesses are not provided. Gradient across a cell is quite variable, but the contours suggest about 20 feet over 3280 feet, or about 0.0061 ft/ft. Applying Darcy's law, the flow through just one north-south column of cells would be about 67,900 af/y. There would be flow exchange between the high K and surrounding lower K cells due to the surface not being perfectly flat. Figure 39 shows groundwater contours, in the upper cross-section showing conductivity by model cell and in the lower plan view, that converge on the high conductivity flow path that represents a fault zone.

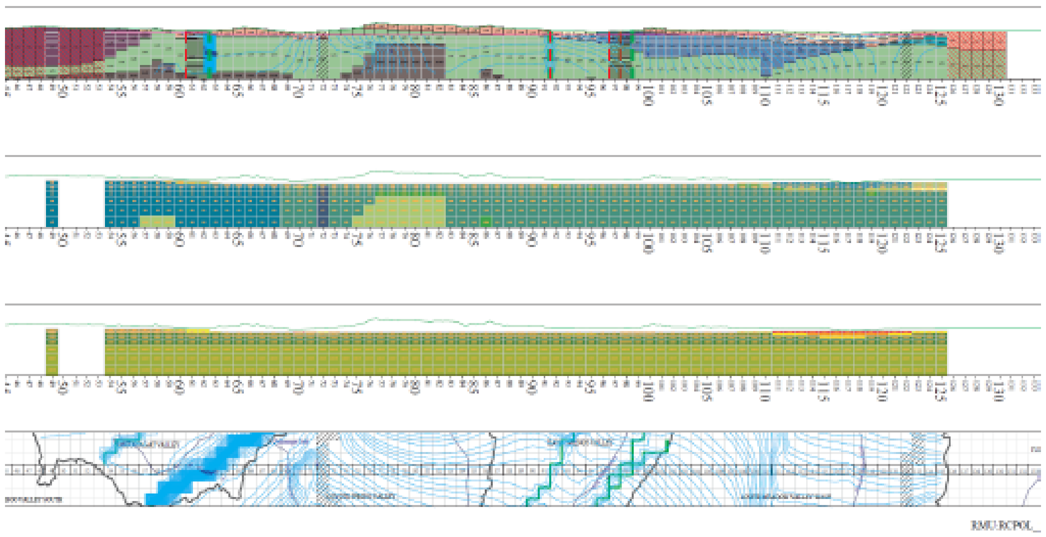
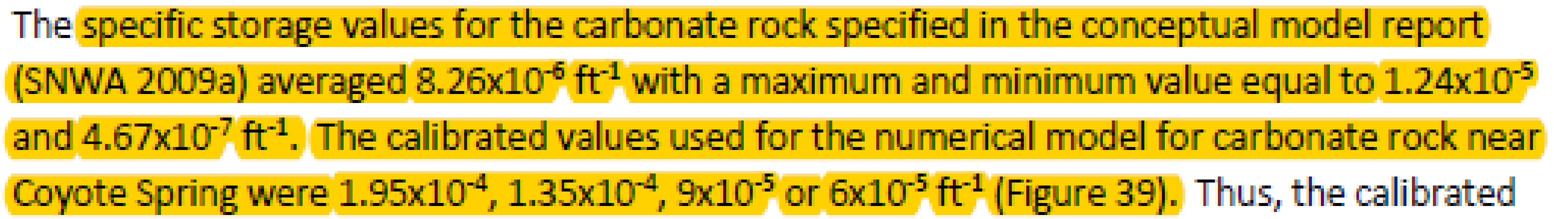
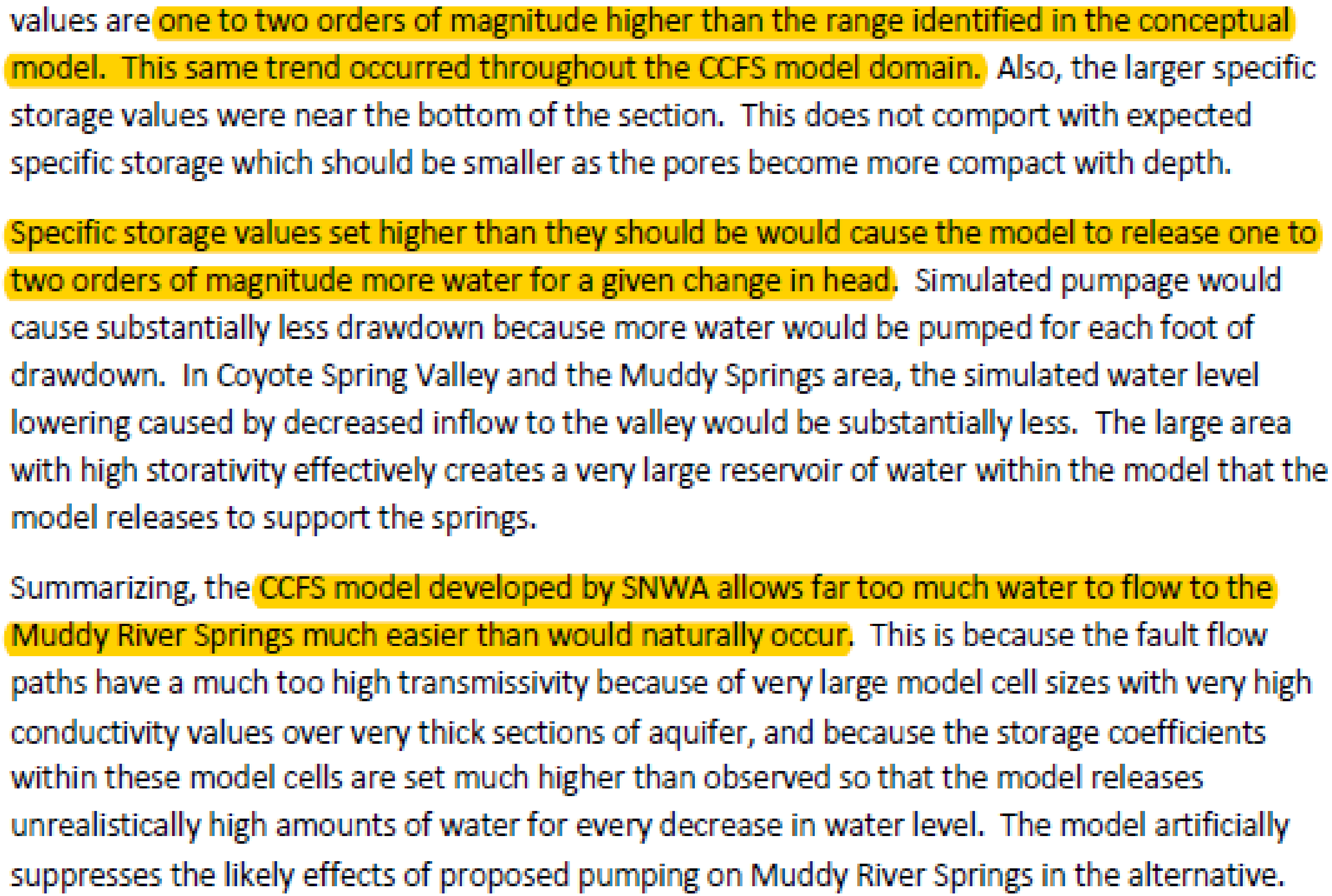


