Technical Memorandum
Review of Draft Environmental Impact Report for the Village at Squaw Valley Specific Plan

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Prepared for Sierra Watch
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SUMMARY

THE DRAFT ENVIRONMENTAL IMPACT REPORT OVERESTIMATES THE AMOUNT OF WATER IN SQUAW VALLEY AND UNDERESTIMATES DRAWDOWN FROM PROPOSED GROUNDWATER PUMPING

The Olympic Valley aquifer is small compared to the demand imposed on it. Recharge to the aquifer is approximately equal to the current demand, and pumping currently pulls water from Squaw Creek. Future development will increase the amount of water drawn from the creek and lower groundwater levels beneath meadows and riparian vegetation. The draft environmental impact report (DEIR) for the expansion of the Village at Squaw Valley acknowledges but grossly underestimates these impacts. The DEIR relies on an erroneous estimate of far more recharge to the aquifer than actually occurs because it uses a grossly incorrect estimate of precipitation in the valley. This excessive precipitation drives the numerical groundwater model which is used to estimate most of the other predictions discussed in the DEIR. The DEIR also underestimates drawdown because the modeling is based on nine pumping wells when the water supply assessment (WSA) assumes that just six well will be needed. The modeling spreads drawdown over a larger area than will actually occur. These problems with the hydrogeologic analysis will cause impacts to sensitive habitats to be much higher than predicted.

The conceptual flow model for the Olympic Valley aquifers includes recharge from rainfall on the alluvial valley, from runoff through streams on the alluvial valley, and from mountain runoff percolating into the aquifer at the mountain front. During runoff periods, the stream in the western part of the valley percolates water to the aquifer until groundwater levels rise level to the stream. Taking the form of runoff and stream flow, groundwater discharges into the creek as long as the groundwater level is above the stream level. Late in the summer season in most years, the groundwater level falls below the stream bottom so that groundwater discharge to the stream ceases. Current pumping in this area increases the rate that groundwater levels decrease and proposed future pumping will increase the length of dry stream segments and the time period during which the stream is dry. Climate change that increase the ratio of rain to snow and snowmelt to occur earlier will increase the length of the dry part of summer during which the groundwater does not discharge to Squaw Creek in the western part of the valley.

East of the village, the meadow and a non-channelized, meandering, stream gains flow from groundwater discharge most of the time because groundwater levels remain high most of the year. There is little current or proposed pumping in the middle of the meadow to cause drawdown and affect

streamflow. Drawdown is concentrated in the western reach of Squaw Creek but does extend into the meadow just east of the parking area and increase critical low flow and drawdown conditions.

THE DEIR USES AN ESTIMATE OF RECHARGE THAT IS GROSSLY TOO HIGH. THIS ERROR CAUSES MANY OTHER ASPECTS OF THE ANALYSIS TO MINIMIZE THE PROJECTED IMPACTS

Recharge depends on precipitation reaching the valley floor, but the high mountain precipitation reported in the WSA is grossly wrong, being estimated as 263 inches per year for 1993 through 2011 which at a 1:10 ratio equates to 219 feet of snow. The Snotel site for the valley shows that that the annual average for that period is 80.6 in/y. This erroneous precipitation estimate is prominent in DEIR references since 2011. Recharge used in the groundwater model increased from about 680 af/y in 2001 to about 3800 af/y because the precipitation estimate increased. Running much more water through the model caused the calibrated hydraulic conductivity to be increased by an order of magnitude which in turn decreases the predicted drawdown caused by pumping. The recharge overestimate also makes more water available to be pumped over a longer time period which offsets pumping demands and limits predicted drawdown.

THE GROUNDWATER MODELING FOR THE PROJECT MINIMIZES THE PREDICTION OF PUMPING IMPACTS BY SPREADING PUMPING OVER MORE NEW WELLS THAN ARE PROPOSED TO BE CONSTRUCTED

The groundwater model used nine new municipal wells to simulate future water supply conditions and predict drawdowns even though the WSA determined that only six new wells would be constructed. Extra wells spread the predicted drawdown over a larger area and makes the vertical drawdown much less. In fact, simulated pumping of the expected 2040 demand from existing and proposed new wells caused the model to estimate less drawdown in areas than the current pumping causes.

THE DEIR UNDERESTIMATES THE PROJECT'S DEMAND FOR WATER AND FAILS TO CONSIDER A RANGE OF LIKELY DEMAND DISTRIBUTIONS

Projected water demand could be incorrectly incorporated into other analyses in the DEIR for at least two reasons. The demand was based on occupancy during the economic recession from 2009 through 2011 and is therefore likely too low. Adjusting this to closer to full occupancy and a few demand factors could increase overall project demand as much as 80%. The second is the distribution of demand. More demand especially in late summer would cause even more drawdown lengthening dry periods and the length of dry stream.

Potentially underestimated demand drawn from more wells than necessary, too much recharge and aquifer parameters that are too transmissive because the model runs too much recharge through it, and ignoring climate change which could decrease the recharge period together cause the DEIR to underestimate impacts caused by the project.

The presentation of impacts in the DEIR are not as quantitative as they should be. The DEIR should include a much more quantitative assessment of drawdown at various locations. Rather than simple assessments of whether the drawdown takes the water level below a given threshold, such as ten feet beneath a stream or riparian area, the DEIR should present drawdown frequency graphs at each point of interest. This would show how much longer the project would draw the groundwater below certain levels, rather than simply assessing whether it goes below a threshold. The DEIR should also provide

improved quantitative descriptions of the changes in flow to Squaw Creek. It should show the changes in flow for different time periods.

THE DEIR FAILS TO ANALYZE ENVIRONMENTALLY SUPERIOR PUMPING PRACTICES

The DEIR analyzes just the alternative of increased pumping associated with increased development. An alternative that should be considered is pumping from certain wells based on the effects it would have on the creek. For example, pumping from wells near the creek has the largest impact on streamflow during the period which streamflow is decreasing from snowmelt runoff to being dry in the western portion of the project. An alternative would be to concentrate pumping near the creek during runoff to draw as much from the creek as possible and to pump as far from the creek as possible during baseflow. When the creek is dry, the effect of pumping near it is much less so the pumping distribution is less important at that time.

THE DEIR DOES NOT ASSESS QUANTITATIVELY THE IMPACTS OF CHANNEL RESTORATION ON SQUAW CREEK. THE DEIR MAKES UNPROVEN CLAIMS ABOUT THE NEW CHANNEL DECREASING SUSPENDED SEDIMENT IN THE STREAM. ESTIMATES OF SEDIMENT TRANSPORT THROUGH THE PROJECT ARE TOO SMALL

The project proposes a restoration of the currently channelized section of Squaw Creek through the project site. The new channel will increase the flood conveyance and also increase the size of a floodplain that high flows can access. The channel will include a low-flow channel as well. The DEIR does not provide a substantial quantitative analysis of the new channel. However, the new channel will probably decrease the sediment transport through the reach by capturing some on the widened floodplains. This will decrease sediment entering the meadow reach which could increase the erosive capacity through the meadow and cause more erosion in the meadow. The DEIR has not considered these impacts, but could do so by including a water surface profile analysis that considers sediment transport

The project will have little impact on sediment flowing off of the upstream watershed areas, but the DEIR predicts that transport from the developed areas will reduce from 200 to 175 tons/y. This is a small proportion of the almost 39,000 tons/y generated by the watershed. The DEIR has underestimated sediment production at high flows from all areas, therefore the overall estimates of sediment production may be too small.

THE DEIR DOES NOT ACCOUNT FOR THE EFFECTS THAT CLIMATE CHANGE WILL HAVE ON THE PROJECT'S ABILITY TO MEET DEMAND WITHOUT CAUSING ADDITIONAL IMPACTS

The DEIR has a chapter concerning climate, but it mostly deals with greenhouse gas emissions from the project. The chapter notes potential changes in snowfall and runoff due to climate change, but there is no consideration in the groundwater model simulations of future conditions of climate change causing more precipitation to fall as rain or for snowmelt occurring earlier in the year. Climate change is also likely to lengthen the dry, or no-recharge, period of a year so there will likely be longer periods during the summer when the stream is dry and no recharge is occurring.

INTRODUCTION

The draft Village at Squaw Valley Specific Plain EIR (DEIR) reviews plans to develop the proposed Village at Squaw Valley Specific Plan (VSVSP), an expansion of hotel and residential development in Squaw Valley CA. The expansion would include a substantial increase in the amount of groundwater pumped for residential and commercial uses in the valley. A separate water supply assessment (WSA) (Farr West et al. 2014) was prepared to evaluate whether there is sufficient water available for the project. The DEIR attaches the WSA as Appendix C and refers to it throughout the water supply discussions.

This technical memorandum reviews hydrogeology and water resources aspects of the DEIR. I completed a separate review of the WSA and attached the review to this memorandum as Attachment 2. The DEIR refers to many hydrogeology studies done as part of the WSA, so my review of the WSA supplements this DEIR review. There are overlaps in review comments because of the similarity of the analysis in each document.

DEIR Chapter 13 contains the primary discussion on hydrogeology, but other chapters add to or rely on the hydrogeology section. Chapter 6 considers the impacts that changes to the hydrogeology have to biological resources. Chapter 14 discusses how changes in public services affect water resources and chapter 18 discusses cumulative impacts which includes the hydrologic and water resources impacts of full development in Squaw Valley.

The DEIR compares the project-induced conditions to baseline conditions. Because the project would occur along with other local growth, the 2040 WSA scenario is with project along with cumulative development in the valley. Baseline is "a description of the physical environmental conditions in the vicinity of the project, as they exist at the time the notice of preparation is published …" (DEIR, p 1-3). The DEIR determines baseline groundwater conditions as those that would occur due to pumping at the level of development that existed when Placer County issued the notice of preparation, or October 10, 2012, not the groundwater conditions as exist on that date.

The format of this technical memorandum follows that of the DEIR. There are major sections on biological and hydrogeological resources, following the Chapters 6 and 13 in the DEIR. Discussions of public utilities and cumulative impacts are included in the relevant sections. Subsections include the impact and mitigation features as specified in the DEIR.

BIOLOGICAL RESOURCES

The biological resources chapter describes and analyzes project impacts to ecosystems on and around the project site. From a hydrologic perspective, the ecosystems of most importance are those associated with the streams, specifically the main channel and North and South Forks of Squaw Creek, and the Olympic Channel. Squaw Creek flows through the project site and a meadow east of the site. Also of importance are riparian areas, wetlands, jurisdictional or not, and seeps. The hydrologic issues primarily pertain to groundwater development for the proposed project, to sediment transport to and through the project site, and to stream habitat issues as affected by grading and proposed stream restoration. Increased groundwater pumping (over existing or baseline conditions) will lower the water table which would change groundwater flows to and from the stream and lower groundwater levels below meadows and riparian areas. Stream channel restoration of Squaw Creek will change streamflow and sediment transport through the reach and into the meadow.

Land cover maps 1 and 2 show the ecosystem, or land cover, types through the project area. They include various sensitive habitats, such as intermittent stream and seeps. DEIR descriptions of the sensitive habitats (DEIR, p 6-10 – 6-14) are insufficient and inaccurate because they do not explain their dependency on groundwater and runoff. For each habitat, the description should include how the vegetation gets its water – whether it survives on snowmelt and rainfall with groundwater too deep to supplement late in the summer or whether it is partially dependent on groundwater. It should also describe the average depth to groundwater in spring and fall. This type of description is necessary because the availability of groundwater controls these habitats and the proposed project would affect groundwater more than just about any other development factor.

The same suggestions regarding groundwater dependence applies to DEIR Tables 6-2 and 6-4. The description of habitat in Table 6-2 notes soil moisture and the presence of seeps and springs, but to understand the effects groundwater management could have it is necessary to know the groundwater conditions for the species. Table 6-4 lists the area of specific wetlands and other waters of the U.S., but should also provide the depth to groundwater to assess the impacts of groundwater management. Additionally, the DEIR should add a table of special status species potentially on the site (Impact 6-8) showing their groundwater requirements, both required and as existing on the site.

The description of Squaw Creek states that there are "deeper pockets of water … behind boulder clusters within the stream channel" (DEIR, p 6-11), referring to stream segments in the meadow east of the proposed project. Deep pockets may contain water perennially and can be quite valuable habitat, and GANDA (2014) considers the impacts of lowering groundwater on this habitat. The DEIR should better describe this deep pool habitat because of its importance. A detailed map of the intermittent stream reaches (DEIR, p 6-10, -11) is also necessary, including a detailed map of the reach over which Squaw Creek is channelized.

Impact 6-1: Removal or degradation of sensitive habitats (jurisdictional wetlands, wet meadows, and riparian vegetation)

Impact 6-1 concerns the direct removal of wetland, meadow, and riparian habitat by construction and ancillary effects of the project that can affect these habitats. Ancillary effects are those caused by groundwater drawdown or changes in surface or groundwater flows. Simulated monitoring wells in the groundwater model are used to track the groundwater level under the stream and sensitive wetlands, as described and critiqued below in the section regarding Impact 13-5. The effects of groundwater drawdown on sensitive habitat are assessed using simulated monitoring wells in the groundwater model. The hydrogeologic effects contribute to other impacts discussed in the biology chapter, including most directly Impact 6-2 (Disturbance or loss of Sierra Nevada yellow-legged frog habitat), Impact 6-3 (Disturbances to nesting raptors and special-status birds), and Impact 6-8 (Disturbance or loss of special-status plants). With respect to hydrogeology, the comments herein regarding Impact 6-1 apply to the habitat being affected for the other biological impacts.

<u>Meadow Vegetation</u>

Groundwater management will lower groundwater levels below the various thresholds specified for specific vegetation types more frequently than currently happens (DEIR, p 6-42). However, the DEIR does not specify, based on model results, the increased periods over which these effects will occur. In other words, under the baseline condition, water levels may drop below the threshold for several

weeks, but under the WSA 2040 or project conditions this period groundwater levels being below the threshold may be longer. The DEIR does not discuss this impact. For example, regarding meadow vegetation, under WSA 2040 conditions, the driest years "would have seasons where groundwater levels drop below the threshold of meadow functionality for the majority of the growing season" but because this die off is a "regular part of ecosystem function," the DEIR claims that meadow vegetation will return during wetter years and concludes the "reduction in meadow vegetation or vegetation productivity during dry years would be minimal and temporary" (DEIR, p 6-44) However, the DEIR does not explain or provide evidence in support of this conclusion.

The DEIR should specify how long simulated drawdown exceeds the threshold during baseline conditions and during WSA 2040 conditions. The DEIR should include a map showing the areas in which groundwater levels will drop beneath certain thresholds for specified time periods.

Riparian Vegetation

The DEIR discussion concerning riparian vegetation has the same issues as for meadow vegetation. The DEIR claims that cottonwoods can be found where groundwater tables are up to 29 feet below ground surface (bgs) and that cottonwoods and willows can be found in the western channel of Squaw Creek where "groundwater elevations can reach 15-17 feet below the ground surface" (DEIR, p 6-42). Deep roots as observed near Squaw Creek indicate that the groundwater level lowers to these levels as often as annually (Id.). These statements should have a reference. The DEIR notes however that "long-term survival and productivity of established and young trees in cottonwood and willow forests appears to typically require groundwater less than 10 feet from the surface and any rapid declines in groundwater depth are not greater than 3.3 feet from lowest annual baseline levels for more than a few weeks or year to year" (Id.). The various studies referenced (see DEIR p 6-42) are for areas other than Squaw Valley. The fact that cottonwood and willow roots in Squaw Valley are substantially lower than the 10-feet threshold specified by the many studies cited in the DEIR indicates strongly that groundwater conditions already stress the existing riparian vegetation. It is probable that existing conditions would not allow new riparian trees to become established in areas where the groundwater levels already drop below ten feet bgs. The DEIR should consider a threshold at the depth of the existing roots in addition to the 10-foot threshold (DEIR, p 6-43).

The establishment of seedlings requires "groundwater depth from surface <3.3 feet" (DEIR, p 6-43), therefore the DEIR should provide graphs or analysis comparing the time the water table is within 3.3 feet of the surface for both baseline and WSA 2040 conditions. Pumping will cause the water level to be more than 3.3 feet below baseline for much more than a few weeks in many years. The DEIR's argument that this causes no problem (DEIR, p 6-42) is obviously wrong. The DEIR should assess the additional time the WSA 2040 condition water level is more than 3.3 feet below baseline by year to show a quantitative analysis. Additionally, germination of seeds requires the ground surface to be saturated (see biologists report reviewing the DEIR), so the DEIR should report similarly the frequency of the water table being at the ground surface for baseline and project conditions.

There are at least three significant thresholds affecting riparian vegetation – 3.3 ft bgs, 10 ft bgs, and 15 to 29 ft bgs, as described in the previous two paragraphs. The water table in many model cells drops below these threshold in some years under baseline conditions but under WSA 2040 conditions the groundwater level will drop below the thresholds for longer time periods in more years (I review the accuracy of the graphs analyzing the groundwater levels below in the groundwater review section). To

quantitatively assess the increased times the groundwater level is below the thresholds, the DEIR should present a drawdown frequency analysis for each monitored model cell showing the actual time groundwater levels go below various levels. The DEIR should also provide a graph showing the amount of time the drawdown exceeds a given drawdown to compare to known root depths.

The bullet point statements on p 6-43 could be quantified using the graphics suggested in the previous paragraphs. The DEIR does not present sufficient evidence to support its conclusion that "groundwater withdrawals …, if managed as currently modelled, are unlikely to result in mortality to established perennial riparian vegetation within the western channel or upper meadow reach" (DEIR, p 6-43, -44). The analysis was qualitative, and the preceding paragraphs specified several graphical analyses which would allow a quantitative comparison among scenarios, especially between WSA 2040 and baseline conditions.

Additionally, modeling of groundwater management underestimates the actual drawdown because the modelers used more wells than projected by the WSA. The modeling spread drawdown over a larger area and caused some predicted water levels to actually be higher than for the baseline. This is discussed in more detail below in the groundwater section.

Groundwater drawdown causes much of the impacts to the ecosystem, but the DEIR does not show a drawdown map. To show potential impacts, these land cover **maps should be shown with the minimum groundwater saturation at several time periods, such as after drought periods.** This would allow visual consideration of which habitats could be harmed by drawdown and where.

<u>Water Quality (DEIR p 6-45)</u>

The DEIR claims that "operation of the Specific Plan" would not create adverse impacts to water quality … related to stormwater management from any changes to creek peak flow, total volume, velocity, or TMDL" (DEIR, p 6-45). The DEIR acknowledges that groundwater impacts to vegetation and snow storage could cause water quality issues (Id.).

Groundwater drawdown could kill some riparian or meadow habitat, as discussed above, which would cause streambank instability because Squaw Creek's banks are sensitive to reductions in vegetation (DEIR, p 6-46). Although acknowledging the impact could be significant, the DEIR does not quantify the potential pollution.

The project will not change total suspended sediment or other quality parameters flowing the through site substantially because there will be little change in impervious area. Storm runoff from the project site will only change by small amounts, mostly decreasing (Shaw and Roberts 2013). The project will not substantially change operations for the watershed above the project site but will pass flows through the site as at present. The biggest change will be a restoration of the trapezoidal channel. Details are reviewed below in the hydrogeology section, but it must be noted that the DEIR discusses that the restoration should decrease sediment transport but does not quantify the amount.

<u>Proposed Mitigation</u>

Mitigation measure 6-1c ensures the "adoption of performance standards, thresholds, and recommendations from the WSA for well system operation, and requiring consistency with applicable groundwater plans" (DEIR, p 6-49). Project-induced drawdown will probably cause vegetation to

respond over time, so monitoring of the vegetation (both meadow and riparian) health is essential. Because the impacts manifest slowly, this monitoring could trigger management changes that will help prevent bad effects on the vegetation. Five years of monitoring beyond project build-out is grossly insufficient because of the slow manifestation of vegetation change and because of the potential for unusually wet years to temporarily compensate for project impacts. Riparian vegetation monitoring should continue until a significant drought has occurred with full project buildout conditions with ongoing monitoring.

A potential compensation for lost riparian vegetation is "irrigation of riparian vegetation to maintain existing habitat" (Id.). This is not a good mitigation strategy because it typically removes more water from the same source to mitigate the loss and ultimately exacerbates the problem into the future.

Mitigation measure 6-1c suggests they substitute modeling for monitoring if the groundwater "modelling indicates that changes in groundwater conditions under the proposed groundwater management regime would not result in a significant adverse effect to riparian and meadow habitat" (DEIR, p 6-50). This is inappropriate because monitoring is required to verify the modeling is yielding accurate predictions. Modeling is not a substitute for monitoring but rather a means of making choices regarding management – choices that may be changed due to monitoring.

Points in mitigation measure 6-1d are from groundwater mitigation measures and will be reviewed below.

Impact 6-11: Construction phase water quality degradation impacts to fish and aquatic resources.

This impact concerns the potential for sediment and other pollution to reach Squaw Creek as a result of active construction activities. The DEIR implies that best management practices (BMPs) would be used to avoid erosion and sediment problems, and acknowledges that if the BMPs fail the project could cause substantial pollution (DEIR, p 6-76). This is a big "if", especially in the sensitive environment of Squaw Valley. The DEIR should analyze the effectiveness of proposed BMPs as part of this DEIR.

The hydrogeology chapter describes mitigation measure 6-11, so these will be reviewed below.

Impact 6-13: Potential long-term impacts to fish and aquatic resources related to increased groundwater extraction …

This impact addresses impacts to fish and aquatic resources related to groundwater management, including the potential for flow changes and the consequent effects on streambank stability (which relates to riparian vegetation, as discussed above). The decreased groundwater levels due to groundwater management will decrease flows and impact vegetation, potentially destabilizing banks. As noted for Impact 6-1, I review the hydrogeology details below.

The DEIR makes an important acknowledgement discussing this impact: "However, if the wellfield is not configured and operated as indicated in the WSA, longer and more frequent drying periods could occur, which could threaten the ability of the creek reaches near the well field to maintain a fish community. In addition, vegetation loss resulting from reduced groundwater could lead to potential erosion and adverse impacts to fish and fish habitat" (DEIR, p 6-79). This effectively acknowledges that if the plan is not followed, the impacts could be much worse. The wellfield will not be configured and operated as modelled for the WSA because the modeling has more wells than the WSA expects to be required; the

WSA estimated a certain number of wells be added to meet demand but simulated several more. See the discussion below on the model and the review of the WSA in Attachment 2. The DEIR should also note that if the groundwater model predictions are not accurate, the impacts could be much worse as well.

Impact 6-14: Long-term changes to fish and aquatic resource habitat in the main Village reach of Squaw Creek due to creek restoration.

In general, the plan intends to restore the channelized portion of Squaw Creek through the main Village area. The DEIR concludes this would be a beneficial impact. I review details of the hydrogeology below, but some of the suggested biologic impacts may be overstated. It suggests that the areas of deep pools at low flow will increase, but this could be countered by the additional drawdown. If the stream bottom is lowered substantially, the increased shallow groundwater could actually increase the groundwater discharge from the streambed. However, increased surface water storage volume in the pools could increase the flows in the stream. The claim that geomorphic restoration would reduce fine sediment supply and transport, increase average substrate size, and decrease embeddedness requires verification. The hydrogeology review (DEIR, p 13-76) notes that if not done properly, the "creek restoration may not provide the anticipated benefits" (Id.).