Figure 39: Snapshot of part of model row 359 from file xs>rmu>rows>rev2-7o-map-hd-kh-s-11lay-ucth813-1-474B showing the modeled formations (top row), conductivity (2nd row), specific storage (specific yield uppermost layer) (3rd row), and plan of 7 rows showing steady state water table contours and simulated faults. This section crosses the southern Pahranagat Valley (left), northern Coyote Springs Valley, central Kane Springs Valley, and Lower Meadow Valley Wash on the right. The green, blue, and purple in the upper row is carbonate rock with the cross-hatched column being a significant displacement fault. The second row is conductivity with the green ranging from 0.1 to 0.5 ft/d, the blue on the left being from 1.5 to 4.0 ft/d, and the vertical dark blue column ranging from 61.4 ft/d to 17.7 ft/d (3rd layer to bottom layer) to model the displacement fault. The third row is specific storage which ranges from 0.000196 ft-1 in the lower layer to .00006 in layer 3; there is no difference in the displacement fault. Water surface contours are 10-foot with the dense cluster on the southeast Pahranagat Valley being a 700 foot drop from about 3100 to 2400 feet, from NW to SE.

GBWN Exh_281, p 63, 64

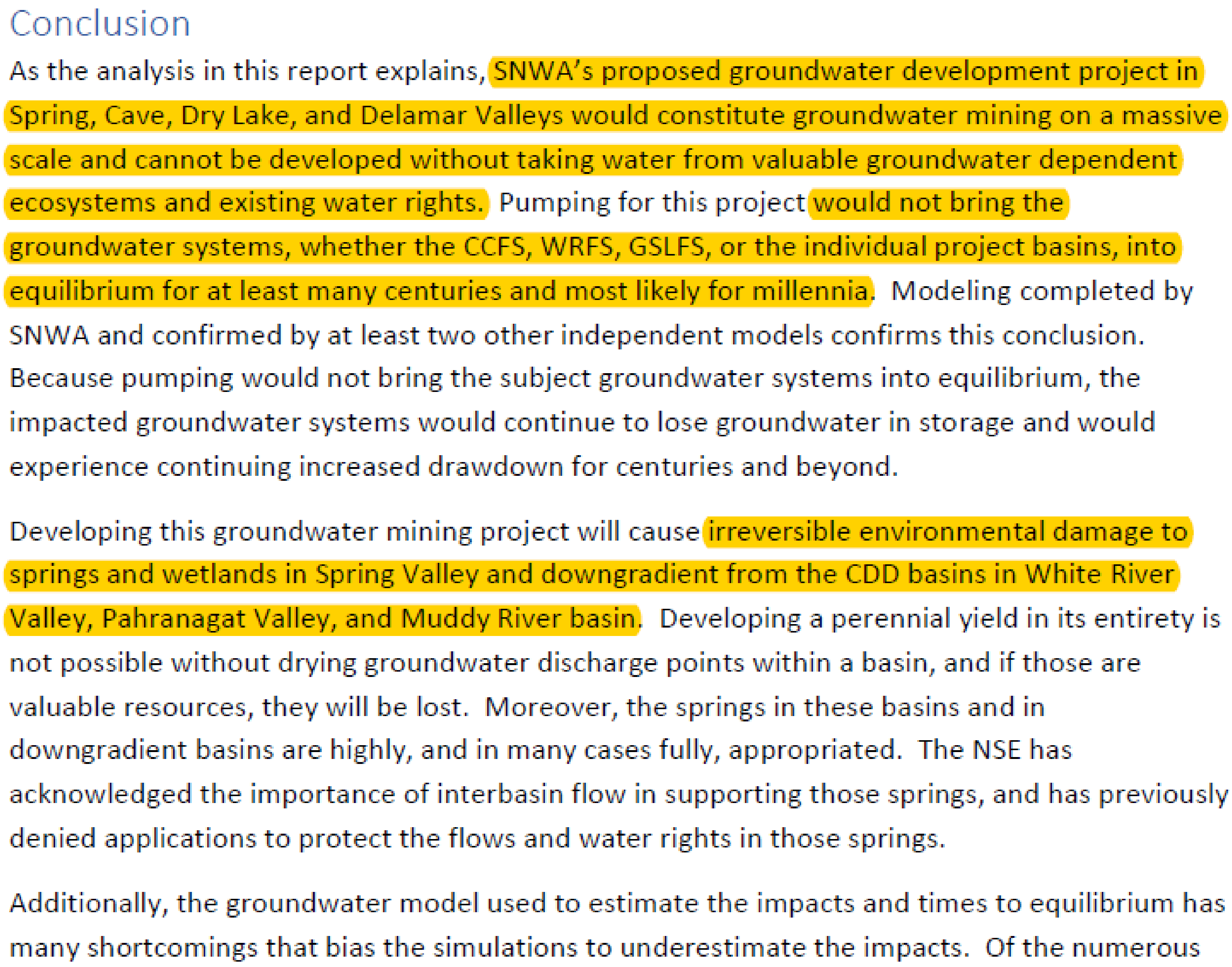
GBWN Exh_281, p 64, 65

The specific storage values for the carbonate rock specified in the conceptual model report (SNWA 2009a) averaged 8.26×10^{-6} ft^{-1} with a maximum and minimum value equal to 1.24×10^{-5} and 4.67×10^{-7} ft^{-1}. The calibrated values used for the numerical model for carbonate rock near Coyote Spring were 1.95×10^{-4}, 1.35×10^{-4}, 9×10^{-5} or 6×10^{-5} ft^{-1} (Figure 39). Thus, the calibrated values are one to two orders of magnitude higher than the range identified in the conceptual model. This same trend occurred throughout the CCFS model domain. Also, the larger specific storage values were near the bottom of the section. This does not comport with expected specific storage which should be smaller as the pores become more compact with depth.

Specific storage values set higher than they should be would cause the model to release one to two orders of magnitude more water for a given change in head. Simulated pumpage would cause substantially less drawdown because more water would be pumped for each foot of drawdown. In Coyote Spring Valley and the Muddy Springs area, the simulated water level lowering caused by decreased inflow to the valley would be substantially less. The large area with high storativity effectively creates a very large reservoir of water within the model that the model releases to support the springs.

Summarizing, the CCFS model developed by SNWA allows far too much water to flow to the Muddy River Springs much easier than would naturally occur. This is because the fault flow paths have a much too high transmissivity because of very large model cell sizes with very high conductivity values over very thick sections of aquifer, and because the storage coefficients within these model cells are set much higher than observed so that the model releases unrealistically high amounts of water for every decrease in water level. The model artificially suppresses the likely effects of proposed pumping on Muddy River Springs in the alternative.