HYDROGEOLOGY AND WATER RESOURCES

The hydrogeology chapter starts with a general description of the watershed and climate, which is generally accurate except there is a **major error with the precipitation shown for Squaw Valley** in Exhibit 13-3 and it carries through the DEIR. The error was also in the WSA (see the review of the WSA in Attachment 2). The suggestion is that annual precipitation at the Squaw Valley Snotel site equals 263 in/y (DEIR, p 13-7). If true, this would be the highest precipitation in the country, excepting a spot or two in Hawaii. Records show that only on the coast of Oregon and Washington does annual precipitation exceed 100 in/y in the continental United States (http://www.currentresults.com/Weather-Extremes/US/wettest.php). Attachment 1 shows the monthly precipitation data for the Squaw Valley Snotel Site. The annual average for 1993-2011 is 80.6 in/y, and since 1981, the average is 71 inches. This is snow-melt equivalent. The 263 inches at a 1:10 ratio would be 219 feet of snow. This erroneous precipitation estimate is prominent in documents and analyses since 2011, except for Shaw et al. (2014, p 5) who indicate the Snotel site gives an average annual precipitation of 65.2 inches.

This error leads much of the DEIR analysis and discussion to underestimate the impacts of the water development. This is because the precipitation drives the recharge estimate for the project. This will be discussed in detail below but it means that every estimated impact due to groundwater production has been underestimated.

The DEIR and some of the groundwater reports claim that groundwater levels fully recover even in dry years. However, data presented in the DEIR contradicts that statement. Groundwater levels fluctuate 10 to 15 feet seasonally and recover to within 10 feet in half of the years. (DEIR, p 13-13). It is not appropriate to say that "even in years with below average precipitation groundwater levels rose to "near the maximum elevations" (DEIR, p 13-13) in a basin that only recovers to a fraction of the annual fluctuation in half of the years. Exhibit 13-8 demonstrates clearly that the average groundwater annual maximum fluctuates up to at least seven feet (J-93 to J-01). The aquifer is generally no more than 150

feet thick (Hydrometrics 2014, West-Yost 2003), so the maximum levels fluctuate almost 10%. The overall average fluctuation is almost 15 feet.

The DEIR also relies on the WSA's conclusion that recharge is rejected because it is available when the basin is already full. It is not correct to state that runoff is "rejected as recharge" (DEIR, p 3-17) due to the aquifer being full. DEIR Exhibit 13-9 does not support this conclusion but shows the aquifer is 100% saturated at most in small parts of two years. In other years, the maximum percent saturation is always a few percent less than full. Exhibit 13-8 shows up to ten feet available in an aquifer that fluctuates from 10 to 15 feet. During snowmelt and significant rain events, substantial runoff may occur because the snowmelt or rainfall rate exceeds the ability of the soil to accept it as infiltration or because the soil has become saturated and cannot accept more infiltration. This is different from saying that the aquifer is full and rejecting recharge.

The DEIR erroneously claims that "pumping from existing wells during periods when Squaw Creek is flowing … captures only a small amount of extracted water from the creek" (DEIR, p 13-18). The claim then that "current groundwater pumping does not substantially alter stream flow" (Id.) is wrong. The WSA estimates that a municipal well pumping at a "customary 8-hour pumping cycle" would capture only 2% of its flow from Squaw Creek. The estimate of the amount of water drawn from Squaw Creek is likely too low because the calculation does not account for cumulative effects because it assumes that at the beginning of any pumping cycle the amount being drawn from the creek is zero. Hydrometrics used a standard formula (Hunt 1999) to estimate the amount of water that the pump test draws from the creek (Hydrometrics 2013a, p 17). Assuming they applied the method properly, they estimated that after 51 hours of pumping (test #1, see Hydrometrics 2013a), 17% of the amount being pumped was being drawn from Squaw Creek. Hydrometrics minimized the importance of this by estimating the amount drawn from the creek over the entire 51-hour period as less than ½ percent of the creek's total flow during that period. Over an eight-hour pumping cycle, the amount captured was much less. The WSA analysis assumes that no more water is drawn from the creek after pumping stops, but this does not account for water drawn from the creek due to drawdown that remains when pumping stops. This drawdown replenishes the aquifer by pulling water from storage elsewhere in the aquifer and from the creek, either by reversing discharge to the creek or by directly drawing from the creek. Ultimately changes in streamflow are necessary to fill the drawdown because all pumping is a new discharge from the aquifer which must be taken from another discharge from the aquifer. **This analysis error leads the DEIR and WSA to underestimate the amount of water that pumping draws from the creek.**

Surface Water Quality

Total suspended sediment (TSS) is the primary water quality issue for Squaw Creek, although the DEIR also mentions nitrates and phosphorus. Squaw Creek is on the 303(d) list for sediment load (DEIR, p 13-25). DEIR Table 13-7 specifies the TMDL sources and loads and Table 13-8 specifies the target reductions in sediment load. Total sediment production from the watershed is 37,900 tons/y with dirt roads, graded ski runs, and undisturbed areas producing the highest sediment delivery; undisturbed areas are considered uncontrollable so the future reductions must come from other areas. Dirt roads and ski runs are to be reduced by 60 and 50%, respectively. Residential and commercial area sediment loads are to be reduced by 25% but the TMDL is just 200 tons/y from these sources; the project would primarily affect this source. Interestingly, alluvial channel erosion inputs 2100 tons/y and is considered

uncontrollable, but the geomorphic restoration of the trapezoidal channel may reduce erosion and therefore sediment (DEIR Chapter 6, Shaw et al. 2014, reviewed below).

TSS from the site is grossly underestimated because the relations developed to estimated TSS underestimate TSS at high flow rates. This occurs because sediment production is highly nonlinear in this watershed. The error applies to baseline and with project conditions.

The errors may be seen in Shaw and Roberts (2013) Figure 3, which relates TSS flux (kg/day) and discharge (cfs) at the confluence of the north and south forks of Squaw Creek, the Olympic channel, downstream of the existing village, and for runoff from the urban area (determined as the difference in measurements above and below the site) (Shaw and Roberts 2013, p 6-7). At higher flow rates, most data plots above the regression line (Shaw and Roberts Figure 3). This indicates the regression (a log-log regression) line is biased to give results that are too low for flows higher than certain rates. At the confluence of the north and south forks, at flow rates higher than 100 cfs, at least eight points are higher than the regression line while just three are below the line; similarly for the site downstream of the project site, at least twelve points are above while just three are below the line for discharge exceeding 100 cfs. For runoff from the urban areas, at least five points plot above the line and none below it for discharge exceeding 20 cfs. These regression lines will underestimate the sediment flux for flow rates higher than the flow rate at which the actual data plots above the regression line.

At high flows, the sediment discharge equations grossly underestimate TSS. This error carries into the sediment hydrographs for the site for the 100 year event (Shaw and Roberts 2013, Figure 6) and any other return interval event for which flows exceed the values for which the relations are accurate (Shaw and Roberts 2013 Figure 7).

Other sources of error in the sediment runoff estimates include:

- The discharge and TSS/discharge relations (Shaw and Roberts Figures 1 and 3) do not consider whether the flow is on the rise or falling leg of the hydrograph. TSS is usually much higher on the rising leg of the hydrograph as the runoff flushes sediment from the watershed, but none of the analyses account for this issue.
- Based on the shape of the simulated storm event hydrographs (Shaw and Roberts Figures 5 and 7, for example), the simulation did not consider snowmelt. To the extent the sediment/discharge relations resulted from flows that were partially snowmelt, the simulated TSS hydrographs are based on the wrong assumptions.
- The sediment/discharge relations may be combining points literally drawn from different populations; some points occur during snowmelt runoff, some are likely during baseflow, and some are just rainfall/runoff. The discharge data (Shaw and Roberts Figure 1) clearly range throughout the year, and although many occur in the spring there are also some in the fall. Considering the low flows, some are clearly baseflow (which may have almost no sediment and should not be included in statistics with runoff events).
- The relations for the urban area were developed by taking the difference between below and above the site. Due to measurement error, low estimates for urban flow should not be included because they are primarily just measurement error.

In summary, total suspended sediment from the site for both existing and with-project conditions for high flows is significantly underestimated. This could lead to faulty design of the channel through the

site because more sediment than designed for could settle thereby decreasing the conveyance capacity. The loss of sediment settling in the channel could lead to cleaner water reaching the meadow which could cause erosion. Failing to consider these sediment budget issues for the channel restoration portion of the project could lead to an incorrect underestimate of the project impacts to the stream channel in the meadow east of the site.

The report also estimates nitrate and phosphorus loads. The same concerns as expressed for TSS probably apply, although the rating curves are not provided. Shaw and Roberts (2013) expects slightly lower loads due to the project, primarily due to slightly decreased flow rates from the project. Those conclusions are probably accurate, even if the predicted loads are grossly wrong, as they probably are due to the way the quality/discharge data were collected.

Impact 13-2: Construction phase degradation of surface and groundwater quality

Most of the issues here are addressed with BMPs, which will protect water quality if they work. This impact includes construction dewatering, but the DEIR does not assess how much dewatering will be necessary. Working in the stream while it is flowing would require diversions and dewatering, but that would be mitigated by working during dry periods. A potentially bigger problem is construction where shallow groundwater could flow into the construction works. This could lower the water table and be a source of water that would have to be disposed of in some way. The DEIR requires a dewatering and discharge plan (DEIR, p 13-51), but absolutely fails to discuss what could cause this type of dewatering, where and how often it would occur, and overall what the potential impacts are. The plan for dealing with dewatering has not been made available for review and there is no estimate the type of pollutants the water could contain. Because the depth to water is mostly known around the site, the DEIR should discuss where there will be temporary dewatering and how the water will be disposed. Failing to estimate the quantity and frequency of dewatering is a failure to disclose a potentially significant impact of this project.

Impact 13-4: Long-term land cover changes and increased groundwater production effects on groundwater patterns, recharge, and aquifer storage in the Olympic Valley Groundwater Basin

This impact considers two vastly different issues. One is the change in recharge, which is simply due to the change in impervious area over the site. The second is the impacts of increased groundwater production, which is a primary huge impact of the entire DEIR, with impacts on hydrologic and biologic resources.

<u>Land-cover changes on recharge</u>

The site is developed now so the impervious area changes on west portion of the project are not substantial. The DEIR concludes any change is less than substantial (DEIR, p 13-53). This is probably correct, although the DEIR fails to actually estimate the recharge rate. Only in the groundwater model portion of the WSA and DEIR analysis is recharge considered. The groundwater modeling completed for the WSA and this DEIR ignores the impervious land cover and simulates a recharge zone all across the west basin, including on impervious developed areas; see the groundwater model review below. This clearly is in error. The recharge rates from this recharge zone did not reflect the fact the area is covered with impervious asphalt and buildings. It may be argued that the overall amount of recharge is the same

but because of impervious area it should have been input to the model differently. However, the amount of recharge estimated is grossly too high because of the high precipitation estimates.

Changes to the East Parcel, which is currently undeveloped, could be important and the DEIR fails to consider them. The project would add "approximately 4.24 acres of impervious surfaces" (DEIR, p 13-53) in that area, but the DEIR dismisses this as not being "in a groundwater recharge zone of importance to the OVGB" (Id.). It is however a tributary to the Truckee River and this lost recharge will be lost to the Truckee River system. While it may just be runoff earlier during the season when the recharge would have occurred, the change in pervious area could change the timing of flow from current conditions; it could decrease baseflow in the Truckee River during the time of year that groundwater discharge to the river is most important. This could be manifestly important in years like this one (2015). Instead of considering it, the DEIR ignores this critical groundwater flow by stating it is not important.

Groundwater production effects

Groundwater management is the major groundwater impact of the project because the increased pumpage due to the development would be 234 af/y on top of the existing water use in the valley of 841 af/y, (DEIR, Table 18-11), for a total 1075 af/y. The valley will grow in other ways adding 131 af/y so the total projected demand in 2040 is 1205 af/y. This significant change represents a substantial draw on the aquifer and could substantially impact many biological factors as well. There are substantial issues with how this demand could be distributed through the year.

A potential large source of error in the demand is the occupancy rate, which I discuss in greater detail in the review of the Water Supply Assessment in Attachment 2. Occupancy could be up to 80% higher than the estimated rate because the WSA assumes annual occupancy is 55.2% based on observed rates from 2009 through 2011, a significant recession period. Full occupancy would be 80% higher than the recession-era occupancy, therefore the water supply sufficiency estimates should be based on much higher potential demand even if the underlying estimates are accepted as accurate. Actual occupancy will likely be temporally variable, therefore the water supply sufficiency analysis, and analysis of environmental impacts for the DEIR, should consider future demand in a variable fashion. This means that the simulation of future demands should consider periods with occupancy much closer to full.

Another issue regarding demand is seasonal timing, as in which seasons the demand is higher and lower. The projections in the WSA rely on past distributions and on the monthly occupancy rates from 2009 through 2011 (Hunt and van Dyne 2014). The projected demand peaks in July and August (Figure 1), which during most years is after recharge has decreased and ceased. The primary issue is that more of the future demand will occur during a period of the year when less water is available. Climate change, which will decrease recharge during late summer, will exacerbate this issue. .

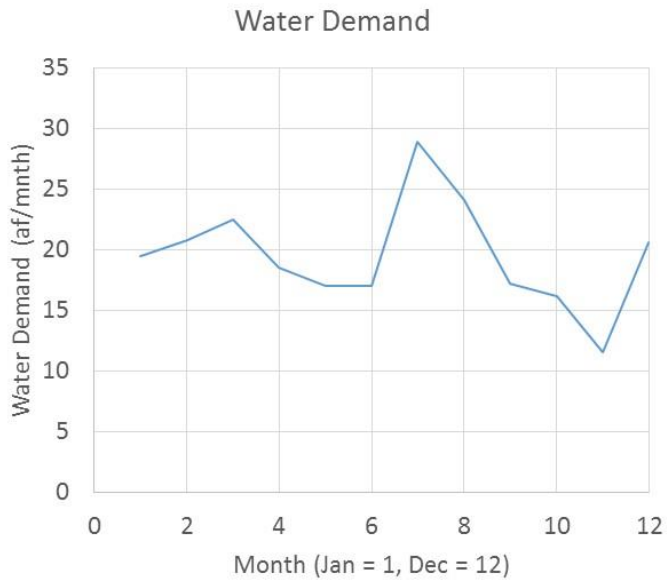

Figure 1: Monthly full-development, 2040, demand for the Village at Squaw Valley. The total is 234 af.

SVPSD uses a MODFLOW-based groundwater flow model to simulate groundwater conditions in the project area (DEIR, p 13-55). Therefore, impacts presented in the DEIR depend on the efficacy of this groundwater model, as do the value of mitigations. The WSA review attached to this memorandum as Attachment 2 reviews some of the earlier hydrogeology studies that go into the groundwater model. I additionally review aspects of the groundwater model as discovered by review of the model input files below. The following comments are of aspects of the analysis that depend on the model or affect the model output.

The WSA concluded six new wells would be necessary "to meet both project and new non-project demands" (DEIR, p 13-55), but they simulated nine potential new well locations in the groundwater model to "better show how the basin as a whole would function with increased demands" (Id.). Taylor et al. (2014) Table 2 shows nine proposed new municipal wells and their Table 3 shows that all of the wells, existing and new with one exception, were simulated to pump the same rate, 54.7 af/y; other entities' wells pump at other rates based on their specific conditions but mostly at rates proportional to their historic pumping. DEIR Exhibit 13-17 shows nine wells labeled as new (07/11, 09/14, 10/12, 15/07, 15/09, 16/10, 23/12, 38/54, and 45/53). The impacts shown in DEIR Exhibits 13-18 through 13-21 are also for all nine wells. The estimated drawdown would be less than if just six wells had been simulated. The simulation of this scenario with more pumping wells than will actually be used is that it spreads the impacts over more wells (Taylor and Reilly 2014).

The DEIR compares with-project conditions to baseline conditions. The WSA refers to baseline conditions as the "maximum saturated thickness values at specific locations do not change, and were **derived from model simulations representing historical actual pumping conditions**" (Taylor et al. 2014, p 14, emphasis added). The DEIR describes baseline as follows: "An EIR must include a description of the physical environmental conditions in the vicinity of the project, as they exist at the time the notice of preparation is published …" (DEIR, p 1-3). This implies that groundwater baseline would be the actual water levels that existed when Placer County issued the notice of preparation, or October 10, 2012, but

that is not what the DEIR nor WSA use as baseline. Baseline as used in the DEIR and WSA is a 20-year time series of simulated groundwater levels as determined based on simulated pumping in the groundwater model at rates that pertain to the year prior to the baseline date. Baseline as shown on DEIR Exhibits 13-18 and 13-20 is a 20-year time series of water levels at various well locations in the project area.

At locations with wells, baseline is a time series of water levels at those wells as affected by the pumping, and seasonal and annual variability in recharge. Between the wells, baseline is the groundwater level resulting from seasonal and annual recharge and as affected by the overlapping drawdown from the various pumping wells. This creates unusual comparisons among baseline and with project or 2040 WSA conditions because the pumping distribution is different. In some locations, the baseline conditions does not have a pumping well. Because the with-project or 2040 WSA conditions have more wells and less pumping per well, the future conditions at some locations have less drawdown than occurs at present due to spreading the effects over more of the valley. Comparison of the differences between with project and baseline conditions shown on DEIR Table 13-11 shows there is more decline (difference between conditions caused by existing pumping and with-project pumping) at the new wells than at the existing wells (average decline for average, max, and min for the new wells is 1.75, 1.11, and 3.65 and for the existing wells is 1.23, 0.71, and 2.33 feet). An additional factor spreading the effects over a larger area is that the DEIR underestimates simulates pumping over nine new wells rather than the planned-for six new wells.

The maximum saturated thickness "occurs when water levels are the highest" (WSA, p ES-3, p 6-5, Taylor et al. 2014, p 14) for the baseline conditions. This occurred in J-93 (DEIR Exhibit 13-18). Table 13-12 also shows the Max saturation to be 99 or 100% for most of the listed wells. The percent saturation is the percent that aquifer saturated thickness is of the saturated thickness occurring at the maximum water level in J-93 (Exhibit 13-20).

The DEIR specifies that maintaining 65% is acceptable (see the next paragraph) for water supply in the valley. Simulations as shown for project-only conditions (DEIR Exhibit 13-19) show the average saturation remains above 80% and only for a few wells in a few years falls below 80%. Their significance criteria based on 65% saturation are not reached. This of course depends on the model being accurate.

The 65% saturation criteria is an operational threshold for maintaining the ability to pump the water from the wellfield and has nothing to do with maintaining any environmental conditions. Taylor et al. (2014) decided on 65% after a literature search because that was the deepest drawdown recorded in the past at existing wells onsite and it did not cause a problem at any wells as far as they knew. 65% is simply the necessary saturation to maintain well pumping efficiency and is meaningless with respect to basinwide groundwater management. The guidance has nothing to do with maintaining a yield or not causing other deleterious impacts to the basin, such as lowering discharge to streams and springs. It also does not consider the cumulative effects of overlapping drawdown cones. In other words, the drawdown from one well will affect nearby wells so that the drawdown at any point is a summation of drawdown from each well. It is possible that the saturation could fall below 65% due to these overlaps.

The DEIR cites the WSA in concluding that the increased groundwater pumping "would not cause any of the wells to drop below 65 percent saturation thickness for more than three consecutive months or more than four times during the study period" (DEIR, p 13-55). As noted, this has little to do with environmental effects and it also depends on the simulation pumping from nine rather than the

proposed six wells. The implication is that if development occurs as proposed in the WSA, the impacts would be less than significant, and only if "different wellfield construction or operations are ultimately implemented, groundwater availability and wellfield operations could be adversely affected" (DEIR, p 13-63). By design, if the WSA well construction plans are followed, they will be different from those simulated in the model.

Mitigation measure 13-4 is designed to assure that development occurs "consistent with the system analyzed in the WSA" (DEIR, p 13-63). If there are development changes, the mitigation is to ensure the effects are similar; essentially the model would be run based on proposed new conditions and the results compared with the saturated thickness requirements and to not cause drawdown that will "cause substantially more refugia pool drying" than shown in GANDA (2014) (DEIR, p 13-64). Other requirements are that the pumping meet criteria identified in the applicable groundwater plans. New wells would be added to the existing monitoring system, and new data would be used to update existing groundwater plans (DEIR, p 13-64).

The drawback of this mitigation is the assumption that the hydrogeology that went into predicting the with-project conditions is accurate. It assumes the groundwater model accurately predicts the future conditions. I review the model in detail below, but one big problem is that any groundwater model used to predict conditions for pumping in excess of rates used for calibration, or in excess of rates ever observed at the site, is that the aquifer may respond differently at higher pumping rates than it does during the calibration conditions. In other words, the further beyond the range of conditions used for calibration the system is stressed, the more inaccurate predictions may well be.

Impact 13-5: Groundwater pumping changes to groundwater and surface water interactions and water quality within and downstream of the plan area

The DEIR considers the drawdown beneath model cells used to simulate Squaw Creek. The DEIR does not estimate flow into or from Squaw Creek along its reach because the model was not calibrated to do so (my review on the groundwater model suggest they should have calibrated flow to the creek because they have sufficient data). The DEIR presents stream boundary cells through the project domain along Squaw Creek (DEIR Exhibit 13-22). It divides the boundary into seven reaches with simulated groundwater monitoring wells at 24 points along the creek (counted from the exhibit). The simulated water levels in the groundwater monitoring wells is not the water level in the stream, which depends on the flow depth in the stream. If the groundwater level is higher than the flow depth, groundwater will flow from the groundwater into the stream; if it is lower than the stream, stream water will flow into the aquifer. The DEIR should present simulated flux to/from the seven reaches rather than to the stream as a whole.

The qualitative observations of the simulated water level hydrographs (DEIR, p 13-67) are generally accurate, but may not go far enough. These simulations reveal significant issues with the proposed pumping. Under all conditions, there are "strong seasonal ranges in groundwater elevations" (DEIR, p 13-67) and "year-to-year variations" (Id.) which are "slightly less than the seasonal range in any given year" (Id.). The greatest reductions are in the far west cells, and the magnitude of decrease is less in the east nearing and through the meadow. DEIR Exhibits 13-23 to -27 provide the water level hydrographs. Interestingly, there are many years (DEIR Exhibit 13-23) during which the groundwater levels in the far west cells do not rise above the streambed. These graphs suggest the pumping is not a problem because groundwater only rarely reaches the stream. Because the stream flows every year regardless of

drought conditions (Hydrometrics 2013b and c), either the groundwater is not connected to the surface water or the model conceptualization is wrong for the west portion of the site. Possibly the model inaccurately simulated recharge from the stream channel in this area (see the model review).

The area within which the groundwater levels are drawn the furthest below the streambed is the "area where the most new wells are planned" (DEIR, p 13-67). Exhibit 13-17, snapshotted into Figure 2, shows that seven of the nine proposed new wells are in the west end of the project area. The DEIR should consider an alternative of putting some of the new wells further east, but still within the proposed development area, to estimate impacts and compare them to the proposed project.