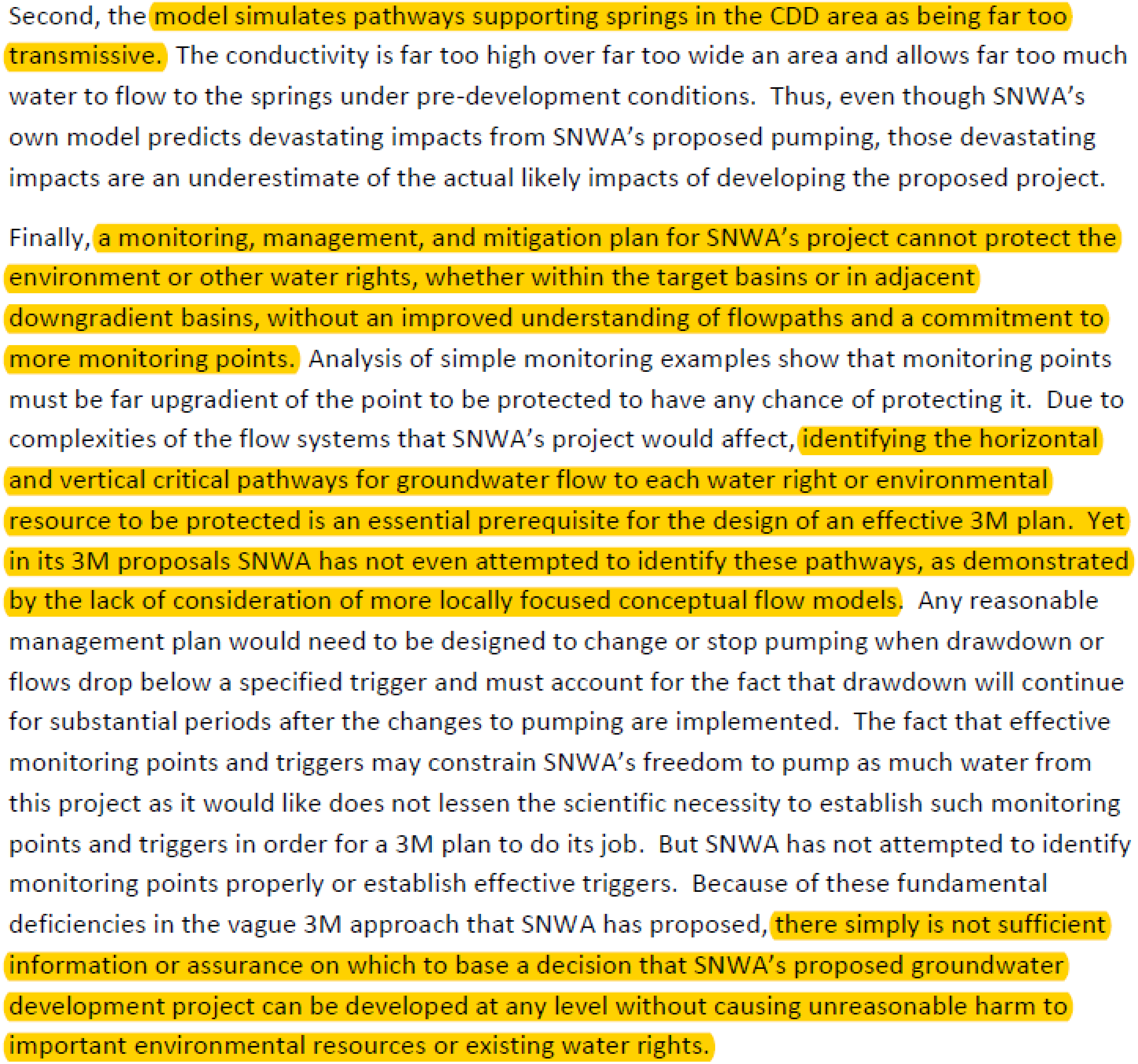
Conclusion

As the analysis in this report explains, SNWA's proposed groundwater development project in Spring, Cave, Dry Lake, and Delamar Valleys would constitute groundwater mining on a massive scale and cannot be developed without taking water from valuable groundwater dependent ecosystems and existing water rights. Pumping for this project would not bring the groundwater systems, whether the CCFS, WRFS, GSLFS, or the individual project basins, into equilibrium for at least many centuries and most likely for millennia. Modeling completed by SNWA and confirmed by at least two other independent models confirms this conclusion. Because pumping would not bring the subject groundwater systems into equilibrium, the impacted groundwater systems would continue to lose groundwater in storage and would experience continuing increased drawdown for centuries and beyond.

Developing this groundwater mining project will cause irreversible environmental damage to springs and wetlands in Spring Valley and downgradient from the CDD basins in White River Valley, Pahranagat Valley, and Muddy River basin. Developing a perennial yield in its entirety is not possible without drying groundwater discharge points within a basin, and if those are valuable resources, they will be lost. Moreover, the springs in these basins and in downgradient basins are highly, and in many cases fully, appropriated. The NSE has acknowledged the importance of interbasin flow in supporting those springs, and has previously denied applications to protect the flows and water rights in those springs.

Additionally, the groundwater model used to estimate the impacts and times to equilibrium has many shortcomings that bias the simulations to underestimate the impacts. Of the numerous

GBWN Exh_281, p 99



Second, the model simulates pathways supporting springs in the CDD area as being far too transmissive. The conductivity is far too high over far too wide an area and allows far too much water to flow to the springs under pre-development conditions. Thus, even though SNWA's own model predicts devastating impacts from SNWA's proposed pumping, those devastating impacts are an underestimate of the actual likely impacts of developing the proposed project.