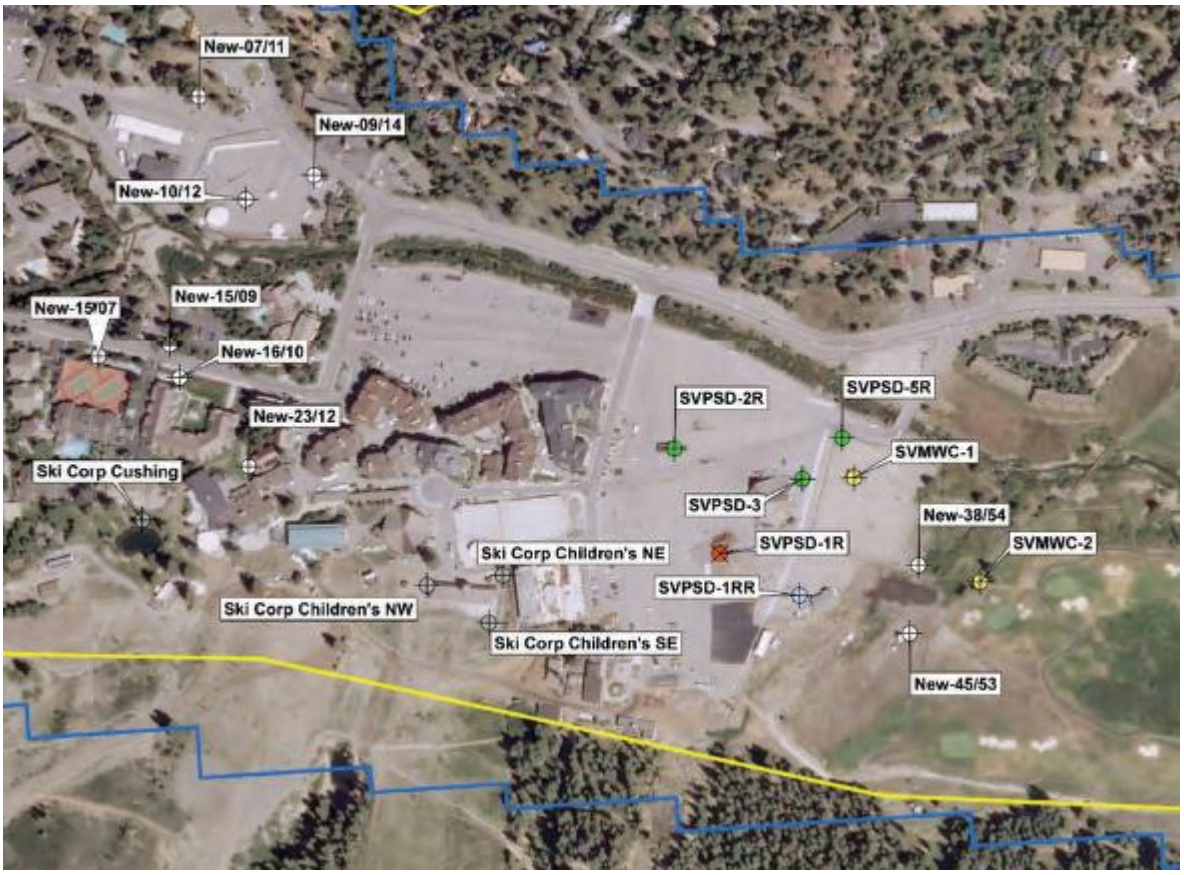

Figure 2: Snapshot of a portion of DEIR Exhibit 13-17 showing the west project area and the location of existing and proposed new wells.

Actual impacts depend on the final locations for the groundwater wells and how they are operated (DEIR, p 13-65). The DEIR provides no rationale for the locations of the proposed new wells. The DEIR suggests that wells near the creek will have little impact during the winter when the stream is full or in the late summer when the stream is empty, but that pumping from wells near the creek during mid-summer when the flow is receding from snowmelt runoff to baseflow will have a significant effect. As noted above in the biology section, this pumping will increase the length of stream that is dry and the time period over which it is dry, along with increased depths to water near the stream. That the DEIR recognizes this suggests that it should consider a project alternative that includes pumping from wells either to the south or east of the creek during mid-summer conditions to limit the impacts to the creek.

It also suggests that the new well locations may not be optimal with respect to minimizing the effect on the creek.

Further east, during most years the simulated groundwater level is above the stream bottom for parts of most years (DEIR Exhibit 13-24 - -26). The length of time the level is below the stream bottom is longer during many years at many points, but the graphs are too coarse to make any definitive observations. The water level drops below the stream bottom as much as 10 feet further for the 2040 WSA conditions than for baseline. To assess the effect of lengthened dry periods and of the time the groundwater level is below various depths, the DEIR should present depth/frequency plots for each point. Simply, the plot should show the proportion of time the water level is below various depths. For example, there would be a percent time the water level is below various levels. Such graphs would improve the assessment of the time the water level is below various critical depths, as may be important for riparian species or other species requiring wet refugia.

Interestingly, Exhibits 13-25 and -26 show the existing stream bed and the proposed level of the restored streambed. For three of the four model cells, the restored bed will be lower than the existing streambed, but in one cell (West Cell I), the restored bed is about 2 feet higher than existing. The groundwater model only uses the existing streambed elevation, so it is not appropriate to make conclusions from these graphs regarding changes in water level due to restoration. Simply because the streambed will be lower does not mean the stream will more frequently be wet. More information regarding the restoration is needed to know whether the stream bottom will be wet.

Finally, water level hydrographs for the east cells (DEIR Exhibit 13-27) are above the streambed much more frequently, both for baseline and with project conditions. Groundwater therefore discharges to the stream most years, but there are a few dry years with substantial time periods during which the groundwater is below the stream bottom. These sites are in the western third of the meadow area. The DEIR should present similar results further east in the meadow to verify that groundwater levels are likewise generally higher than the streambed.

Impact 13-5 would be mitigated by implementing Mitigation Measure 13-4. I discussed above that this mitigation essentially assumes the hydrogeology and modeling completed for the WSA are correct and appropriate for this analysis.

Impact 13-6: Reconfiguration of Squaw Creek and the Olympic Channel

The DEIR portrays the geomorphic restoration of the Squaw Creek and the Olympic Channel as a positive impact unless it is not properly done, so the mitigation is to simply assure that it is done properly. The DEIR makes various claims but provides no analysis to support those claims.

The DEIR assumes the design objectives (DEIR, p 13-75) will be met therefore the project will be positive. The objectives concerning sediment transport and conveyance are difficult to verify and fail to consider some downstream impacts. A broader channel with various flow-slowing snags will capture sediment and allow the stream floodplain and banks to grow naturally. In concept this is correct, as analyzed by Shaw et al. (2014).

Squaw Creek bed load was approximately 80% of the total sediment load in 1988, a year with above-average flow (Shaw et al. 2014, p 9). They recognize that the proportion could change during drier years. Sediment load is divided relatively equally between north and south forks, but 25 to 30 percent

of total sediment load is from Olympic Channel (Shaw et al. 2014, p 10). The even split between north and south forks seems inconsistent with the fact that the south fork contains geology with more erodible volcanics than the north fork.

The current trapezoidal channel efficiently passes sediment to the downstream meadow which causes sedimentation problems there (Shaw et al. 2014, p 12). There is also some deposition above the north and south fork confluence (Id.). Capturing sediment in the restored channel will decrease sediment entering the meadow reach, which could increase the erosive capacity through the meadow. Flow with lower sediment content can be considered "hungry" for additional sediment and disturbed sections of the channel in the meadow could more easily erode to satisfy that additional sediment transport capacity. If the restoration increases the flood conveyance capacity, less water will be temporarily detained so that flow rates through the meadow could be increased. Thus, increased flow rates with lower sediment concentration could cause more erosion in the meadow. The DEIR has simply not considered these impacts.

Impact 13-7: Long-term management of runoff volumes, peak flows, and snow storage, and risks of potential degradation to water quality.

Stormflow from the site would decrease slightly due to different flow paths through the site. Flows from above travelling through the site would change very little due to only minor influence of the project offsite (DEIR, Table 13-14). These estimate flows were used with the TSS relations to estimate TSS loads for various storm return intervals. Analysis above of Shaw and Roberts (2013) showed how the TSS loads may be grossly underestimated due to the misapplication of statistical methods. However, the project will not have large effects on the sediment entering the site. According to the TMDL analysis, the annual sediment delivery from (uncontrollable) undisturbed sources is 14,000 t/y and from (controllable) dirt roads and graded ski runs is 9300 and 9000 t/y, respectively (DEIR, Table 13-8). This sediment loading is from sources that would be allowed to pass through the site as "upstream clean" runoff through the Mountain Interception and Conveyance System (DEIR, p 13-77). The residential/commercial area generates a sediment flux of just 200 t/y (Id.), so the existing development is not a significant cause of the 303(d) listing nor a significant source in the TMDL. Predicted TSS from the main village area (DEIR, Table 13-7) is of similar order of magnitude to the TMDL calculations (DEIR, Table 13-8), which indicates the site will have little effect on the TMDLs for the valley. In fact, the DEIR touts the mountain system as preventing the offsite water from entering the onsite LID systems (DEIR, p 13-79) so that it can treat onsite water better. Paradoxically, this may have the effect of allowing more sediment to pass through the site and into Squaw Creek because the offsite runoff will not receive any treatment and therefore may reach the Creek with less sediment removed than there is currently. The DEIR does not consider the ancillary benefits of allowing some offsite water to mix with the onsite system.

The DEIR mentions low impact development (LID) stormwater quality protection measures but, other than in passing does not list the measures nor provide any substantial description of an LID measure. It is therefore difficult to review the value of the LID measures and, therefore, the DEIR fails to adequately disclose the measures being used to assure that poor water quality does not run off the site.

Cumulative Impacts

Chapter 18 considers cumulative impacts for the project, primarily considering the effect of additional development in Olympic Valley on water resources because groundwater development beyond the local valley would have no impacts on the water levels within the valley. The existing water use in the valley is 841 af/y, and the Village at Squaw Valley project would add 234 af/y to the use by 2040 (DEIR, Table 18-11). Other cumulative projects would add 131 af/y by 2040 for a total of 1205 af/y (Id.). Simulations of the additional pumping increases the groundwater declines over baseline by an additional several feet, but the reduction in percent saturation never goes below 65%, so the DEIR concludes the impacts of pumping for the cumulative condition is less than significant, as long as the previously mentioned mitigation measure is observed. The WSA discussed many of the water resources' issues regarding the 2040 demand, and my review of that document covers those issues.

Groundwater Model

The DEIR uses a numerical groundwater model (Hundt and Williams 2014, Hydrometrics 2013, West-Yost 2003, Williams 2001) to assess the environmental impacts of meeting demand in the Squaw Valley. The WSA used this model to assess the ability of the aquifer to meet demand by determining how proposed pumping will affect the percent saturation of the aquifer. The review of the WSA describes the conceptual flow model for the area. Williams (2001) developed the model initially; there have been several updates since then (Hydrometrics 2014, 2013a, 2007a and b). The model is difficult to review because no one report thoroughly documents its current structure and accuracy. However, the important aspect is how well it performs today.

Hydrometrics provided MODFLOW input and output files for three scenarios for review. The scenarios were baseline, calibration, and WSA runs. I read the MODFLOW files into GWVistas™ to visually review the models. Hydrometrics set hydraulic conductivity equal to 100 for all model cells so it was not possible to actually run the model. The output files were .hds and .cbb files, or head save and cell by cell flow files. Head save files have the water table or potentiometric surface for each cell and cell by cell flow files have flows through the six sides of the cell and change in storage for that cells. Having read the MODFLOW files, I could read the hds and cbb files and look at the results graphically. I could also use features in GWVistas™ to consider mass balance analyses, to plot profiles along any transect, and to plot flow or flux hydrographs. For example, I could determine the model recharge for any time step over any section of the model.

The calibration model runs had 237 time step, with the first one being steady state. The 236 transient time steps totaled 7184 days, or 19.68 years. Based on the location of a 28 day period, for February, the first transient period is May 1993. Starting with the fourth February, leap days were considered. The last month was December 2011. The Baseline and WSA runs did not start with a steady state simulation. The baseline and WSA runs were transient using 228 transient periods.

<u>Model Structure</u>

Figure 3 shows layer 1 and a cross section of the model at column 17, on the west end of the model. The green line through the middle of the grid is a stream boundary for Squaw Creek including the North and South Forks in the far west and a tributary in the meadow. It is actually divided into numerous Stream segments not identified on the figure.

Drain cells in yellow cover most of layer 1. The head in these Drain cells equals the ground surface and conductance is very high. When the groundwater table reaches the ground surface, the Drain boundary removes it from the model domain. These cells are apparently designed to prevent the water level in the aquifer from extending above the ground surface, in an effort to simulate rejected recharge (West-Yost 2003). The Drain cells remove about half of the recharge in the current model.

The dark blue boundary on the far east is a constant head boundary for flow through the moraine bounding the east end of the valley. During the calibration run, the discharge through this end in the model is about 660 af/y. The conceptual model estimate for flow through the moraine was 220 af/y (Williams 2001). In 2003 the simulated flow across the moraine for model calibration was 83 af/y. The boundary was originally applied only in layers 2 and 3 (West-Yost 2003, Williams 2001), now is in layer 1. I found no description of why layer 1 was added but it may have been necessary to accommodate the much larger recharge running through the current model as compared to the earlier model.

Groundwater contours show a steep water table near the mountain front on the western third of the model (Figure 3). Groundwater would flow perpendicular to the contours, directly toward the center of the model domain and the green stream boundary. This steepness would require substantially lower conductivity in that area, but the K in this area (Hundt and Williams 2014, Figure 6) is over 200 ft/d in some areas. The steep contours are not observed in layer 2 (Figure 4). The thinness of layer 1 near the edge, as can be seen in the cross-section (Figure 3), probably reduces the transmissivity which requires the steep gradient. Layer 2 is no flow, and the groundwater contour in layer 1 is actually lower than the bottom of the layer. This probably does not cause a problem with the overall simulation results, but it does suggest localized water balance issues in the west end of the model.

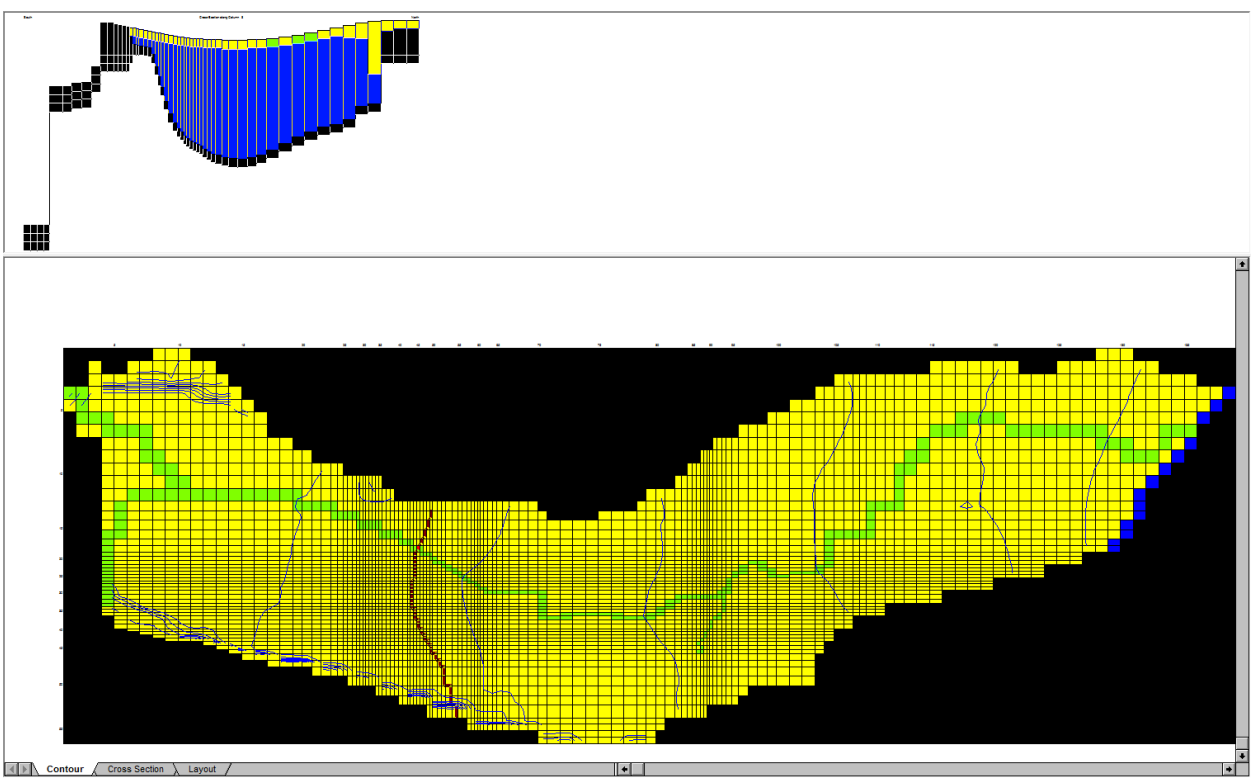

Figure 3: Screen capture of Squaw Valley model layer 1 and cross-section along column 17

Figure 4 shows the plan for layer 2 and a longitudinal profile along row #17. The dark blue boundary on the east is the constant head boundary as discussed for layer 1. There is also one cell of stream boundary in the in the middle toward the bottom (south) of the layer. It lies adjacent to the boundary cells in layer 1, and has flows similar to that stream reach, so it is probably part of that stream reach. The figure also shows one GHB cell in the north boundary on the east. Flow through GHB cells are minor and this boundary is probably irrelevant. The cross section shows the changes in thickness of the alluvial aquifer varies substantially. The aquifer thickness would help control the location that water enters and leaves the stream by constricting the thickness of the alluvium and the area of the cross-section through which the groundwater flows. The area just west of the meadow where groundwater levels become higher and intersect with the stream bottom corresponds with the west end of the thinner section just west of the middle of the cross-section (Figure 4).

The purple line about a third of the distance east from the west boundary is a fault, or slurry wall as modeled in GWVistas™ as 1 foot thick with K= 0.3603 ft/d, which is not very impermeable but is significantly less conductive than the K values in the model cells around, which are generally greater than 14 ft/d and range to greater than 200 ft/d. The fault appears in all three layers. It apparently flattens the groundwater table west of the fault and causes a several foot step to lower levels east of the fault.

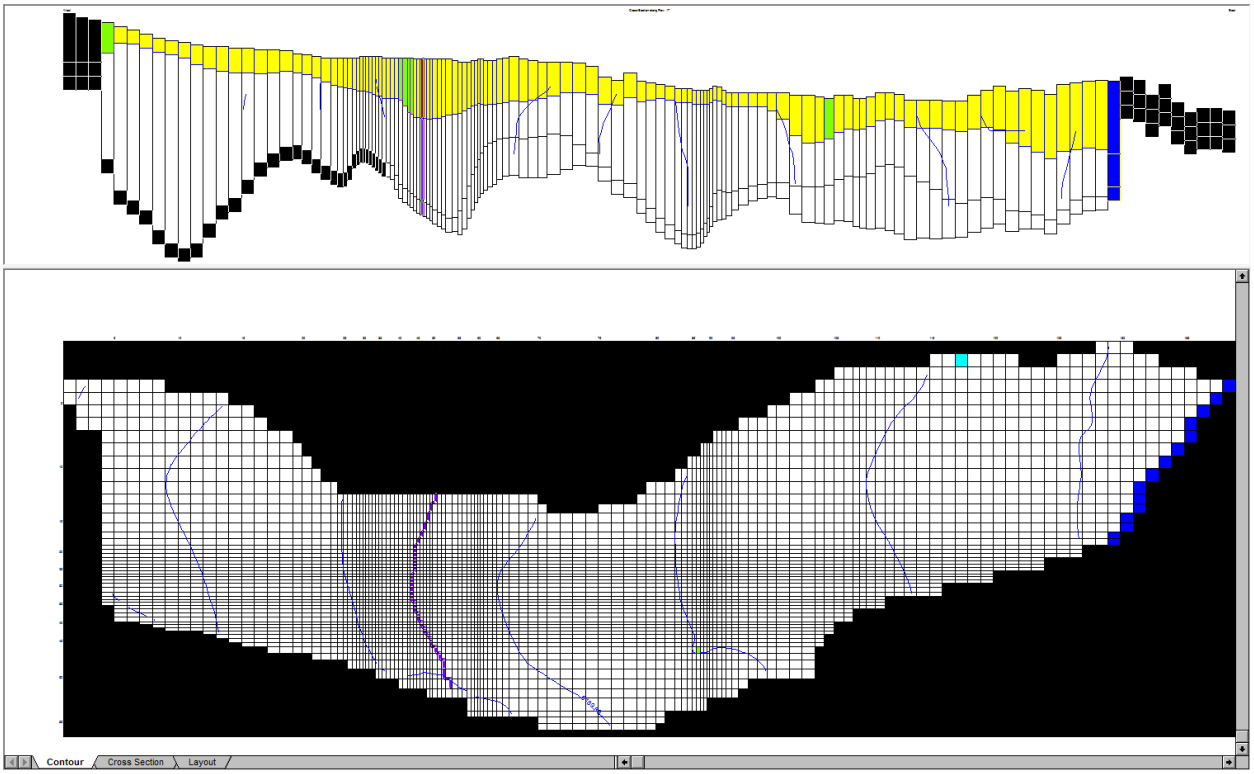

Figure 4: Screen capture of Squaw Valley model layer 2 and profile along row 17.

Layer 3 does not extend as far to the west (Figure 5) as does the layer 1 and 2 model domain (Figures 3 and 4). Hundt and Williams (2014) Figure 1 shows the bottom elevation of layer 2 in the west is approximately the same as layer 3 just to the east. The profile in Figure 4 shows that layer 3 pinches to west but the aquifer thickness undulates but averages the same as further east. This western area is the

location of many of the pumping wells, so this domain configuration would require that most wells pump from just layer 2. Pumping may be more efficient this way because water would not have to flow between layers which would be limited by the vertical anisotropy; this could minimize the drawdown caused by the wells. Now that the model uses MNW routine for wells, the pumping can be as efficient from two as from one layer so the model should have layer 3 extend as far west as layer 2 to better account for differing vertical conductivity.

Groundwater contours in the cross-section at column 109 suggest a vertical circulation from layer 1 near the boundary through layer 3 and back to discharge to the stream in layer 1 (Figure 5).

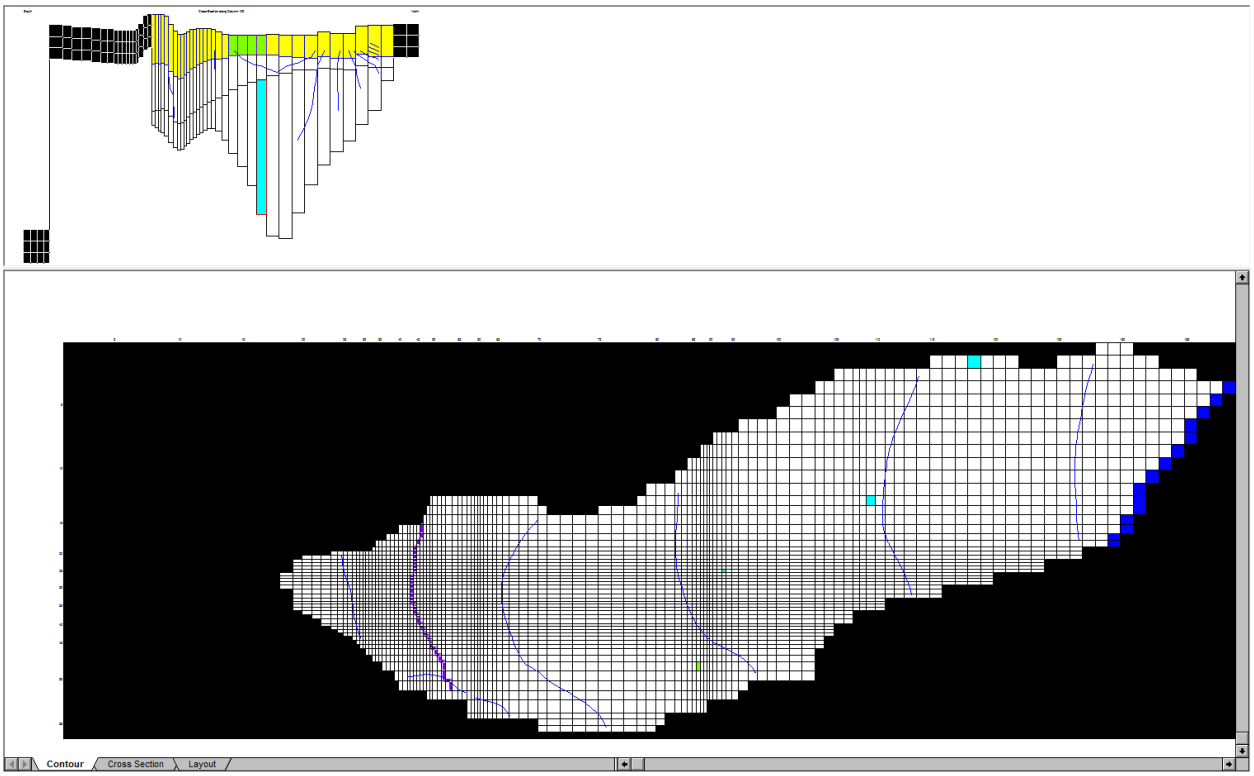

Figure 5: Screen capture of Squaw Valley model layer 3 and cross-section along column 109.

Figure 6 shows how Williams defined recharge zones and Figure 7 shows the most recent (Hundt and Williams 2014) variation. Recharge zones are specified flux boundaries, meaning the modeler specifies the rate in length/time. Williams (2001) apparently set constant values (Figure 6) meaning that water entered the model distributed evenly over the area of the zone. Recharge as applied to the model apparently includes many sources of water, including distributed recharge from precipitation on the spot, irrigation, leaks from sewer pipes, and others. Currently, recharge is estimated as a percent of monthly precipitation as discussed below. Zone 9 (Figure 7) covers the current development which means the model assumes recharge through the parking lots, which is impossible. The differing zones along the edges of the domain suggests simulation of mountain front recharge.

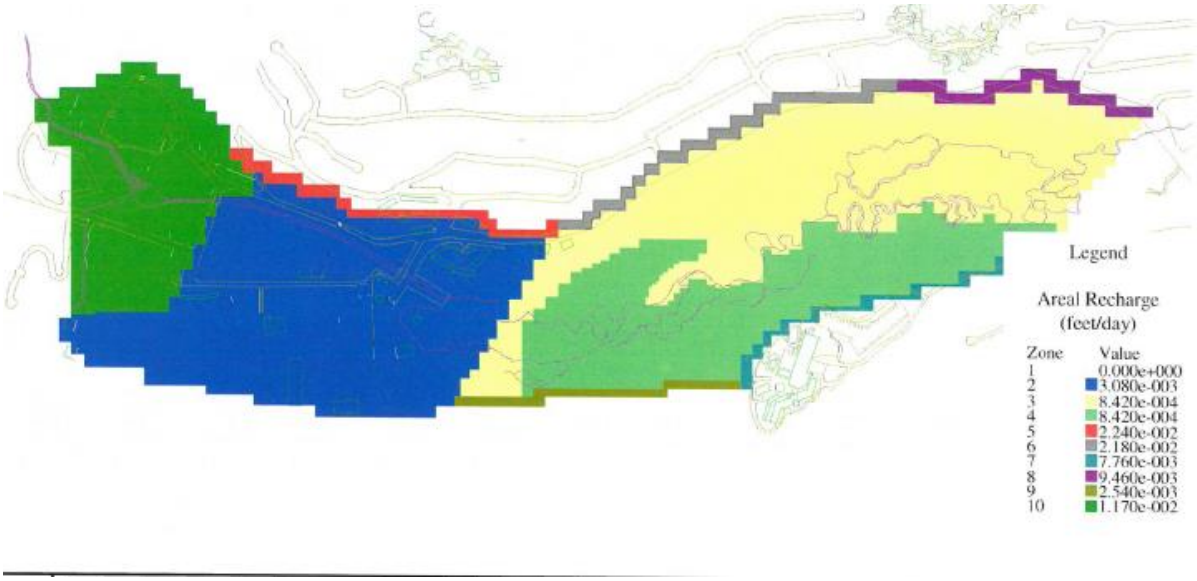

Figure 6: Williams, Figure 32 showing recharge zones.

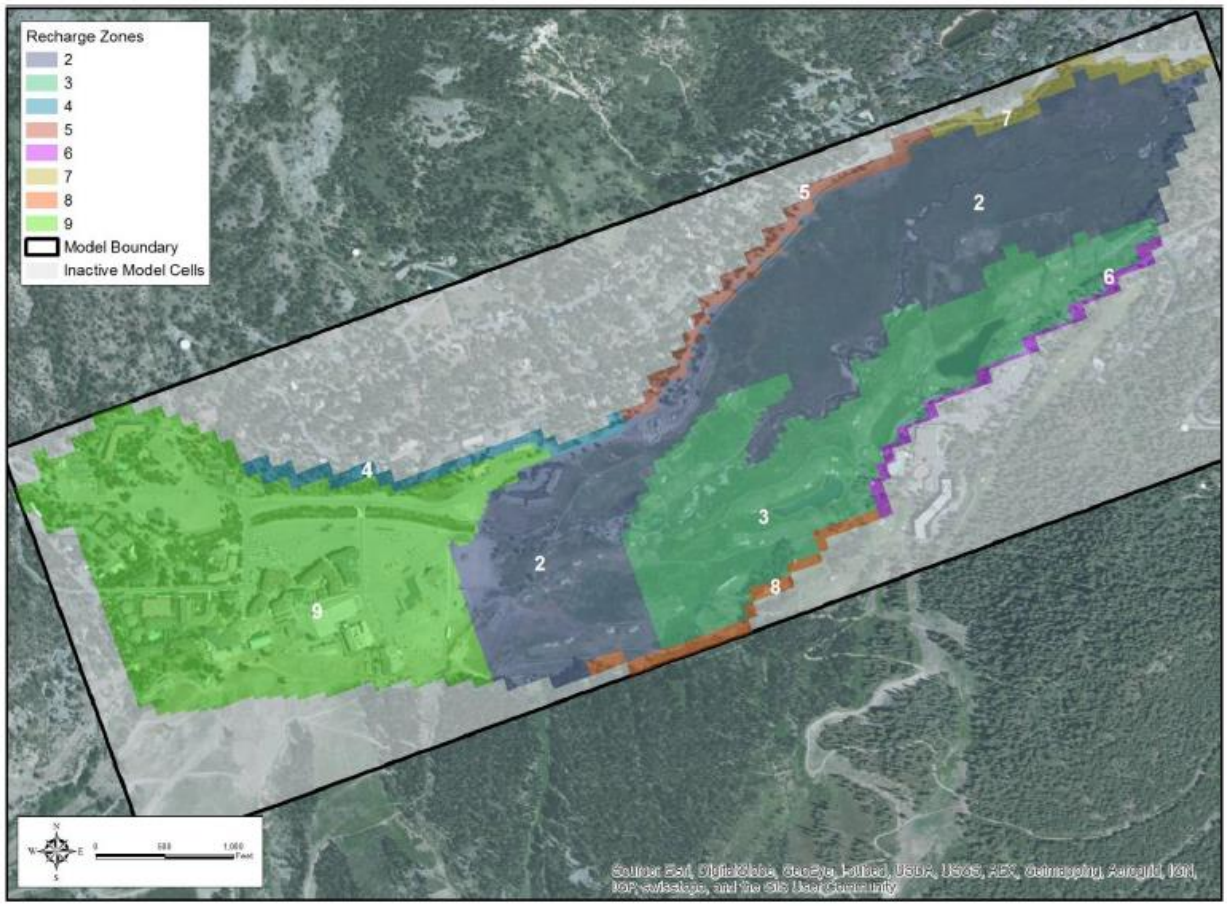

Figure 7: Hundt and Williams (2014) recharge zones.

Distribution of recharge through the year depends on the availability of precipitation or snowmelt, so Hundt and Williams (2014) distributed precipitation availability during winter as 50% of precipitation during the month it occurs and 25% in the following two months. All precipitation which falls in December is available to recharge by the end of February; all precipitation in February is available for recharge by the end of April. March percentages are 60 and 40%, respectively, so all March precipitation is also available to recharge by the end of April. From April through November, all recharge occurs during the month the precipitation falls. I use "available" with recharge because it will runoff if there is no soil moisture capacity available. It seems unreasonable to assume that all December precipitation melts and recharges by the end of February; this could cause the simulated water levels to recover too soon. More importantly, the excessive precipitation estimate drives the recharge used in the model.

Figure 3 in Hundt and Williams (2014) show precipitation and delayed infiltration in inches (presumably per month) but is unclear whether each value is actual recharge or precipitation. I plotted two years of recharge from the model files for recharge zone 9 (Figure 7); the values the model tries to input into the aquifer exceed an inch per day during winter months (Jan-93) and also during Oct-94, a month during which all precipitation is available for recharge.

Figure 8 shows the monthly recharge variation as simulated from 1993 through 2011 by month in the calibration model. Some months there is barely any recharge, with values less than 20,000 ft^3/day, and other months more than 3,000,000 ft^3/ day (Figure 9). The currently estimated recharge converts to about 3900 af/y, which is much larger than that used in the first editions of the model, which were 688 af/y (West-Yost 2003, Williams 2001). The current recharge amount is a gross overestimate due to the gross overestimate of precipitation.

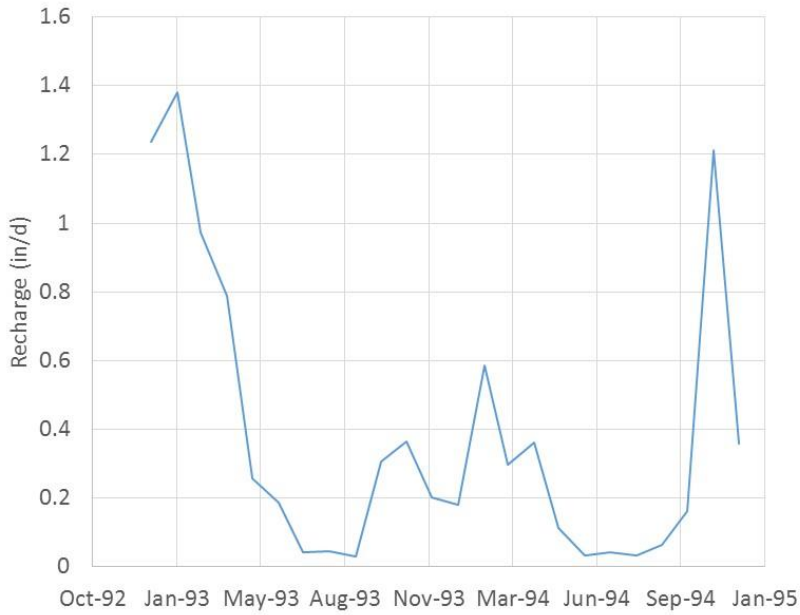

Figure 8: Recharge to model zone 9 for the first two years of the baseline simulation, converted to in/day.

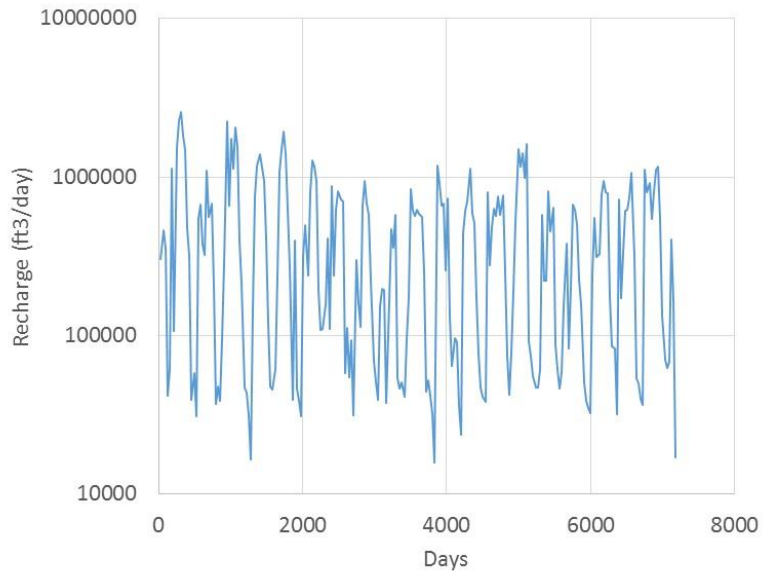

Figure 9: Recharge to the model domain, by month, for the calibration run from 1993 to 2011.

Williams (2001, p 19) simulated inflow from the bedrock using general head boundaries (GHBs). Recent studies have concluded little water enters the basin from the bedrock, therefore simulating this with a GHB is inappropriate. GHB flow in the current water balance is miniscule, but there is really no reason for these boundaries to continue to be in the model.

Hundt and Williams (2014) estimated conductivity using pilot points, a method which essentially establishes parameter fields across the model domain. The methodology needs more description than provided in the report (Hundt and Williams 2014, p 11). The number of wells used for calibration does not seem to be sufficient to create up to 78 pilot points per layer for calibration (Id.). The resulting parameter fields do not resemble hydrogeologic patterns, however, as can be seen on the circular patterns shown on Figures 10 and 11. Figure 10 shows circular areas with horizontal conductivity exceeding 100 ft/d in the middle of areas with conductivity much less than 100 ft/d. Vertical anisotropy has fewer circular zones, but those that occur in layers 2 and 3 are areas where the model will simulate very little vertical flow. It is also very unusual to have the very high anisotropy in surface layers (layer 1 in Figure 11) because surface formations tend to be sorted rather than exhibiting continuous layers.

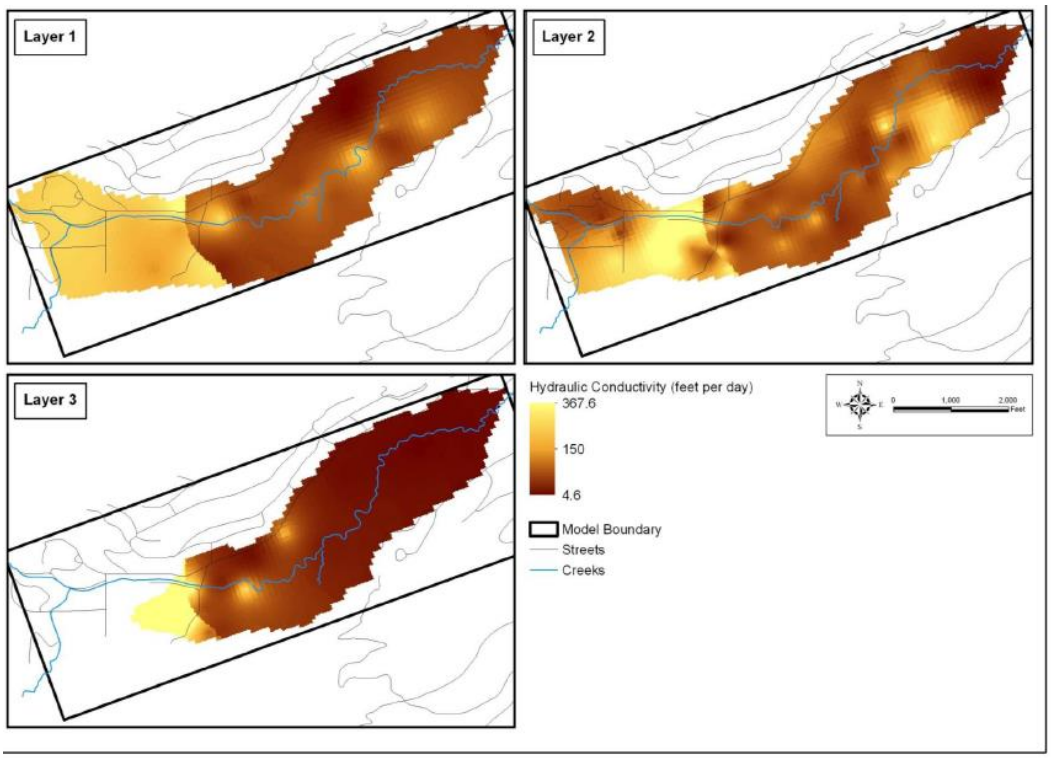

Figure 10: Figure 12 from Hundt and Williams (2014) showing the distribution of horizontal hydraulic conductivity.

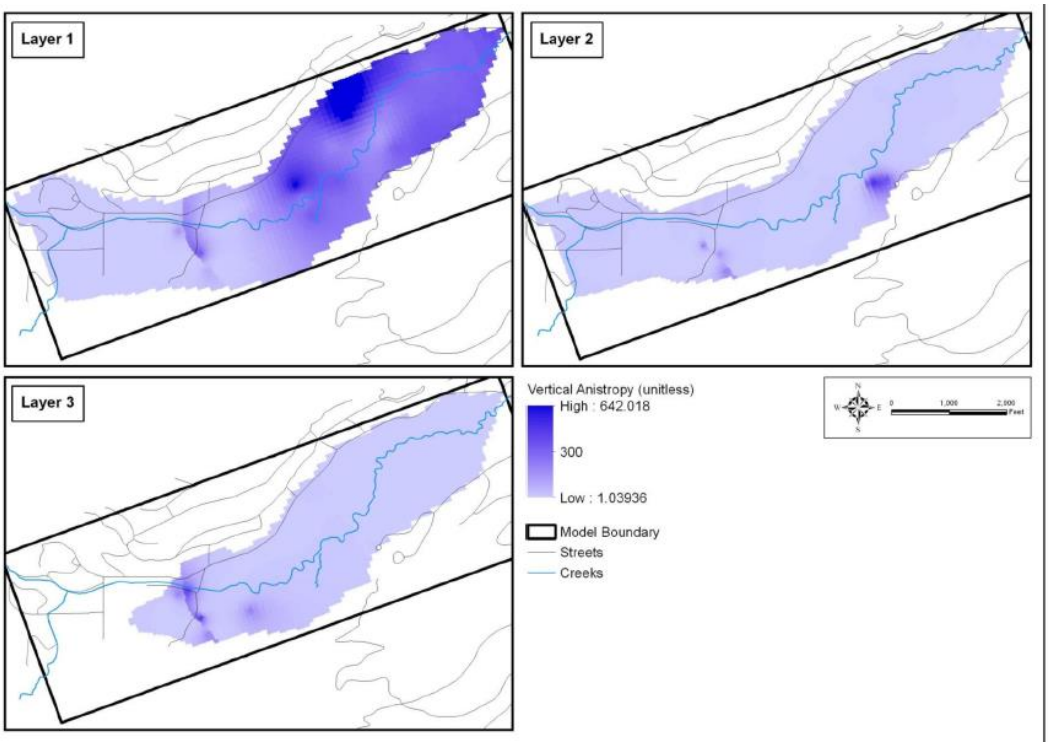

Figure 11: Figure 13 from Hundt and Williams (2014) showing vertical anisotropy, or the ratio of horizontal to vertical conductivity.

The model calibration also reveals inaccuracies in the model. Hundt and Williams (2014) considered the model "calibrated when simulated results match the measured data within an acceptable measure of accuracy, and when successive calibration attempts did not notably improve the calibration statistics" (p 10). Usually, calibration is considered complete when various test statistics are minimized to less than a specified value. Hundt and Williams Figure 11 and the test statistics show that the new calibration is pretty good, although they utilized more than one observation from each well which raises questions about the independence of the observations. Groundwater levels at a well are highly autocorrelated which means individual observations are not independent. Using a set of observations for each well may be a form of pseudoreplication which could artificially improve the test statistics, especially if the observations are made frequently.

Hydrographs of simulated water levels are best used for simple graphical comparison. The hydrographs often indicate potential problems not indicated by calibration test statistics or scatter plots. Simulated water levels in some wells are consistently higher or lower than the observations, apparently by as much as ten feet. This is a problem if the areas of over or underestimation affects flows to the creek or the thickness of the saturated zone. There is insufficient information to assess these effects.

The discussion on stream conductance is very confusing – the statement "[t]he final values obtained from calibration equate to average streambed hydraulic conductivity values of 1.1×10^{-3} feet per day and 1 foot per day" (Hundt and Williams 2014, p 12) is confusing. It is impossible to know what these values refer to – the two values differ by three orders of magnitude. There is no information regarding discharge to the stream, which conductance would control. The calibration file shows that conductance in the stream boundary is based on a one-foot thickness with conductivity from about 10 to 75 feet per day. The conductance for each cell then would depend on the cell size. The values used are high enough that conductance does not limit flow into or from the stream boundary.

Water Balance

The model report should present final water budget amounts, including recharge, pumping, and discharge to the stream, but the reports since 2003 have not done so other than to show graphs of recharge similar to the ones I constructed below. Hundt and Williams (2014) only mention water budget in reference to small changes being made to the recharge input regarding sewer leakage (Id., p 7). A graph showing where the model simulates flow to or from the stream is essential, and should be completed for representative time periods (wet conditions, late summer baseflow conditions). This section considers those water balance issues.

Water balance hydrographs for all fluxes were downloaded from the provided output files for each of the runs – calibration, baseline, and WSA. Recharge, drain outflow, well outflow, stream outflow, and CH out (constant head outflow) were the largest fluxes for the three scenarios (Table 1, Figure 12). The recharge, about 3900 af/y, is much larger than that used in the first editions of the model, which had been estimated at 688 af/y (West-Yost 2003, Williams 2001), probably due to the overestimated precipitation.

Drain outflow, simply water being removed from the model surface, exceeds the fluxes to the well and stream; this of course suggests much water remains that could be exploited in the model; the Drain out flow is not simulated as streamflow so it is not possible to compare it to measured streamflows. GWVistas™ allows the user to observe flux from each Drain model cell, but it is difficult to display in a

figure; most Drain flux occurs during wet years or months (Figure 12) and observations of the locations on the GWVistas™ screen show that most Drain flux occurs very near the stream in the west and over much of the meadow in the east. During dry periods Drain flux occurs east in the meadow if at all. Because the Drain boundary is set equal to the ground surface elevation, the water table at these discharging cells is slightly above ground surface.

Constant head discharge barely changes between scenarios (Table 1), which reflects the fact the boundary is in the far east end of the model domain, away from the pumpage.

Small fluxes include GHB in, Stream in, and GHB out, at 3, 229, and 0.4 af/y (Figure 13). The GHB flux is not important, which reflects the fact that fractured bedrock flow is not a significant part of the water balance (Moran 2013). Stream in is less than a third of the Stream out value, which means the model simulates much more flow to the stream than from the stream, and the streams in the model provide only a small amount of recharge from the stream. However, as noted above, increasing pumpage does induce flow from the stream to the model domain.

Table 1: Average water balance fluxes for the calibration, baseline, and WSA model simulation. Diff is the difference between baseline and WSA. All values are acre-feet/year. Flux terms are described in the text.