Finally, a monitoring, management, and mitigation plan for SNWA's project cannot protect the environment or other water rights, whether within the target basins or in adjacent downgradient basins, without an improved understanding of flowpaths and a commitment to more monitoring points. Analysis of simple monitoring examples show that monitoring points must be far upgradient of the point to be protected to have any chance of protecting it. Due to complexities of the flow systems that SNWA's project would affect, identifying the horizontal and vertical critical pathways for groundwater flow to each water right or environmental resource to be protected is an essential prerequisite for the design of an effective 3M plan. Yet in its 3M proposals SNWA has not even attempted to identify these pathways, as demonstrated by the lack of consideration of more locally focused conceptual flow models. Any reasonable management plan would need to be designed to change or stop pumping when drawdown or flows drop below a specified trigger and must account for the fact that drawdown will continue for substantial periods after the changes to pumping are implemented. The fact that effective monitoring points and triggers may constrain SNWA's freedom to pump as much water from this project as it would like does not lessen the scientific necessity to establish such monitoring points and triggers in order for a 3M plan to do its job. But SNWA has not attempted to identify monitoring points properly or establish effective triggers. Because of these fundamental deficiencies in the vague 3M approach that SNWA has proposed, there simply is not sufficient information or assurance on which to base a decision that SNWA's proposed groundwater development project can be developed at any level without causing unreasonable harm to important environmental resources or existing water rights.