Flux terms	Calibration	Baseline	WSA	Diff
CH out	-660.3	-659.9	-659.6	-0.2
Drain out	-1871.0	-1868.7	-1755.3	-113.4
GHB in	3.1	3.1	3.1	0.0
GHB out	-0.4	-0.4	-0.4	0.0
Recharge	3903.4	3881.0	3928.2	-47.3
Storage in	585.2	574.3	650.4	-76.1
Storage out	-579.1	-581.4	-654.8	73.4
Stream in	229.6	249.7	364.4	-114.7
Stream out	-921.2	-887.2	-741.6	-145.6
Well out	-690.1	-710.8	-1137.8	427.0
Wells in	0.9	0.3	3.3	-3.0
Total out	4722.1	4708.3	4949.5	
Total in	-4722.1	-4708.3	-4949.5	
Error	0.03	0.02	0.02	

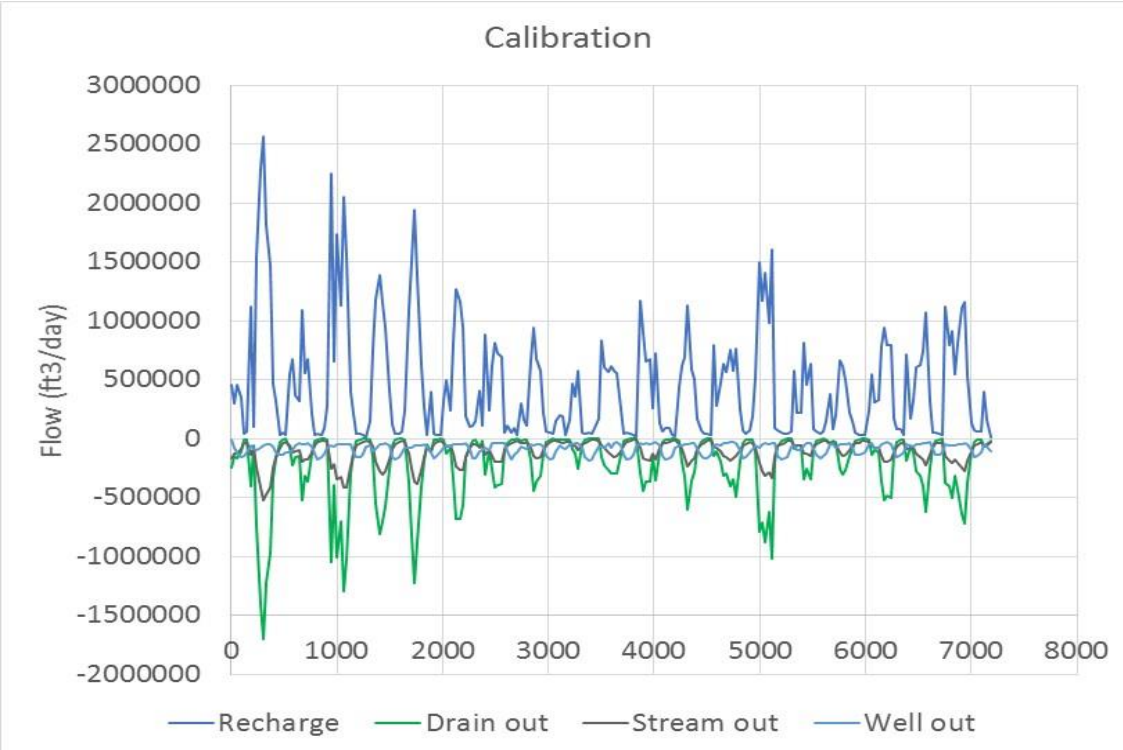

Figure 12: Hydrograph of model fluxes for the calibration model run. This figure shows the larger fluxes; see Figure 13 for the smaller fluxes.

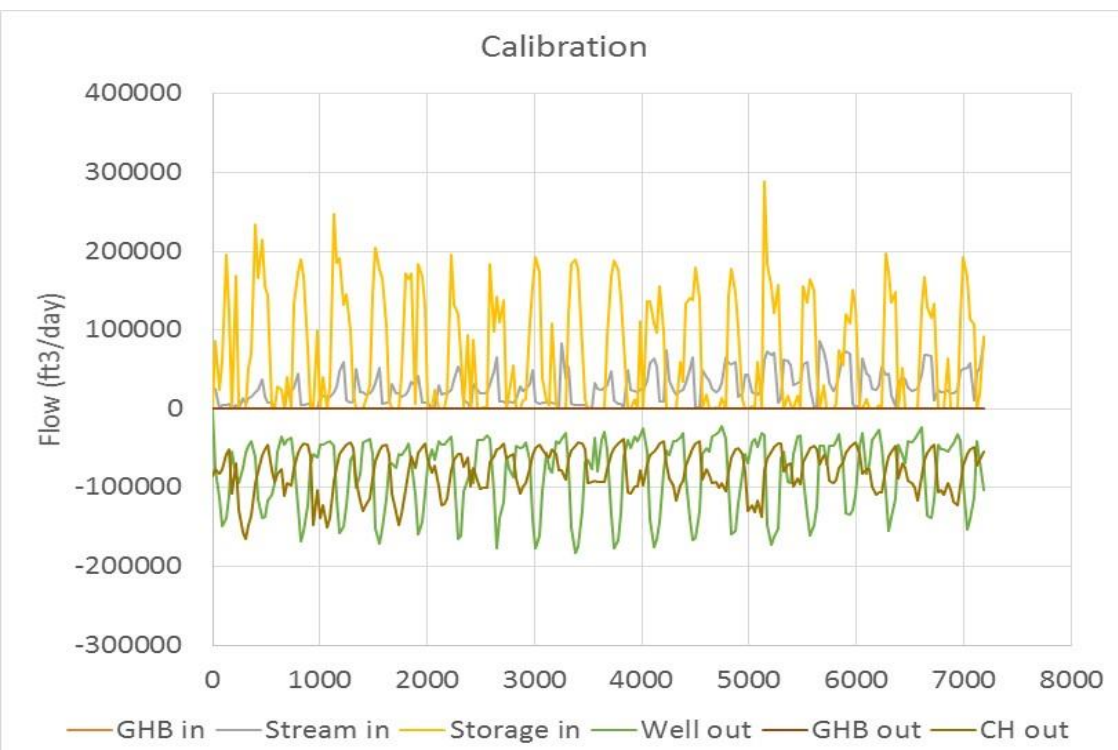

Figure 13: Hydrograph of model fluxes for the calibration model run. This figure shows the smaller fluxes; see Figure 12 for the larger fluxes

Well out for baseline is close to observed pumping from 1993 through 2011, not including water sources from the horizontal bedrock wells (Table 1, Figure 12). It is similar to the well pumpage for the calibration run except the observed pumpage for calibration is more variable (Figure 14). Pumpage for the WSA is close to the anticipated 2040 demand and is almost the same from year to year (Figure 14). The difference between Well out for Baseline and for WSA is the pumpage expected for the project, or about 427 af/y in the model (Table 1, fifth column).

Increasing pumpage by an average 427 af/y draws water from other fluxes. The largest changes are to both Stream in and Stream out, meaning that more and less water draws from the stream and discharges to the stream, respectively. The decreased discharge to the Drain boundary reflects a decreased water level in the alluvial aquifer. Discharge to the stream decreases the most, and discharge to the Drains and induced recharge from the streams are about the same in second place.

Recharge controls the discharge to the Drains and to the streams (Figure 12). The observed pumpage during the calibration run was a small proportion of the recharge, much less than 20%. If recharge were still estimated as it was in 2003, the calibration pumpage would be very close to the recharge. The overestimate of recharge effectively controls the large amount of discharge to the streams and to the drains.

Curiously, recharge to the model increased by 47.3 af/y from the baseline to the WSA run. It is probably because the modelers included some additional recharge from onsite sources such as sewage or irrigation return flow, but the additional recharge effectively accounts for 10% of the additional pumpage. As shown on Figure 15, the increase primarily occurs during the low recharge portion of the year. Additional recharge during late summer would enter the aquifer and counter the ongoing drawdown, since even with the excessive recharge simulated for this model significant drawdown occurs during late summer.

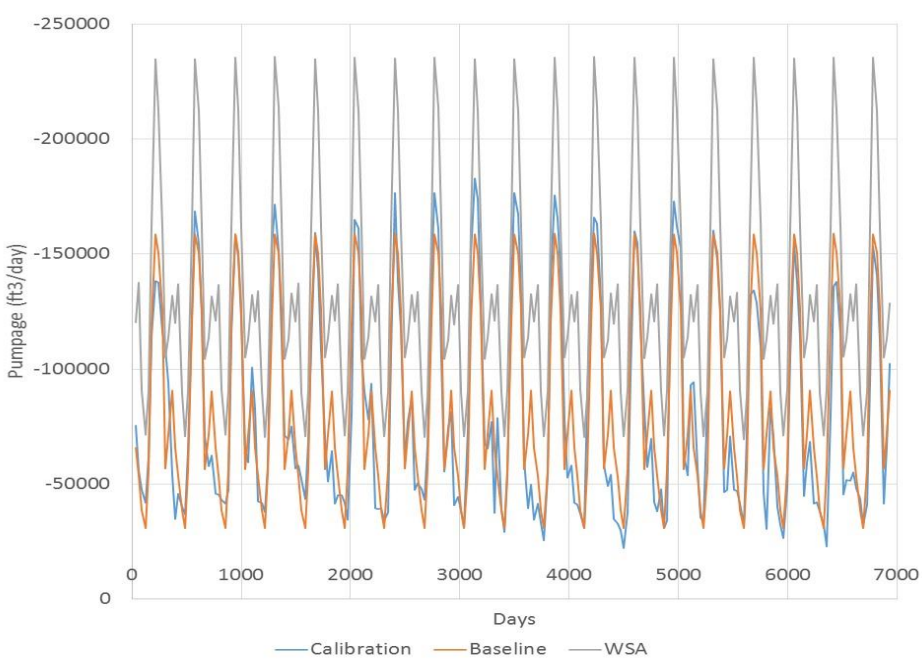

Figure 14: Hydrograph of model pumpage for the three scenarios.

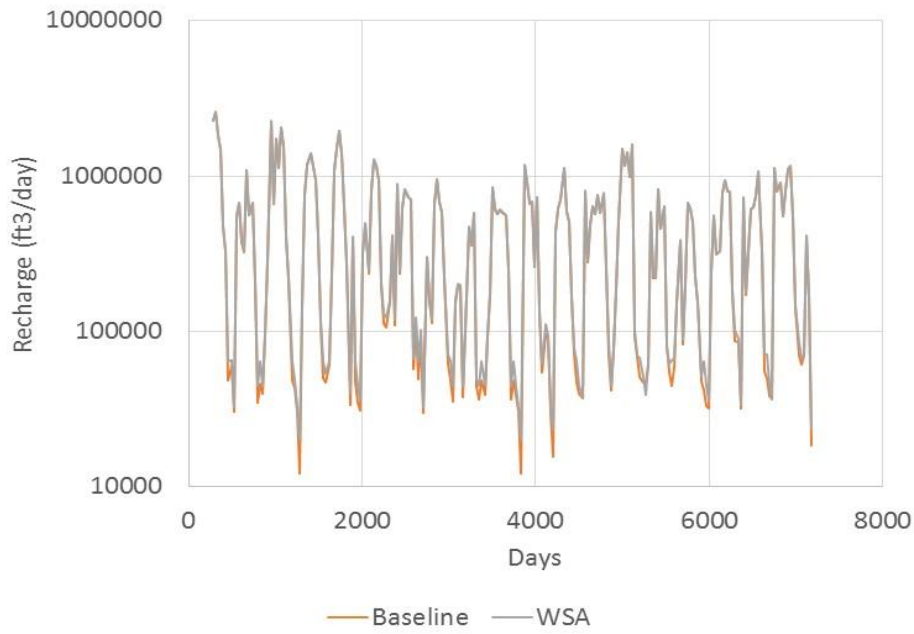

Figure 15: Hydrograph of simulated recharge for the baseline and WSA model runs. Calibration recharge is almost exactly equal to the baseline recharge.

Water flowing in and out of storage increases with pumpage too, but changes in Storage in and out effectively cancel each other. For the calibration run, storage in and storage out were approximately equal at 582 and 576 af/y, respectively, as they should be over a long time period; the small difference indicates the aquifer has lost a small amount of water with time since Storage in means water leaving storage and entering the water balance calculation. The flux is similar for the baseline run because the amounts are similar. For the WSA scenario, the amount has increased by from 73 to 76 af/y (Table *) reflecting the increased movement of water from and to storage.

Figures 16 and 17 show examples of inflow and cumulative streamflow to the stream for periods during which the upstream inflow is vastly different (less than 40,000 ft^3/d for Oct, 2011 (Figure 16) and greater than 3,000,000 ft^3/d during June, 1994 (Figure 17))[1]. The steps in the graphs reflect the two confluences in the stream boundary (Figure 3). During the drier period, little flow added to the stream from the south at the upstream most confluence (Figure 16). For the upper 5000 feet, the stream generally lost flow, from about 40,000 to 30,000 ft^3/day. From about 5000 to 7200 feet, or about the eastern confluence (which is in the meadow), about 20,000 ft^3/d discharge to the stream. A step of almost 80,000 ft3/d added to the stream at the confluence. Below that it increased relatively steadily about another 20,000 ft^3/d. The flow magnitude is much higher in the wetter period (Figure 17), so small changes are difficult to see. Groundwater discharged to the reach through the domain but the main changes were at the confluence. During the wetter period, flow almost doubled at the upper confluence which reflects the large surface water flow simulated to enter the model domain. The stream trended up about 200,000 ft^3/d between confluences and then stepped up about 100,000 ft^3/d

[1] The graphs in Figures 16 and 17 have been adjusted to accommodate a model coding error. The model input files did not show stream segment 3 as a tributary to segment 10. This error applies only for the calibration files because there is no stream segment 10 in the baseline and WSA runs.

in the meadow. The small step reflects that reach carrying only discharge from the groundwater into the short reach before it joins the main stream. In general, the stream boundary performs similar to that expected from the streamflow synoptic studies (Hydrometrics 2013c), although the model was calibrated only at the upstream and downstream end (Taylor and Reilly 2014).

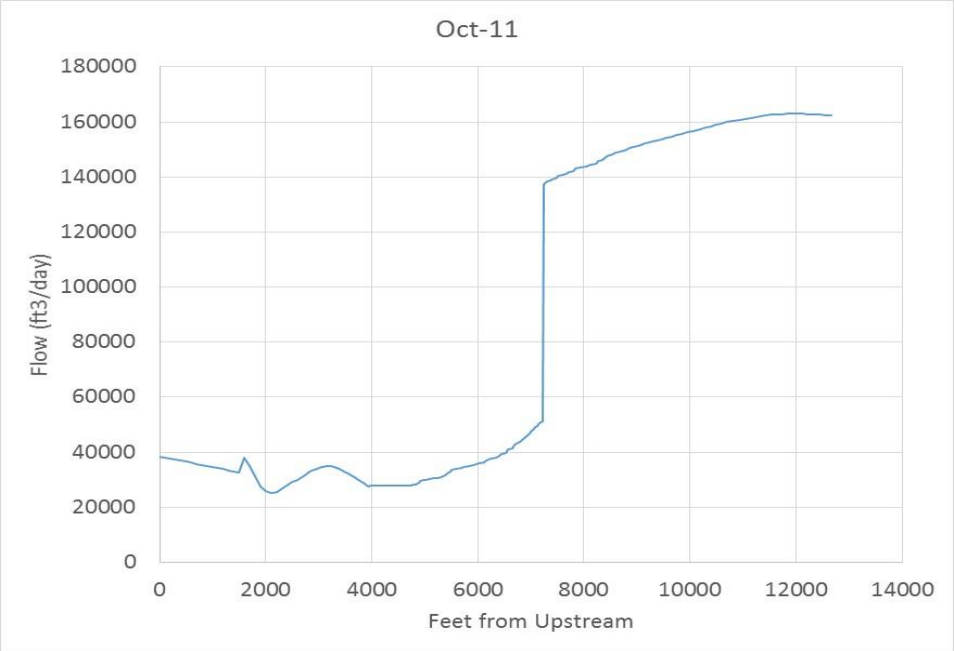

Figure 16: Streamflow along the stream boundary for conditions in October 2011 for the calibration run.

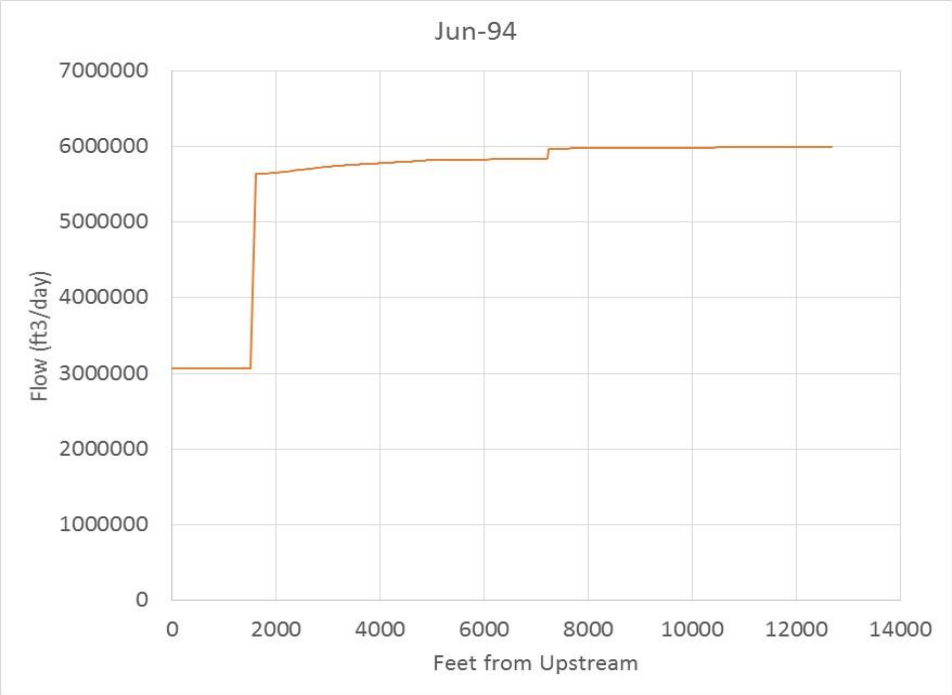

Figure 17: Streamflow along the stream boundary for conditions in June 1994, for the calibration run.

Consequences of Increased Simulated Recharge

I have mentioned several times through this review that the DEIR and WSA use an incorrect precipitation estimate for Squaw Valley, based on a faulty precipitation reading for the Squaw Valley Snotel site, overestimating precipitation by about three times. Simulated recharge increased from about 680 to 3800 af/y from modeling completed in 2003 to modeling completed in 2014 due to consideration of this additional precipitation. During some months much more than a foot of water enters the aquifer. Now, much more water runs through the model than when the model was first conceptualized and parameterized. The calibrated hydraulic conductivity had to be increased by an order of magnitude to allow more water through the aquifer while maintaining observed water levels. The amount of drawdown simulated by pumping with higher conductivity is less than with lower conductivity, so the model accommodates more pumping with less drawdown and less environmental effect on the river than before when a lower recharge had been used.

About half of the recharge leaves the model through Drain cells as rejected recharge. Additional simulated project pumping can simply use this rejected recharge rather than causing additional drawdown. The earlier model reports (West Yost 2003) do not report the amount leaving through Drain cells, but they may have been combining it with stream discharge; either way the amount would have been much less than currently simulated to leave the model.

Flow through the moraine, modeled as a constant head boundary, on the east end increased by four times due to the additional recharge. It scarcely changes due to increased pumping which indicates the pumping is able to draw water from other sources.

Precipitation generally becomes available to recharge in October. The extra precipitation primarily allows recharge to substantially recover the aquifer in October and allows the recharge to replenish ongoing pumping later in the spring and early summer. The overall effect of the overestimated precipitation is to limit the time the stream is dry and groundwater levels are deeper than threshold values. This effect will increase as pumping rates increase because the excess recharge can simply replace the pumping when it occurs.

In summary the recharge overestimate provides much more water over a longer time period which offset pumping demands and causes the model to have a much higher conductivity so that less drawdown occurs for the pumping. It generally causes the DEIR to grossly underestimate the effects of increased pumping on the aquifer.

Climate Change

The DEIR has a chapter concerning climate, but it mostly deals with greenhouse gas emissions from the project. The chapter notes potential changes in snowfall and runoff due to climate change, but there is no consideration of climate change with future groundwater model simulations or other consideration of the effect of climate change on the hydrogeology of the valley or how climate change will combine with the project to significantly impact the environment. The WSA acknowledges the climate change could change the patterns of runoff, but also does not complete any simulations that include expected changes in recharge. In fact, the WSA notes there is so much recharge due to the incorrect precipitation estimate that the changes in timing will not matter.

Climate change is likely to affect precipitation and snowmelt timing in ways that will lengthen the dry, or no-recharge, period of a year. As the snow shifts to rain and snowmelt occurs earlier, there will likely be longer periods during the summer during which there is no runoff recharging the aquifer, which will increase the seasonal period during which drawdown can affect the aquifer. Climate change may not change the precipitation but will provide for less available water during the later dry part of the summer.

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ATTACHMENT 1
Squaw Valley G.c. (784)
California SNOTEL Site - 8029 ft

	Oct Precipitation Increment - Snow-adj (in)	Nov Precipitation Increment - Snow-adj (in)	Dec Precipitation Increment - Snow-adj (in)	Jan Precipitation Increment - Snow-adj (in)	Feb Precipitation Increment - Snow-adj (in)	Mar Precipitation Increment - Snow-adj (in)	Apr Precipitation Increment - Snow-adj (in)	May Precipitation Increment - Snow-adj (in)	Jun Precipitation Increment - Snow-adj (in)	Jul Precipitation Increment - Snow-adj (in)	Aug Precipitation Increment - Snow-adj (in)	Sep Precipitation Increment - Snow-adj (in)	Total
1980												2	
1981	1.9	3.7	5.3	13	6.3	11.5	2.1	3.6	0.5	0	0	1.1	49
1982	8.2	24	24	16.1	10.8	25.9	14.7	0.8	3	0.2	0.4	8.3	136.4
1983	10.4	15.2	17.8	14.2	25.4	17.7	15.3	2.1	1.2	0.7	2	2.7	124.7
1984	5.8	23.5	22	1.5	5.8	8.8	4.8	2	3.2	1.1	0.6	0.2	79.3
1985	5	15.9	2.1	1.2	7	9.1	2.4	0.3	0.4	0.9	0	4.5	48.8
1986	3.5	11.7	9.1	10.6	30.4	11.1	2.6	1.1	0.1	0.2	0	5.7	86.1
1987	0.8	1.6	2.6	7.7	11.2	9.5	1.2	1.6	0.8	0.1	0.1	0.2	37.4
1988	1.9	4	12.4	12.7	0.8	1.5	3.1	3.9	0.9	1.3	0.3	0.2	43
1989	0.2	18.3	10.9	3.4	8.1	19.6	2.6	2.2	2.4	0	2.4	4.9	75
1990	6.2	4.8	0.1	8	12.2	3.8	3.8	6.9	0.9	0.5	0.8	2.5	50.5
1991	1.8	1.7	3.2	1.4	3.1	24.2	3.2	4.8	1.1	0.5	0.2	0.7	45.9
1992	6.1	4.9	3.8	1.7	15.5	3.1	1.7	0.8	3.6	1	0.9	0.5	43.6
1993	6.8	1.3	29.4	29.6	26.7	7.7	3.4	3.4	2.5	0.5	0.4	0.3	112
1994	4.9	5.1	6.5	4.2	15.1	2.1	3.5	3.1	0.4	0	0	1.2	46.1
1995	1.6	16.5	15.2	36	2.4	33.7	11.9	4.6	0.6	0	0	0	122.5
1996	0	1.5	15.6	27.3	17	17.1	4.7	8.9	0.3	0.7	0.2	1.3	94.6
1997	3.3	12.7	53	29.3	5.1	2.8	3.6	1	3.8	0.2	0.2	0.2	115.2
1998	4.1	6.9	5.7	24.5	30.5	12.6	5.4	6.1	2.6	0.8	1.3	4.5	105
1999	1.6	14.3	4.4	20.5	23.6	6.3	5.3	2.2	1.3	0	1.8	0.2	81.5

2000	4.3	5.7	4.1	20.6	23.5	3.9	3.5	4.6	0.4	0	0	2.2	72.8
2001	5.5	3.6	7.1	5.3	11.1	3.6	6.5	1	0.2	0	0	0.9	44.8
2002	1.8	12.3	27.2	6.6	5.4	14.2	4	2.2	0	0	0	0	73.7
2003	0.3	12.3	24.7	9.5	3.1	6.5	13.1	3.6	0.3	0.2	1.8	0.4	75.8
2004	1.8	5.1	23.3	7.1	12.5	2.3	3.1	2.1	0.3	0.2	0.1	0.5	58.4
2005	8.6	4	18.4	18.5	7.8	16	5	10.7	3.5	0.2	0.3	0.7	93.7
2006	2.6	8.4	34.4	17.6	8.8	15.9	13.2	1.8	0.2	0.3	0.2	0.2	103.6
2007	0.4	9.8	8.8	2.7	18.2	2.6	4.5	2.2	0.5	0.3	0.6	1.5	52.1
2008	5.4	1.4	9.3	17.5	8.6	4	0.7	2.8	0	0.7	0.3	0	50.7
2009	3.6	6.9	13.8	4.1	13.3	13.1	2.3	7.1	2.4	0.2	0.9	0	67.7
2010	6.8	2.7	13.6	11.3	5.6	10.5	8.7	5	1.6	0	0	0.1	65.9
2011	13.2	12.5	23.1	1.8	7.5	20.5	8.1	4.8	4	0	0.1	0.3	95.9
2012	5.8	2.8	0.2	9.1	5	19.3	5.1	0.6	0.9	0.9	0.5	0.5	50.7
2013	5.4	11.7	16.4	1.5	0.9	4.3	1.8	3.1	2.8	1.4	0.5	2.1	51.9
2014	1.4	1.2	2.8	3.8	13.9	5.9	4.1	1.2	0.3	0.3	0.7	2.3	37.9

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ATTACHMENT 2

Technical Memorandum
Review of Water Supply Assessment
Village at Squaw Valley

July 13, 2015

Prepared for: Sierra Watch
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Summary

The Olympic Valley aquifer is small compared to the demand imposed on it, with recharge from rainfall on the alluvial valley, runoff in streams onto the alluvial valley including from Squaw Creek, and from mountain runoff percolating into the aquifer at the mountain front. During runoff periods, stream reaches in the western part of the valley percolate water to the aquifer and groundwater levels rise. As runoff and stream water level decreases, groundwater begins to discharge into the creek maintaining flows for a period. The stream in this area has been channelized such that the stream bottom is lower than it had been prior to channelization. Groundwater discharges to the stream probably more frequently than it did prior to channelization and therefore naturally lowers easily to the bottom of the stream channel. Late in the summer season in most years, the groundwater level falls below the stream bottom so that groundwater discharge to the stream ceases. Pumping in this area increases the rate that groundwater levels decrease. Rapid recharge of the first runoff in the fall causes the groundwater level to rise rapidly.

Further east is a meadow and a non-channelized, meandering stream. Through this area, the stream gains flow from groundwater discharge most of the time and groundwater levels remain high most of the year. There is little pumping in the middle of the meadow to cause drawdown and affect streamflow.

Because the stream in the west part of the valley already reaches dry or near-dry conditions, groundwater development currently increases the time period that low flow conditions occur. Additional development could draw groundwater levels deeper than previously experienced and extend the length of stream reaches affected by low flows and probably lengthen the time during the fall until recovering groundwater levels restore flows to the stream. Climate change that causes the proportion of precipitation to fall as rainfall to increase and snowmelt to occur earlier will increase the length of the dry part of summer during which the groundwater does not discharge to Squaw Creek in the western part of the valley.

The WSA estimated project and non-project water demands for the next 25 years, commencing in 2015. The annual average occupancy rate of 55.2% was determined based on just the recession period 2009

through 2011 when occupancy would have been lower than average. Although the per capita demand of 100 gpd could be inaccurate, underestimating occupancy by up to 80% would cause a much higher error in the total demand estimate. There is simply insufficient description of how the commercial water use demand, rated at 0.24 gpd/sf, was estimated so its effect on total demand is unclear. Demand timing, with more of the total 1135 af/y demand occurring in late summer after recharge, could affect the water sufficiency estimates more than expected if these potential errors occur. More demand especially in late summer would cause even more drawdown lengthening dry periods and the length of dry stream. Significant drawdown could carry over from year to year during dry periods and cause significant water supply issues.

The WSA considers water supply sufficiency based on maintaining saturated thickness at 65% of the maximum saturated thickness. The maximum saturated thickness is considered to be historic conditions, including the existing pumping, with no consideration of whether the aquifer is currently stressed. It was determined with model simulations of existing pumping. The 65% of maximum saturated thickness is an operational limit which maintains well pumping efficiency and is meaningless with respect to basinwide groundwater management, such as maintaining a yield or not causing other deleterious impacts to the basin.

The test for water supply sufficiency involved groundwater modeling of pumping the expected 2040 demand from existing and proposed new wells. The modeling used nine new municipal wells even though the WSA determined that only six would be needed. This spread the pumping over more wells than will occur so that the average pumping rate per well was actually lower than the existing pumping rate in some cases. Their simulation shows that the 65% criteria is met on average over the well field and for individual wells although percent saturation varies widely. The analysis of water sufficiency does not account for changes in streamflow that occur because of a connection between surface and groundwater or changes in wetland conditions. It would be useful to compare both existing baseline and project future WSA 2040 conditions with a simulated no development condition in the valley to show just how development has affected true natural conditions.

Recharge depends on the precipitation in the valley reaching the valley flow, but the high mountain precipitation reported in the WSA is grossly wrong, being estimated as 263 inches per year for 1993 through 2011. The Snotel site for the valley shows that that the annual average for that period is 80.6 in/y. If all 263 inches fell as snow at a 1:10 ratio it would be 219 feet of snow. This erroneous precipitation estimate is prominent in documents and analyses since 2011. This large amount of precipitation is about 50 times the water demand so the WSA concludes there will always be sufficient water for the project.

Analysis of pump test data allowed the suggestion that only a small proportion of pumpage would draw from the creek if they use 8-hour pumping cycles. This ignores that drawdown that exists when pumpage ceases will continue to draw streamflow into the aquifer.

There is no consideration of climate change with future simulations, although it is likely to affect precipitation and snowmelt timing in ways that will lengthen the dry, or no-recharge, period of a year. As the snow shifts to rain and snowmelt occurs earlier, there will likely be longer periods during the summer during which there is no runoff recharging the aquifer, which will increase the seasonal period during which drawdown can affect the aquifer. Changing climatic conditions expected in the 21st century renders bare reliance on the recent historical record insufficient to assure adequate future

supplies. The WSA should acknowledge this fact and simulate groundwater pumping under conditions representative of future climate change scenarios. As it is, the simulations of future conditions considering the period 1993 to 2011 does not even include the ongoing 2012 to present drought. The WSA results should be amended to include simulations that at least include the ongoing drought to be more realistic.

The Olympic Valley aquifer groundwater appears to be flowing in a subterranean stream, in that (1) there is a subsurface channel present, (2) the channel has relatively impermeable bed and bands, (3) the course of the channel is known, and (4) groundwater flows in the channel. The Olympic Valley aquifer is alluvium that lies in a glacial-carved valley of granitic bedrock. The granitic bedrock forms a subsurface channel and defines its banks. Groundwater flows in the aquifer from west to east where it discharges in Squaw Creek or the Truckee River. The groundwater in the aquifer originates almost exclusively from recharge into the alluvium from snowmelt or runoff in Squaw Creek or a tributary and is less than a year old. Very little groundwater enters the aquifer from bedrock fractures in the alluvium.

Introduction

This technical memorandum reviews the Water Supply Assessment (WSA) for the Village at Squaw Valley Specific Plan (Farr West Engineering et al. 2014) (hereinafter WSA). The WSA estimates the current water usage from the Olympic Valley aquifer, projects increased demand for the Village at Squaw Valley and other reasonably foreseeable development, discusses the most recent hydrogeology studies for the aquifer including revisions of a numerical groundwater model, and estimates whether the water supply will meet the water demand until 2040 for the proposed project and other development using the numerical groundwater model. This memorandum reviews the adequacy of the hydrogeology assessment, the conceptual flow model for the Olympic Valley aquifer, the numerical groundwater model, the current and future demand for water, and the supply sufficiency analysis. The memorandum reviews the WSA and supporting documents completed since 2001, although specific issues of those reports and the groundwater model are discussed only in regard to usefulness of the current WSA

The first step in understanding the hydrogeology of an aquifer is to write a conceptual flow model (CFM) for the aquifer; that is the first section of this review. The review of the CFM includes specific sections regarding recharge, precipitation, and stream/aquifer interactions. Then, there are sections on water supply sufficiency, water demand, and specific criticisms of the groundwater model. There have been some substantial changes in thinking about the aquifer with time. The review focuses on the current considerations of the CFM but it some cases it is essential to consider how thinking on various issues evolved over time.

Conceptual Flow Model

The development of a CFM is the first step in understanding the hydrogeology of an aquifer or groundwater basin, herein defined as Olympic Valley including the mountain side slopes draining to the valley. A CFM is simply a description of the flow paths through an aquifer including the geologic formations, from recharge to discharge, quantifying flow rates where possible.

Olympic Valley is glacially carved and about 2.5 miles long by 0.4 miles wide. The valley drains ridges of the Sierra Nevada east to the Truckee River. The total area is 5146 acres with the Olympic Valley floor

being 701 acres so that the remaining 87% of the valley is mountain slopes and uplands. The Olympic Valley Groundwater Basin (Basin # 6-108 by the Cal DWR) (hereinafter "basin") consists of unconsolidated, predominantly alluvial sediments, which the WSA divides into three units (WSA, p 5-4). In general, unit one in the west is very shallow, up to 20 feet below ground surface (bgs), and consists of fine sand and silt. Unit 2 is below unit 1 and composed of gravel and sand becoming finer to the east, toward the meadow. It somewhat grades into unit 3 in the eastern portion of the basin in the meadows.

There is an upward gradient from depth for flow to Squaw Creek, with average water levels in piezometers more than 100 feet below ground surface in May 1986 being up to six feet above Squaw Creek on both the north and south sides of the creek (Figure 1). In the western portion of the valley including the well fields, high water levels vary annually more than six feet (Figures 2 and 3). There is typically significant seasonal drawdown but 1994-1995 provides an example of how widely groundwater levels may vary in a calendar year. During fall 1994 after a dry year, the drawdown was up to ten feet below the normal drawdown but after a very wet winter a substantial recovery occurred in spring 1995, with groundwater levels up to six feet above the normal levels (Figures 2 and 3). During most years aquifer water level recovery is not to a completely full condition which occurs only during very wet years.

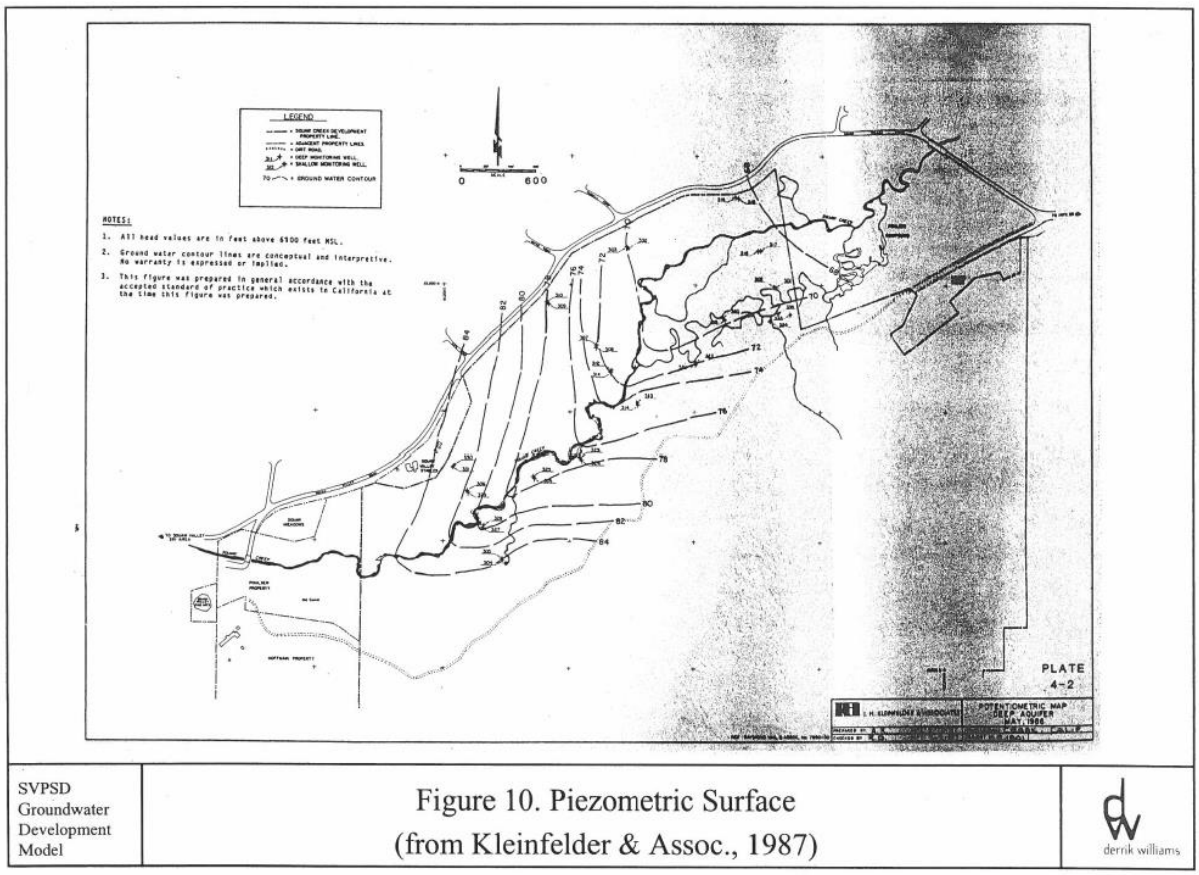

Figure 18: Figure 10 from Williams (2001) showing peizometric surface for the Olympic Valley aquifer, mostly on the east end of the valley. The 2-foot contours show a distinct flow pattern from the aquifer toward the creek reflecting a gaining stream. The highest contour, in the southwest end is 6184 feet above mean sea level.

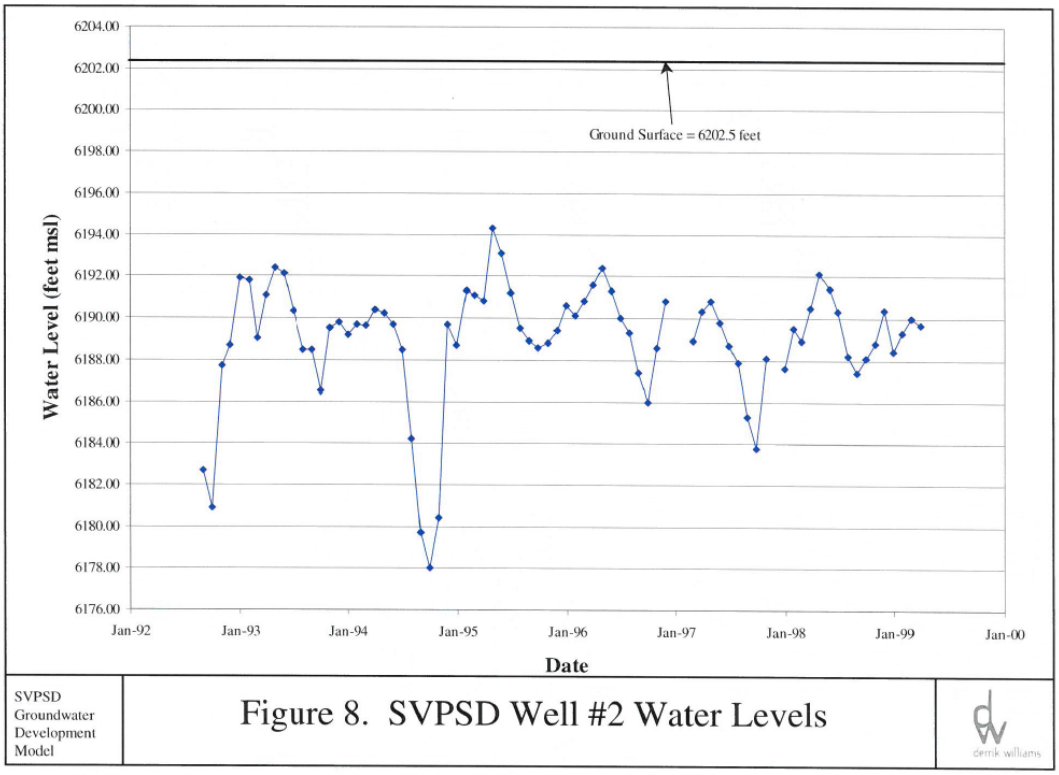

Figure 19: Figure 8 from Williams (2001) showing groundwater levels for SVPSD well #2.

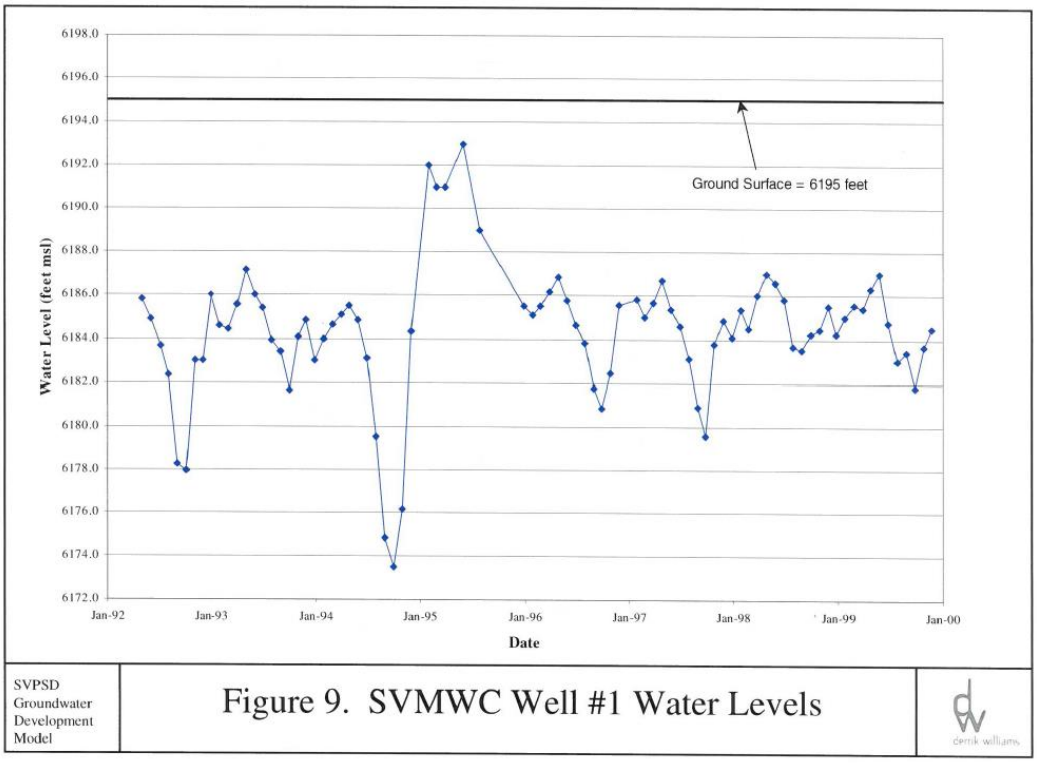

Figure 20: Figure 9 from Williams (2001) showing groundwater levels for SVPSD well #2.

Precipitation

The high mountain precipitation reported in the WSA, Table 3-1, is grossly wrong. The table claims the high mountain precipitation, as snowwater equivalent, is 263 inches per year for 1993 through 2011. The actual data from the snotel site, Squaw Valley at 8029 feet[2], shows that that the annual averages for the periods 1981-2014, 1981-2011, and 1993 -2011 are 73.3, 75.9, and 80.6 in/y, respectively. Attachment 1 shows a summary of the data. Note that 263 inches is 21.9 feet of precipitation which at a 1:10 ratio would be 219 feet of snow. It is not clear where the WSA obtained such high values, but they are clearly wrong. The choice of years used in the WSA, 1993 – 2011, is the wettest of the actual record. This extreme precipitation has been used in all of the studies cited in the WSA since 2011. An annual precipitation map for Olympic Valley in 2007 (Hydrometrics 2007a) shows that annual precipitation varies from about 43 in/y in the east to 57 in/y in the higher elevation western portion.

In the climate change discussion, the WSA (p 7-2) uses the wrong precipitation estimates to estimate there is 60,194 af/y of precipitation in the overall watershed which over 5146 acres the depth would be 11.7 feet. The WSA argues that because snowmelt is this high, significant changes due to climate change would not affect the availability of water. Because the precipitation estimate is grossly wrong, this argument is based on grossly wrong assumptions and should be rejected.

Recharge

Recharge is precipitation or snowmelt that percolates through the soil to the groundwater table. In general, the precipitation either runs off the soil because it falls faster than it can infiltrate into the soil or it enters the soil. Infiltrating water either evapotranspires or passes the root zone to enter the groundwater as recharge. Precipitation also runs off because the soil pores are full as rejected recharge.

Recharge to the alluvial aquifer in Squaw Valley occurs in several ways. There is precipitation that recharges where it falls, percolation from streams flowing across the basin, and at the mountainfront where runoff from the mountains encounter high permeability unconsolidated sediments. Figure 4 shows a general circulation of groundwater recharging on the streambanks and mountain front. The Olympic Valley basin also has numerous anthropogenic sources including recharge of irrigation water and leaks from pipes (WSA).

[2] http://www.wcc.nrcs.usda.gov/nwcc/site?sitenum=784. The data were obtained as monthly values for each year since 1980. The annual averages were for water years, October through September.

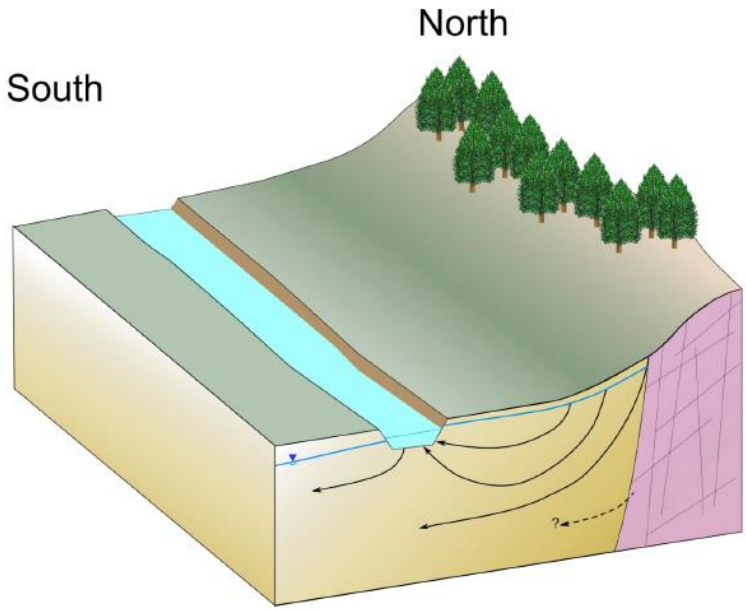

Figure 10: Conceptual Diagram of Stream/Aquifer Interaction during Late Spring and Early Summer

Figure 21: Figure 10 from Hydrometrics (2014). Hydrometrics (2014) suggests mountain front recharge on the north side of the valley circulates to different levels, with some inflowing to Squaw Creek, but only on the north side. Water seeps from the creek and continues southward from the stream; this is supported by the water loss surveys. More water enters than leaves the stream, so synoptic surveys find the stream is gaining in these reaches. There is no evidence that water at depth, flowing from the north, continues southward under the creek.