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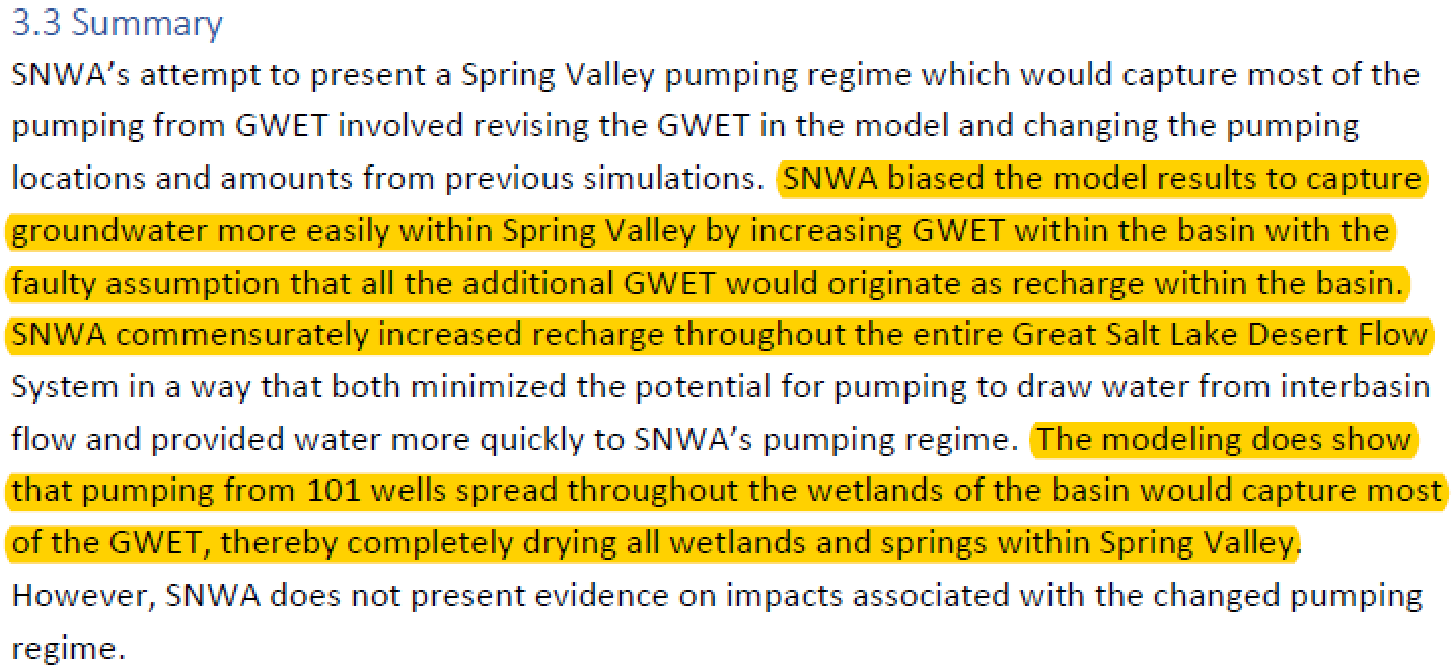

3.3 Summary

SNWA's attempt to present a Spring Valley pumping regime which would capture most of the pumping from GWET involved revising the GWET in the model and changing the pumping locations and amounts from previous simulations. SNWA biased the model results to capture groundwater more easily within Spring Valley by increasing GWET within the basin with the faulty assumption that all the additional GWET would originate as recharge within the basin. SNWA commensurately increased recharge throughout the entire Great Salt Lake Desert Flow System in a way that both minimized the potential for pumping to draw water from interbasin flow and provided water more quickly to SNWA's pumping regime. The modeling does show that pumping from 101 wells spread throughout the wetlands of the basin would capture most of the GWET, thereby completely drying all wetlands and springs within Spring Valley. However, SNWA does not present evidence on impacts associated with the changed pumping regime.