Mountainfront recharge occurs in zones around the valley at near 6350 feet and, based on isotope and geochemical analyses (Moran 2013), provides the largest proportion of basinwide recharge. Upward gradients observed in deep piezometers reflect the deeply circulating mountain front recharge that ultimately discharges to the creek (Hydrometrics 2014) (Figure 4). No evidence supports the idea that the upward gradient also means that deep groundwater does not flow upward due to there being "some level of confinement in the deeper aquifer" (Hydrometrics 2014, p 3).

Water recharges from Squaw Creek into the aquifer during runoff periods, mostly in the western portion of the aquifer (Hydrometrics 2014). During late summer and fall after groundwater levels have risen sufficiently groundwater discharges to the creek. As groundwater draws down, recharge may begin again if there is any remaining runoff; if not, the stream becomes dry.

The third natural recharge source is precipitation and snowmelt directly on the alluvial aquifer, which is distributed recharge. The rate can be specified as a percent of the precipitation usually distributed evenly across the basin. Additional recharge sources are anthropogenic, including irrigation return flow, pipe losses, and sewer inflow and outflow (Hydrometrics 2013, Table 2).

The WSA does not present an estimate of recharge to the basin, although it notes the various components and the likely temporal variability. Hydrometrics (2007b) revises the groundwater model recharge zones and indicates the recharge rates are changed accordingly, but does not specify the new

rates. Hydrometrics (2007a) discusses that planning objectives must include the identification of recharge zones and rates. Later documents suggest that mountain front recharge is most important (WSA, Hydrometrics 2014). Only the earlier documents actually estimate recharge.

West-Yost (2003) and Williams (2001) estimated annual recharge to the basin to equal 688 af/y, but do not explain the estimate. Williams (2001) used the model HELP (Hydrologic Evaluation of Landfill Performance) for the estimate. As may be suspected from its title, HELP is not commonly used for watershed scale recharge estimates – it used for estimating seepage through a landfill cover. HELP simply does a water balance calculation among layers assuming one-dimensional vertical flow without considering unsaturated flow through the soil. Being one-dimensional, it does not account for differing conditions around the area or for recharge of water that has flowed downhill. Figure 4-7 in West-Yost (2003) shows monthly recharge estimates from 1992 through mid-1999, which are similar to the output expected from HELP. The monthly variation indicates the annual estimate has a large variability.

The recent studies do not include a water balance estimate for the aquifer, but the earlier studies do and include the 688 af/y recharge estimate (West-Yost 2003, Williams 2001). They combine it with other recharge sources and pumping estimates to estimate a groundwater discharge to Squaw Creek equal to 434 af/y. They acknowledge a huge uncertainty due to all of the inflow values being gross estimates. Recharge varies substantially from year to year (Figure 4-7, West-Yost 2003), therefore the idea of a steady state annual water balance is not very useful.

Stream/Aquifer Interactions

The exchange of water between groundwater and Squaw Creek indicates how groundwater pumping will affect flow in the creek. Hydrometrics (2013b) used temperature probes and piezometers to estimate seepage rates and gradients across the stream bottom in Squaw Creek near the parking lot in western part of the valley. Water temperature variations can show where groundwater flows into the creek because it causes measurable temperature changes. Piezometers measure water levels at specific levels in the aquifer near the stream so that gradients to or from the stream can be estimated.

Seepage rates estimated with temperature are highly variable since the temperature data varied even across a cross-section. This suggests that groundwater may be entering the stream on one side and discharging from the stream on the other side, as suggested on Figure 4. The piezometers and stilling basins in the channel estimated mostly small head drops, either up or downward until the stream dries at which point the water levels dropped to as much as seven feet beneath the stream bottom. The conductivity values estimated with Darcy's law using the estimated seepage and gradients ranged from 0 to 40 feet/day.

The summary is that in the west part of Olympic Valley, near most of the municipal wells and where the creek is in a trapezoidal channel, the water from the stream percolates to groundwater when the streamflow is relatively high or when the groundwater is drawn down. During late summer, the stream may go dry and the water table may fall below the bottom of the stream. At this point the stream also recharges the aquifer if it contains water.

Pump tests show that the groundwater in Squaw Valley is connected to the creek. The transmissivity is high, although the tests as performed and analyzed were inaccurate. For one, the tests are completed near the creek so the pumping clearly drew water from the creek during the early season test when the creek was flowing. A second test, when the creek was empty, showed signs of the limiting size of the

aquifer, with a no flow boundary on the far (north) side of the creek. Although the authors acknowledged these issues, they analyzed the pump test data with the standard Theis (1935) method which does not account for boundaries or stream leakage (Hydrometrics 2013b). The conductivity estimates ranged from 235 to 755 ft/d, which is probably too high due to the issues with the tests just identified, although a proper analysis would still likely result in estimates of the same magnitude .

The WSA claims the groundwater is percolating rather than flowing in a subterranean stream (WSA, p 5-7), but does not support this contention. Groundwater flowing in the Olympic aquifer appears to be flowing in a subterranean stream, as described in the Garrapata decision[3], in that (1) there is a subsurface channel present, (2) the channel has relatively impermeable bed and bands, (3) the course of the channel is known, and (4) groundwater flows in the channel[4]. As described above, the Olympic Valley aquifer is alluvium that lies in a glacial-carved valley of granitic bedrock. The granitic bedrock forms a subsurface channel and defines its banks. Williams (2001) shows profiles and cross-sections that show the maximum depth to bedrock is about 150 feet over its approximate one and half mile length and quarter mile width. Cross-sections also show alluvium confined on both side and underneath[5].

Groundwater flows through the aquifer from west to east where it discharges to Squaw Creek or the Truckee River. Groundwater originates almost exclusively from recharge into the alluvium from snowmelt or runoff in Squaw Creek or a tributary. Moran (2013) showed the age of shallow groundwater was less than a year. Upward gradients in the alluvium show that water through the entire section of the aquifer eventually circulates to the stream, even though the travel time may be a few years.

Very little groundwater enters the aquifer from bedrock fractures in the alluvium. Horizontal wells intersect bedrock fractures above the alluvial aquifer and produce about 70 af/y (WSA 2014). This fracture flow is not recharge to the aquifer because it occurs above the basin aquifer, not within it. Williams (2001, p 12) used the flow rate from these wells to estimate an “average annual recharge from bedrock fractures” (Id.) to be 436 af/y. Williams presents no data to show that similar flow rates occur in the fractures that do not have horizontal wells. Even if flows occur, they would be springs above the valley floor, not discharges into the alluvium. Moran (2013) showed geochemically that there is not a strong connection between the basin and fractured bedrock groundwater system which means the geochemical signature of bedrock water did not appear in the alluvial groundwater. The WSA acknowledged there is “little connection between the Basin and fractured bedrock groundwater” (WSA, p 5-3). Because the bedrock is generally impervious and the bedrock fractures provide spring flow above the valley floor rather, the bedrock contributes almost no flow to the aquifer. The earlier (2001) estimates of bedrock inflow to the aquifer should be disregarded.

[3] Decision 1639, In the Matter of Application 29664 of Garrapata Water Company, State of California State Water Resources Control Board.
[4] These four criteria were presented on page 4 of the Garrapata decision, note 3.
[5] Garrapata also defined the channel as alluvium. Note 3, p 5.

Water Supply Sufficiency

The WSA considers water supply sufficiency rather than a safe or perennial yield for the basin[6]. None of the previous studies have found the basin to be in overdraft (WSA, p 5-1), but the WSA does not define what "overdraft" would be. The WSA implies that the aquifer is small compared to the amount of water fluxing through it and that recharge essentially fills the aquifer each year regardless of drought conditions (2014 and 2015 may ultimately be an exception). This is not accurate as discussed above regarding Figures 2 and 3. Also, simulations of existing pumping (Hydrometrics 2014) show that groundwater levels in the western portion of the aquifer (the well field) recover to different levels after a pumping season. Groundwater levels recover to a similar level each year only in the eastern portion of the aquifer[7]. The west end of the valley where most of the recharge occurs refills to levels that vary among years during the springtime peak.

This also means the WSA overplays the idea of "rejected" recharge in the Olympic Valley aquifer. A full aquifer will "reject" potential recharge during periods of high recharge because aquifer volume limits storage. Because much of the aquifer in the eastern meadow portion of the aquifer is full, some potential recharge may be rejected there but since there are few wells there and none of the new wells are proposed there, there is little opportunity to increase the recharge.

The water supply sufficiency of the aquifer to the proposed project pumping and increased pumping is mostly discussed in a memorandum from Todd Groundwater (Taylor et al. 2014). Basically, Taylor et al. (2014) determined that it was necessary to maintain saturated thickness at 65% of the maximum saturated thickness. The maximum saturated thickness "occurs when water levels are the highest" (WSA, p ES-3, p 6-5, Taylor et al. 2014, p 14). Maximum saturated conditions represent "current average pumping conditions (WSA, p ES-3, p 6-5). Taylor et al. specify that "maximum saturated thickness values at specific locations do not change, and were derived from model simulations representing historical actual pumping conditions" (Taylor et al. 2014, p 14) which they also refer to as "baseline conditions". "Maximum saturated thickness is the highest groundwater elevation minus the Basin bottom elevation. The maximum saturated thickness values at specific locations do not change, and these **values were derived for the existing and new well locations** from **model runs representing historical actual pumping conditions** in the calibrated model" (Taylor et al. 2014, p 16, emphases added). This establishes that the maximum saturated thickness therefore depends on historical conditions with pumping, there is apparently no consideration of whether the aquifer is currently stressed by those existing pumping conditions. In other words the method assumes that baseline, existing conditions, are not causing overdraft in the basin and may be compared against by conditions going forward with future development.

Taylor et al. (2014) decided on 65% after a literature search because that was the deepest drawdown recorded in the past at existing wells and it did not cause a problem at any wells as far as they

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[6] California conflates safe yield with perennial yield, defining the latter as "the maximum quantity of water than can be withdrawn annual from a groundwater resources under a given set of conditions without causing an undesirable result" (Bachman et al. 2005, p 268). Continuing the "phrase undesirable result is understood to refer to a gradual lowering of the groundwater levels resulting eventually in depletion of the supply, subsidence, increased energy costs, dessicated wetland or degraded water supply" (Id.).

[7] Hydrographs for Wells RSC-328, -304, -308, -321, and -307 recover to almost the same level each year regardless of recharge (Hydrometrics 2014). All wells in the east recover to similar levels.

understood. Thus, 65% is an operational limit because it is simply the necessary saturation to maintain well pumping efficiency[8] and is meaningless with respect to basinwide groundwater management. The guidance has nothing to do with maintaining a yield or not causing other deleterious impacts to the basin, such as lowering discharge to streams and springs

The baseline (maximum saturated thickness) is determined at the new and proposed well locations based on simulated historic drawdown at those locations. In other words, they run the groundwater model with existing pumping, recharge, and all other conditions to determine the groundwater levels for each time step; this would be the same period they used to calibrate the model. The baseline at the existing wells is therefore the simulated drawdown at the pumped well and at the new wells will be the drawdown as caused only by pumping the existing wells. If a proposed well is beyond the drawdown of existing wells, its baseline will be background aquifer water levels. The baseline is existing conditions over the 1993 to 2011 period. As noted above, comparing future pumping to this definition of existing conditions establishes or implies that there is no overdraft or basinwide problems with the existing pumping.

Taylor et al. test for water supply sufficiency by simulating pumpage at the expected 2040 demand from existing and proposed new wells. They simulate pumping the same demand regardless of drought conditions because there has been no decrease in the past due to drought – this is reasonable; I review the projected water demand below. However, the WSA identified that six new wells would be need to meet demand by 2040 (Taylor et al. 2014, p 11), but the simulations of future conditions placed wells "in all of the locations identified as being favorable for groundwater production" (Id.). For modeling, they placed new wells "in locations where no Project buildings are planned and were selected to take advantage of deep and productive areas, maintain distance between wells to minimize interference, maximize distance from Squaw Creek, and distribute pumping over a large area to reduce cumulative drawdown effects in any one area" (Id.). Taylor et al. Table 2 shows nine proposed new municipal wells and Table 3 shows that all of the wells, existing and new with one exception, were simulated to pump the same rate, 54.7 af/y; other entities' wells pump at other rates based on their specific conditions but mostly at rates proportional to their historic pumping. In other words, water supply sufficiency, assessed based on drawdown, was simulated using more wells than is actually proposed for the project. This spreads the pumpage over three extra wells and leads to simulated pumping rates that are almost half the current historic pumping rates (Taylor et al. 2014, p 12). "Existing SVPSD Basin groundwater production from four wells was approximately 3809 AFY on average (95 AFY per well). In the modeled 2040 pumping scenario there are 14 SVPSD wells producing a total of 700 AFY, or 50 AFY per well" (Id.).

The WSA therefore simulates operational demands by pumping less from each well than was pumped from the existing wells, historically. Their simulation shows that the 65% criteria is met on average over the well field and for individual wells although percent saturation varies widely (Figure 5). The average percent saturation hardly drops below 80%. The decrease in percent saturation in their chosen dry year, 2007, is similar to that in other "wetter" years such as 2008 and less than 1994. Their three-year dry

[8] A peer review letter prepared for the water supply assessment explains in detail the need to maintain the operational thickness. Letter from Dwight Smith, Interfluve, Inc. to Mike Geary, Squaw Valley Public Services District, Re: Preliminary review of sufficiency of supply memorandum dated May 15, 2014. May 29, 2014.

periods, 1999-2001, caused much lower percent saturation than did the driest year[9] (Figure 5). During no year does percent saturation return to 100%.

Any MODFLOW-based groundwater model estimates drawdown over a model cell, not specifically at the well bore. This is because groundwater models operate by completing water balance calculations for each cell and the change in storage (ie from pumping) is averaged over the cell. It is possible that actual drawdown at a well will be higher than reported in the WSA[10]

The period 1993-2011 does not include the driest years the area could experience because it does not include the 1987-92 drought or the ongong 2012-15 period, which may turn out to be the driest period on record. Also, changing climatic conditions expected in the 21st century renders bare reliance on the recent historical record insufficient to assure adequate future supplies. The WSA should acknowledge this fact and simulate groundwater pumping under conditions representative of future climate change scenarios. Once data is available through 2015, the model should again be run and the WSA rewritten to better assess and describe the water supply sufficiency under drought conditions. It would be useful to add years without recalibrating the model to verify the model calibration and conceptual model (Anderson and Woessner 1992).

[9] Peer reviews by Dwight Smith have noted that 1999 is not generally considered a drought year in the Truckee River watershed. Review file: Draft_Village_at_Squaw-Valley_Specific_Plan_WSA_6-17-14_DSmith.pdf.

[10] Peer reviews also raised this issue. Letter from Dwight Smith, Interfluve, Inc. to Mike Geary, Squaw Valley Public Services District, Re: Preliminary review of sufficiency of supply memorandum dated May 15, 2014. May 29, 2014. From p 2 of 4: "In estimating saturated thickness at specific pumping wells, the model output also will overpredict the saturated thickness available to the well. This is because the pumping water level in the well can only be based on the water level in the model cell in which the well is located. The model cell represents an area surrounding the well. In reality, there is a cone of water level depression with a focal point at the well."

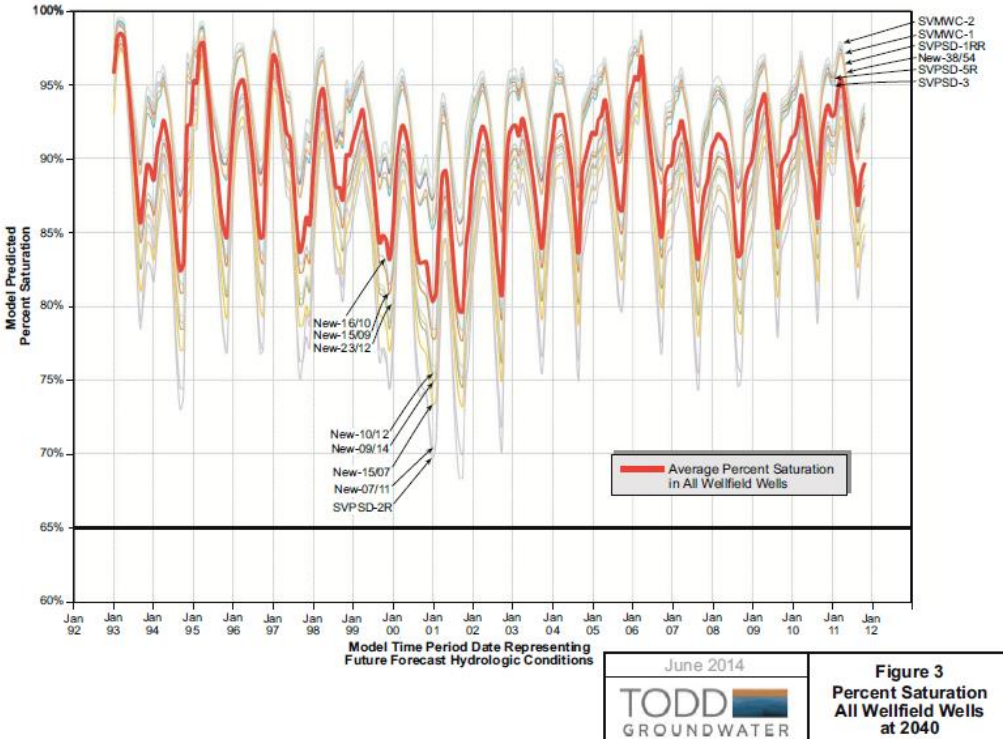

Figure 22: Figure 3 from Taylor et al. (2014) showing the percent simulated saturation at all wells.

The analysis of 1993 through 2011 indicates three things. First, the aquifer does not fill every year so which refutes the WSA's discussion of full recovery; recharge has not refilled the aquifer if the water level never returns to the baseline condition. Second, drawdown from each well must overlap such that a well pumping just 50 af/y is drawn down more than it was when it pumped 95 af/y (the baseline was set based on existing wells pumping 95 af/y). Third, because percent saturation was lower in the three-year dry period than in the one-year dry period, there is carry-over drawdown affecting water level recovery in the longer dry period.

Model predicted saturated thickness varies up to twenty feet annually and the aquifer thickness is quite variable, varying from about 50 to over 150 feet (Figure 6). It would be more useful to provide a map showing water levels and one showing drawdown for a dry year. This would show where the pumping draws water from and where the aquifer may be most stressed. Additionally, they should provide a hydrograph of recharge from different areas, pumping, and discharge to Squaw Creek to show the effect that development has on other parts of the aquifer.

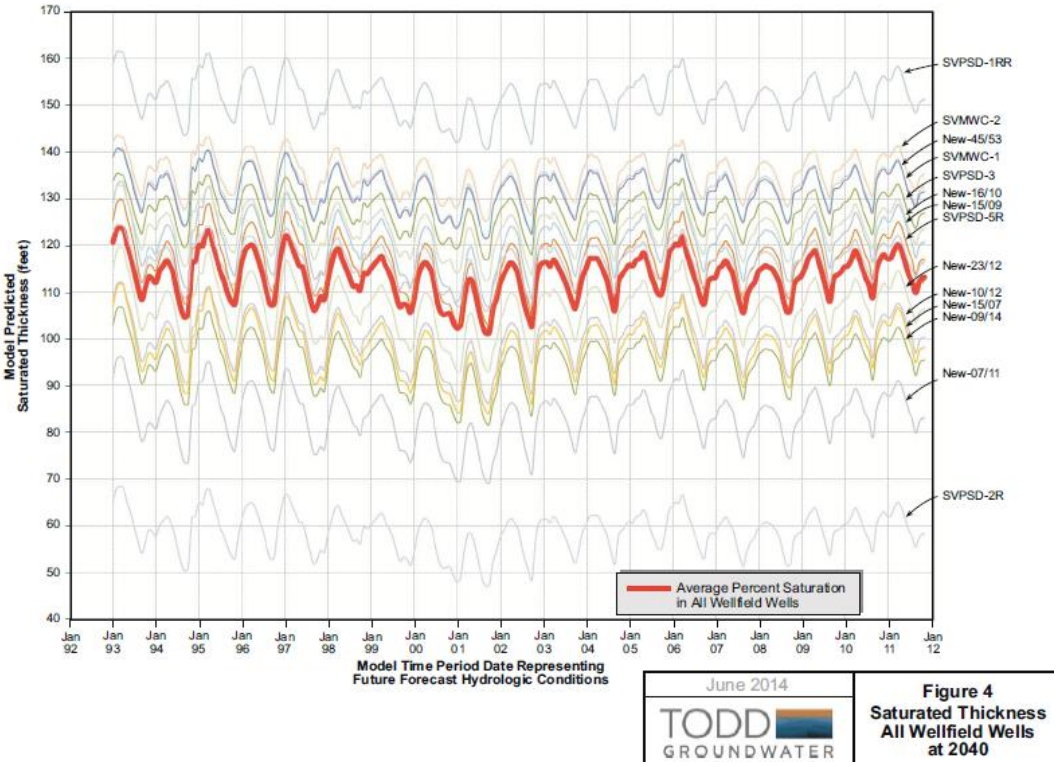

Figure 23: Figure 4 from Taylor et al. (2014) showing the saturated thickness at all wellfield wells.

Overall, Taylor et al's (and the WSA) analysis of water sufficiency does not account for:

- Changes in streamflow. There is a connection between surface and groundwater such that drawdown could decrease streamflow, both during dry and wet periods. As the water table lowers, it will draw water from the creek as long as water is available in the creek. Increasing pumpage will increase the time periods during which the creek has low or no flow as well as increase the lengths of stream that actually go dry.
- Changes in wetland conditions: The allowable loss in aquifer saturation would lower the water table beneath wetland areas as well. The proposed project would exacerbate the drawdown in the meadows and lengthen the time period that the meadows are dry.

Baseline as analyzed herein is the legal definition for CEQA and does not consider predevelopment conditions. It would be useful to consider predevelopment conditions with no pumping in the valley because the current baseline assumes there are no problems with the current water supply system. Comparison with predevelopment conditions would allow an assessment of just how much predevelopment natural conditions have changed. This could be simulated with the model with just recharge without return flow and pipe leakage and discharge to the stream. The simulation would establish groundwater levels that could be considered the maximum saturation level. Analysis of pumping should consider two levels of development. First would be existing conditions and second would the proposed 2040 development conditions. Percent saturation then may be quite a bit less than currently determined because the maximum saturation would be a thicker aquifer with less annual variability.

Additional Groundwater Development Considerations

The WSA estimates that a municipal well pumping at a "customary 8-hour pumping cycle" would capture only 2% of its flow from Squaw Creek. The estimate of the amount of water drawn from Squaw Creek is likely too low because the calculation does not account for cumulative effects because it assumes that at the beginning of any pumping cycle the amount being drawn from the creek is zero. Hydrometrics used a standard formula (Hunt 1999) to estimate the amount of water that pumping draws from the creek (Hydrometrics 2013a, p 17). Assuming they applied the method properly, they estimated that after 51 hours of pumping (test #1), 17% of the amount being pumped was being drawn from Squaw Creek. Hydrometrics minimized the importance of this by estimating the amount drawn from the creek over the entire 51-hour period as less than ½ percent of the creek's total flow during that period. Over an eight-hour pumping cycle, the amount captured was much less. The method does not account for water drawn from the creek due to drawdown that remains when pumping stops; this drawdown fills by pulling water from storage elsewhere in the aquifer and from the creek, either by reversing discharge to the creek or by directly drawing from the creek. Ultimately changes in streamflow are necessary to fill the drawdown because all pumping is a new discharge from the aquifer which must be taken from another discharge from the aquifer.