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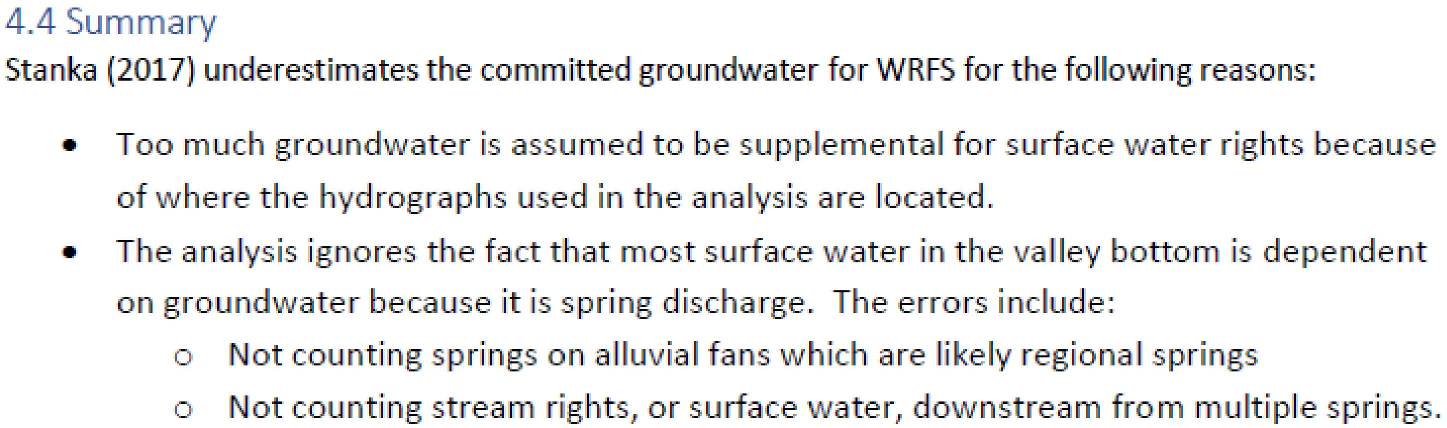
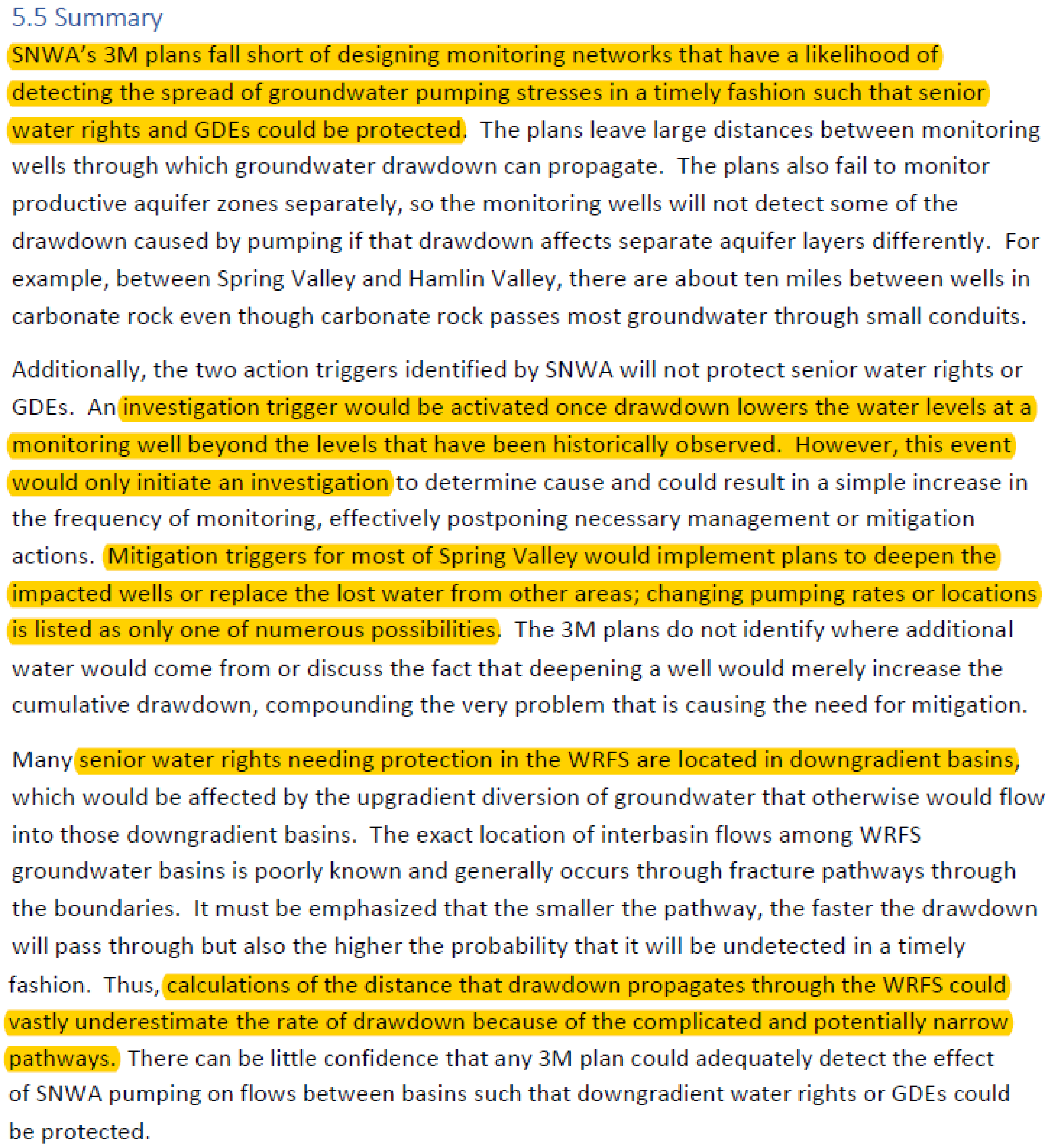