There is no consideration of climate change with future simulations, although it is likely to affect precipitation and snowmelt timing in ways that will lengthen the dry, or no-recharge, period of a year. As the snow shifts to rain and snowmelt occurs earlier, there will likely be longer periods during the summer during which there is not runoff recharging the aquifer. Recharge replaces pumping discharge during spring, but not during later summer and early fall; that period will likely increase in length so the drawdown will likely increase.

Water Demand

Most of the water demand analysis in the WSA was completed by Hunt and van Dyne (2014), a memorandum attached to the WSA as Appendix A. Hunt and van Dyne rely on a memorandum prepared by MacKay and Somps (Giberson 2014) to support their estimates.

The WSA estimated project and non-project water demands for the next 25 years, commencing in 2015. Total demand for the valley in 2040 would be 1205 af/y (Hunt and van Dyne 2014, p 2) but existing horizontal bedrock wells will continue to produce 70 af/y through 2040. Because the WSA assumes, appropriately, the bedrock wells are separate and independent from the valley groundwater system, the WSA subtracts this bedrock production to establish demand equal to 1135 af/y. In five-year intervals from 2015 through 2040, the project demand is 0, 82, 129 175, 210, 234 af/y while the total valley water demand is 772, 880, 975, 1044, 1100, 1135 af/y, respectively.

The WSA estimates water use for single family residences (SFR) as 550 and 400 gpd/connection for the SVPSD and SVMWC areas, respectively. They also assume full build-out of empty lots by 2040, so there is a total 74 af/y of SFR demand. Hunt and van Dyne (2014) distribute that demand over the year in a "bell curve pattern" (Id., p 9) which results in 40% of the annual demand being required from July through September. Much of the SFR demand occurs during the season when less water recharges the aquifer, so meeting the demand stresses the aquifer more. These estimates are reasonable.

The WSA estimates occupancy based on 2009 through 2011; at full build-out it is projected to be just 55.2% annually varying from 26% in November to 72% in March (Table 1, Giberson 2014). For commercial use, the demand per sf is reduced based on the occupancy rate (Id.). No justification is given for using 2009 through 2011, and the choice should be questioned because those years were at the peak of an economic slow-down when travel to resorts was likely at a low point as compared with pre-recession or even now.

The occupancy combines with the usage per capita for lodging to create a resort demand (not including irrigation). Hunt and van Dyne (2014) used 100 gpd/capita with two people per room (although Giberson (2014) used 90 gpd/capita). They also used a 9.8% factor of safety to account for unbilled water losses.

Commercial water use is the second largest demand, rated at 0.24 gpd/sf (Hunt and van Dyne 2014, Table 10). It is used throughout the demand tables in Giberson (2014). This was based on observed commercial demand from 2005 through 2012, but there is no description of how the estimate was made. A simple estimate of water use by area would not account for occupancy.

Hunt and van Dyne (2014) combine water used based on bedroom occupancy and commercial area development. They estimate project water demand for 2040 at 55,471 for full occupancy, based on 2 per bedroom and 100 gpd/capita and 0.24 gpd/sf for 80,500 sf commercial development (Hunt and van Dyne 2014, Table 10). They then adjust this amount based on the occupancy rates discussed above.

The two largest obvious sources of potential error are in the occupancy rate and the 0.24 gpd/sf/capita estimates. Occupancy could be up to 80% higher than the estimated rate. This is based on full occupancy being a little more than an 80% increase. There is too little disclosure of how 0.24 gpd/sf was estimated to assess its potential variability. Because the occupancy could increase as much as 80% the future demand should be considered in a variable fashion. In other words, the water supply sufficiency estimates should be based on much higher potential demand even if the underlying estimates are accepted as accurate.

Another issue regarding demand is timing, as in the distribution of demand through the year. Much of the current and projected demand occurs during late summer from July through September after recharge has decreased. The existing basis for distributing total demand among months has many uncertainties, but is probably more uncertain for the existing and non-project used because it involves various types of irrigation. When considered annually it might appear there is sufficient groundwater to meet demand but due to the small aquifer volume and the lack of recharge during late summer, pumpage may lower groundwater levels and cause significant environmental damage to streamflows or riparian vegetation. If climate change further lengthens the time period without recharge, the potential impacts could increase. Groundwater drawdown could exceed the 65% criteria established for water supply sufficiency.

Conservation could decrease demand on the system. The WSA suggests a variety of water-saving devices, including: “installation of high-efficiency fixtures and fittings, use of recirculating hot water systems, implementing graywater system applications, minimizing water intensive landscape, and use of smart irrigation controllers” (WSA, p 4-5); the WSA also notes that it is difficult to assign conservation saving to a specific use, so the demand as analyzed does not account for conservation. Also, much of the non-consumptive use returns to the aquifer as wastewater discharge.

Groundwater Model

The WSA uses a numerical groundwater model (Hundt and Williams 2014, Hydrometrics 2013, West-Yost 2003, Williams 2001) to assess the ability of the aquifer to meet demand by determining how proposed pumping will affect the percent saturation of the aquifer. Williams (2001) developed the model initially; there have been several updates since then (Hydrometrics 2014, 2013, 2007a and b). The model is difficult to review because no one report thoroughly documents its current structure and accuracy. However, the important aspect is how well it performs today.

Three aspects of the model are problematic for its intended purpose - to assess water supply sufficiency. First, recharge rates were estimated in a very unusual way and are distributed evenly across the model domain rather than attempting to account for actual sources, with the exception of some mountainfront recharge. The temporal distribution of recharge (Hundt and Williams 2014) also makes more water available to the aquifer at inappropriate times. Second, general head boundaries allow inflow from the bedrock to the basin aquifer which will inappropriately maintain groundwater levels in the basin aquifer. These original model structures have survived mostly intact until now. Third, recent revisions converted the aquifer property estimation to a use of pilot points which does not account for prior knowledge of the formation boundaries. The following paragraphs expand these issues.

Figure 7 shows how Williams defined recharge zones and Figure 8 shows the most recent (Hundt and Williams 2014) variation. Recharge zones are specified flux boundaries, meaning the modeler specifies the rate in length/time, or ft/d in Figure 7 (also Table 1), that water enters the model distributed evenly over the area of the zone. Recharge as applied to the model apparently includes many sources of water, including distributed recharge from precipitation on the spot, irrigation, leaks from sewer pipes, and others. Williams (2001) explains that they estimated "infiltration from rainfall and snowmelt" (section 2.5.1.1)[11] using the HELP model, as discussed and criticized above in the recharge section.

Table 2: Recharge rates for recharge zones in Figure 7.

Zone	ft/d	ft/dy	in/y
2	3.08E-03	1.12	13.49
3	8.42E-04	0.31	3.69
4	8.42E-04	0.31	3.69
5	2.24E-02	8.18	98.11
6	2.18E-02	7.96	95.48
7	7.76E-03	2.83	33.99
8	8.46E-03	3.09	37.05
9	2.54E-03	0.93	11.13
10	1.17E-02	4.27	51.25

[11] Throughout the reports they authors frequently interchange infiltration and recharge. Infiltration is precipitation that enters the soil through the soil surface; it may become soil water and be evapotranspired. Recharge is the infiltration that flows through the soil layer to the groundwater table.

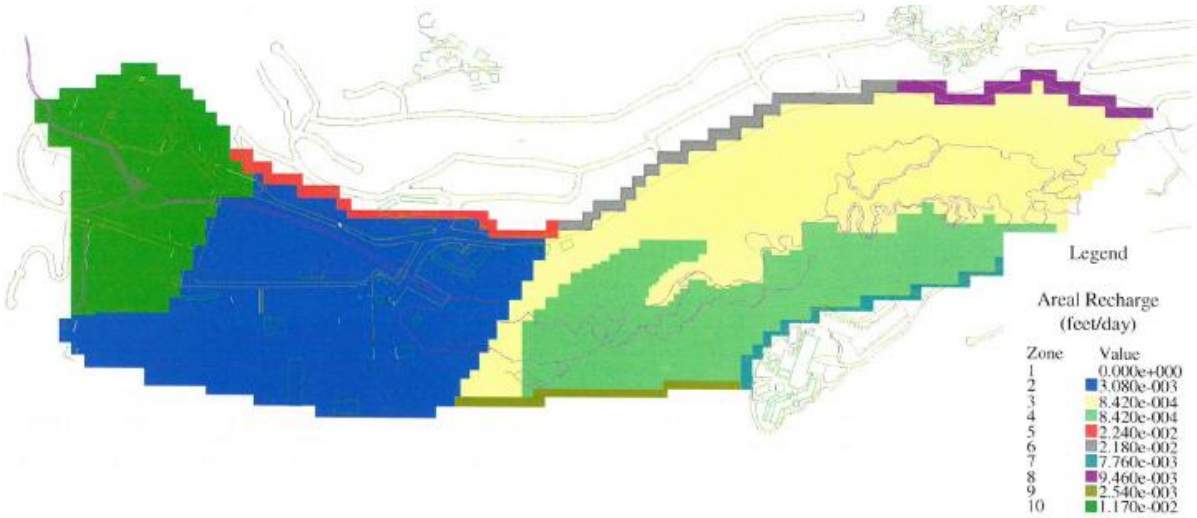

Figure 24: Williams, Figure 32 showing recharge zones.

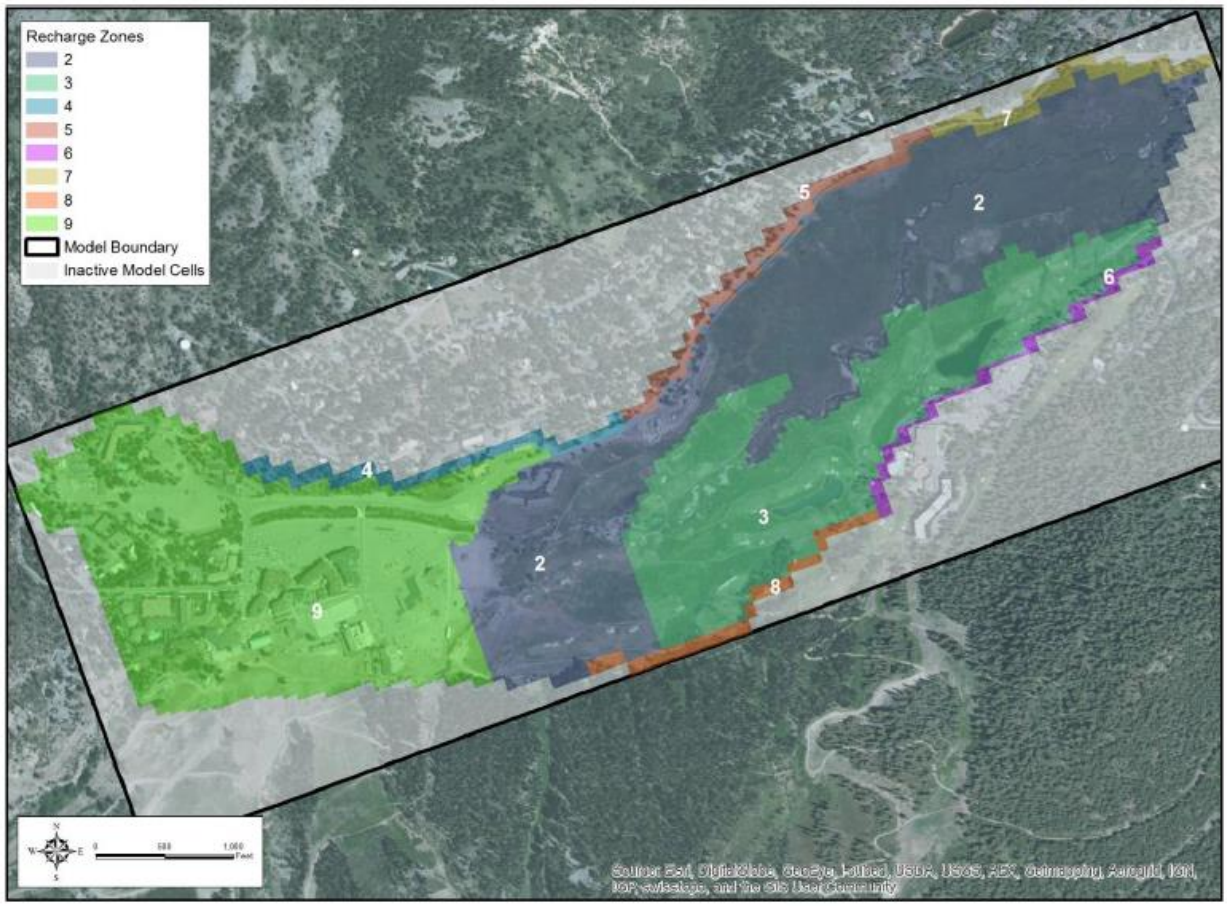

Figure 2: Recharge Zones

Figure 25: Hundt and Williams (2014) recharge zones.

Figure 7 shows zones along the edge of the basin which apparently add runoff from the mountains as recharge to model, but the report does not describe how the flux rate for those zones was determined. The rates shown on Figure 7 for zones 5 and 6 (and Table 1) are substantially higher than those used over the rest of the model area, as they should be if they truly represent mountainfront recharge, but they cover such a small area that the total recharge would not be much.

The distribution of recharge through the year depends on the availability of precipitation or snowmelt, so Hundt and Williams (2014) distributed precipitation availability during winter as 50% of precipitation during the month it occurs and 25% in the following two months. All precipitation which falls in December is available to recharge by the end of February; all precipitation in February is available for recharge by the end of April. March percentages are 60 and 40%, respectively, so all March precipitation is also available to recharge by the end of April. From April through November, all recharge occurs during the month the precipitation falls. I use "available" with recharge because it will runoff if there is no soil moisture capacity available. It seems unreasonable to assume that all December precipitation melts and recharges by the end of February; this could cause the simulated water levels to recover too soon.

Williams (2001, p 19) simulated inflow from the bedrock using general head boundaries (GHBs). The discussion above has shown that recent studies have concluded little water enters the basin from the bedrock, simulating this with a GHB is inappropriate. A GHB allows groundwater to enter or leave the basin based simply on the difference in water level between that simulated for the aquifer and specified for the boundary and the conductance of the boundary. Williams located the GHBs at fractures where flow could have entered. A GHB artificially maintains the water levels in the aquifer at a specified level which is inappropriate and could make the calibration appear more accurate than it actually is. It also artificially limits the drawdown predicted by the model.

Third, Hundt and Williams (2014) estimated conductivity using pilot points, a method which essentially establishes parameter fields across the model domain. The methodology is interesting, but needs more description than provided in the report (Hundt and Williams 2014, p 11). The number of wells used for calibration does not seem to be sufficient to create up to 78 pilot points per layer for calibration (p 11). The resulting parameter fields do not resemble hydrogeologic patterns, however, as can be seen on the circular patterns shown on Figures 9 and 10. Figure 9 shows circular areas with horizontal conductivity exceeding 100 ft/d in the middle of areas with conductivity much less than 100 ft/d. Vertical anisotropy has fewer circular zones, but those that occur in layers 2 and 3 are areas where the model will simulate very little vertical flow. It is also very unusual to have the very high anisotropy in surface layers (layer 1 in Figure 10) because surface formations tend to be sorted rather than exhibiting continuous layers.

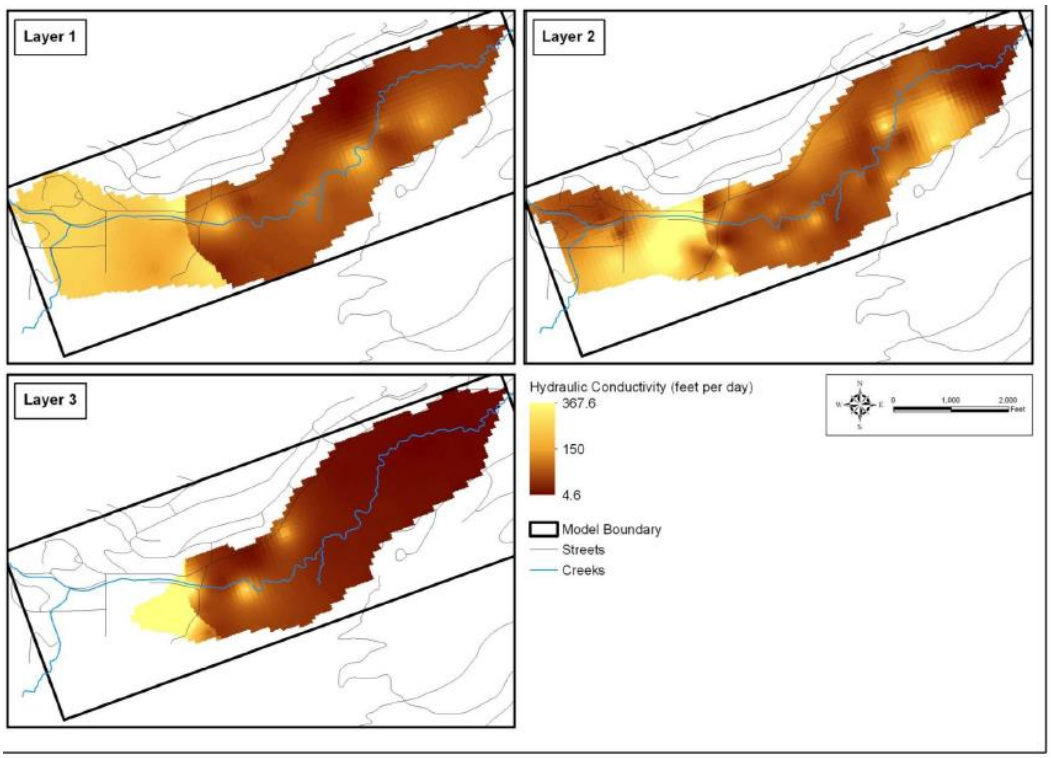

Figure 26: Figure 12 from Hundt and Williams (2014) showing the distribution of horizontal hydraulic conductivity.

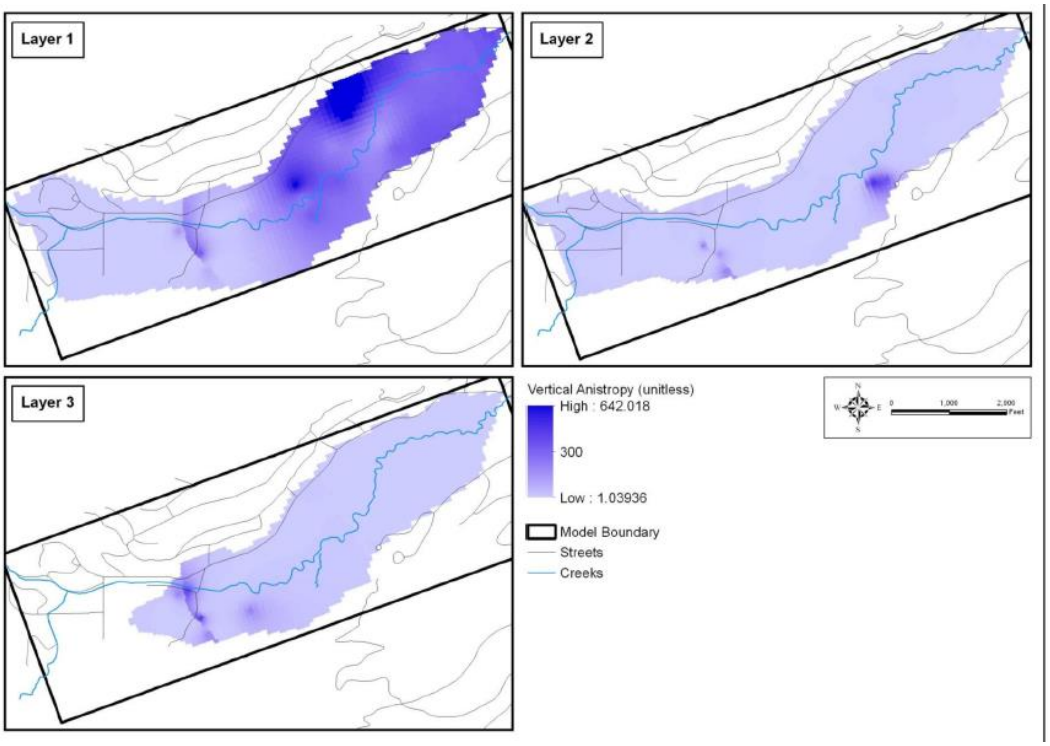

Figure 27: Figure 13 from Hundt and Williams (2014) showing vertical anisotropy, or the ration of horizontal to vertical conductivity.

The model calibration also reveals inaccuracies in the model. Hundt and Williams (2014) considered the model "calibrated when simulated results match the measured data within an acceptable measure of accuracy, and when successive calibration attempts did not notably improve the calibration statistics" (p 10). Usually, calibration is considered complete when various test statistics are minimized to less than a specified value. Hundt and Williams Figure 11 and the test statistics show that the new calibration is pretty good, although they utilized more than one observation from each well which raises questions about the independence of the observations. Groundwater levels at a well are highly autocorrelated which means individual observations are not independent. Using a set of observations for each well may be a form of pseudoreplication which could artificially improve the test statistics, especially if the observations are made frequently.

Hydrographs of simulated water levels are best used for simple graphical comparison. The hydrographs often indicate potential problems not indicated by calibration test statistics or scatter plots. Simulated water levels in some wells are consistently higher or lower than the observations, apparently by as much as ten feet. This is a problem if the areas of over or underestimation affects flows to the creek or the thickness of the saturated zone. There is insufficient information to assess these effects.

The discussion on stream conductance is very confusing – the statement "[t]he final values obtained from calibration equate to average streambed hydraulic conductivity values of 1.1×10^{-3} feet per day and 1 foot per day" (Hundt and Williams 2014, p 12). It is impossible to know what these values refer to – the two values differ by three orders of magnitude. There is no information provided regarding discharge to the stream, which conductance would control, so the value must be based on groundwater levels. Conductance would be highly insensitive to these values.

Hundt and Williams (2014) Figure 1 shows the aquifer is much thinner in the west; layer 3 is most useful in the eastern sections where the valley is gouged up to 100 feet deeper. This simply means that project pumping occurs in layer 2, although I also note that the model descriptions do not adequately describe the depth of pumping in the model.

The model report should present final water budget amounts, including recharge, pumping, and discharge to the stream. A graph showing where the model simulates flow to or from the stream is essential, and should be completed for representative time periods (wet conditions, late summer baseflow conditions). There is no information regarding this potential flux in the model. The model reports should also show drawdown plots for several times during the simulation so that the reader can assess from where the water is drawn rather than just the proportion of saturated aquifer.

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Attachment 1

http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca8474

SQUAW VALLEY, CALIFORNIA (048474)

Period of Record Monthly Climate Summary

Period of Record: 10/13/1955 to 10/31/1975

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	39.5	41.9	44.6	50.8	61.6	71.7	80.1	79.1	72.1	61.4	48.5	41.0	57.7
Average Min. Temperature (F)	14.6	15.8	20.3	23.9	30.9	37.5	42.1	41.3	35.5	27.7	22.4	15.3	27.3
Average Total Precipitation (in.)	9.74	7.64	6.58	3.44	1.62	1.15	0.67	0.83	0.91	2.84	6.58	9.01	51.02
Average Total SnowFall (in.)	54.9	49.8	36.4	21.8	7.8	0.3	0.0	0.0	0.6	4.3	23.9	46.9	246.6
Average Snow Depth (in.)	33	44	40	21	3	0	0	0	0	0	4	19	13

Percent of possible observations for period of record.
Max. Temp.: 90.1% Min. Temp.: 90.3% Precipitation: 91.3% Snowfall: 85.5% Snow Depth: 83.9%
Check Station Metadata or Metadata graphics for more detail about data completeness

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