4.4 Summary

Stanka (2017) underestimates the committed groundwater for WRFS for the following reasons:

- Too much groundwater is assumed to be supplemental for surface water rights because of where the hydrographs used in the analysis are located.
- The analysis ignores the fact that most surface water in the valley bottom is dependent on groundwater because it is spring discharge. The errors include:
  - Not counting springs on alluvial fans which are likely regional springs
  - Not counting stream rights, or surface water, downstream from multiple springs.

GBWN Exh_297, p 29



5.5 Summary

SNWA's 3M plans fall short of designing monitoring networks that have a likelihood of detecting the spread of groundwater pumping stresses in a timely fashion such that senior water rights and GDEs could be protected. The plans leave large distances between monitoring wells through which groundwater drawdown can propagate. The plans also fail to monitor productive aquifer zones separately, so the monitoring wells will not detect some of the drawdown caused by pumping if that drawdown affects separate aquifer layers differently. For example, between Spring Valley and Hamlin Valley, there are about ten miles between wells in carbonate rock even though carbonate rock passes most groundwater through small conduits.

Additionally, the two action triggers identified by SNWA will not protect senior water rights or GDEs. An investigation trigger would be activated once drawdown lowers the water levels at a monitoring well beyond the levels that have been historically observed. However, this event would only initiate an investigation to determine cause and could result in a simple increase in the frequency of monitoring, effectively postponing necessary management or mitigation actions. Mitigation triggers for most of Spring Valley would implement plans to deepen the impacted wells or replace the lost water from other areas; changing pumping rates or locations is listed as only one of numerous possibilities. The 3M plans do not identify where additional water would come from or discuss the fact that deepening a well would merely increase the cumulative drawdown, compounding the very problem that is causing the need for mitigation.

Many senior water rights needing protection in the WRFS are located in downgradient basins, which would be affected by the upgradient diversion of groundwater that otherwise would flow into those downgradient basins. The exact location of interbasin flows among WRFS groundwater basins is poorly known and generally occurs through fracture pathways through the boundaries. It must be emphasized that the smaller the pathway, the faster the drawdown will pass through but also the higher the probability that it will be undetected in a timely fashion. Thus, calculations of the distance that drawdown propagates through the WRFS could vastly underestimate the rate of drawdown because of the complicated and potentially narrow pathways. There can be little confidence that any 3M plan could adequately detect the effect of SNWA pumping on flows between basins such that downgradient water rights or GDEs could be protected.

GBWN Exh_297, p 54, 55