Joe Serrano

From: Don Stevens <donstevens52@gmail.com>
Sent: Thursday, May 27, 2021 3:47 PM
To: Joe Serrano
Cc: Don Stevens
Subject: UCSC Long Range Development Plan - LAFCO Draft Comment Letter
Attachments: SantaCruz final4.pdf

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May 27, 2021

Joe Serrano
Executive Officer
Santa Cruz LAFCO
701 Ocean Street #318D
Santa Cruz, CA 95060

Subject: UCSC Long Range Development Plan - LAFCO Draft Comment Letter

Dear Mr. Serrano,

Thank you for taking the time this morning to speak with me about the draft letter and to answer my questions. I have a few comments that I would like to share with you and the Commissioners.

In the Closing Remarks of the draft comment letter, it is stated that: "A preliminary analysis of the 5 development projects proposed for outside the City boundaries under the 2020 LRDP (shown in the attached map) likely may not pose major issues in accordance with the Act." I believe it is premature and unwarranted for LAFCO to make this statement. In fact, there is strong contrary evidence to show that water, for example, is and will be a major issue according to LAFCO's current Water Policy. As a result, I believe that the statement also compromises LAFCO's intention to play a neutral role if current disputes between concerned parties are not resolved satisfactorily or should new disputes arise.

Section 3 of LAFCO's Water Policy requires, for any boundary change, that the potential water provider, in this case the City of Santa Cruz, "demonstrate the availability of an adequate, reliable and sustainable supply of water." The City currently does not have an adequate, reliable and sustainable supply of water. The City has shortfalls during "dry years" and, according to the 2015 Urban Water Management Plan, the City will face water shortages by 2025 in so-called "normal rainfall" years. Water Policy Section 3. a) states: "In cases where a basin is overdrafted or existing services are not sustainable, a boundary change proposal may be approved if there will be a net decrease in impacts on water resources;"

However, the proposed 2020 LRDP does not meet the above standard. It will require an estimated additional 134.6 million gallons per year, of which approximately 42 MGY will be for projects located outside the the Santa Cruz service area, rather than the net decrease in impacts on water resources that LAFCO Water Policy requires. If anything, it can reasonably be argued that LAFCO should advise the University that water supply is a major issue and that the conclusions of the University's Draft EIR are not consistent with current LAFCO Water Policy.

Therefore, I believe there is more than sufficient reason to remove the above mentioned statement from the draft letter and hope that you will do so.

On a side note, and for your reference, I am attaching a DEIR comment letter by a nationally renown karst hydrogeology expert that explains why the University's expressed intention to use a campus well to supply water to projects outside the current service area is not feasible, should the City, for whatever reason, be unable or choose not to provide that water. The comment letter concludes that if the University were to pump the campus well at an average rate of approximately 113,000 gallons per day as called for in the DEIR, it would likely lead to the drying up of the 14 springs that are supplied by the campus karst aquifer and potential catastrophic sink hole collapse.

Thank you so much for your consideration.

Sincerely,
Don Stevens

Hydrogeologic Review of
University of California Santa Cruz 2021 Long Range Development Plan EIR

March 4, 2021

Thomas Aley, PHG & RG
Senior Hydrogeologist and President
Ozark Underground Laboratory, Inc.

Introduction

I have been retained by Stephan C. Volker, Esq., to conduct a review of hydrogeologic statements in the UC Santa Cruz 2021 Long Range Development Plan Draft Environmental Impact Report (DEIR). A copy of my resume is attached to this hydrogeologic review as Appendix A. I hold BS and MS degrees from the University of California, Berkeley and have spent my career as a professional hydrogeologist specializing in karst hydrogeology and groundwater tracing studies using fluorescent tracer dyes. I hold national certification as a Professional Hydrogeologist (#179) from the American Institute of Hydrology and am licensed as a Registered Geologist or Professional Geologist in the states of Missouri, Arkansas, Kentucky, and Alabama. I am the author of a chapter on groundwater tracing with fluorescent dyes in the textbook "Practical Hydrogeology Principles and Field Applications" published by McGraw Hill (Aley, 2019) and have taught numerous professional short courses on karst hydrology and groundwater tracing.

Comment 1. A basic understanding of the nature of porosity in karst aquifers and their ability to store and transport groundwater will assist readers of this evaluation in understanding subsequent comments.

Karst aquifers have three types of porosity; some authors have assigned slightly different terms but the following are commonly used.

- Matrix porosity is intergranular porosity and in this marble aquifer is insignificant and does not produce any significant water that could be extracted by wells. DEIR page 3.10-20 describes a boring drilled 300 feet deep within 30 to 50 feet of an inferred north-south fracture zone in Lower Jordan Gulch that *"did not encounter groundwater"*. This illustrates matrix porosity; areas with matrix porosity must be expected to routinely form effective barriers to lateral and vertical water movement in the karst aquifer under the UCSC campus.
- Fracture porosity is the primary provider for wells that do not intersect solutionally enlarged karst conduits. Page 3.10-23 of the DEIR summarizes construction details on four wells on the UCSC campus. No well yield is given for MW-1B but it is undoubtedly

small and is reflective of water yields from fracture porosity. DEIR page 3.10-24 states: *"Monitoring Well MW-1B is located approximately 37 feet west of [Water Supply Well 1] WSW#1, at the western edge of Jordan Gulch. Although this well is completed in fractured marble at a similar ground surface elevation and depth as WSW#1 and MW-1A, it is evidently completed in a separate hydraulic fracture regime and shows a distinctly higher water level (i.e. 40 to 50 feet higher), and no pumping influence from pumping in WSW#1 in 1989 or 2007."* Water stored in most brecciated zones are part of fracture porosity. Water derived from fracture porosity supplies much of the water discharging from karst springs under dry weather conditions.

- Conduit porosity is provided by solutionally enlarged openings. WSW#1 (described in the DEIR at page 3.10-20) encountered conduit porosity described as: *"abundant open to rubble-filled fractures and void spaces. Problems with borehole collapse and loss of circulation were frequent."* The ability of this well to extract 92.5 gallons per minute (gpm) is consistent with a well encountering conduit porosity. Conduit porosity is likely associated with what are identified as "major fractures" on the UC Santa Cruz campus (DEIR Figure 3.10-4). WSW#1 was constructed at the intersection of two of the major fractures. Sinkholes that can accept water at rates of at least 5 or 10 gpm are commonly directly connected with conduit porosity. DEIR page 3.10-18 states: *"More than 50 sinkholes are located throughout the marble-underlain area on the main residential campus and these features are estimated to capture up to 40% of campus runoff (Johnson 1988)."* Conduit flow accounts for most of the water discharging from springs surrounding the UCSC campus.

Comment 2. Based on data in the DEIR approximately 1,000 acres of land is underlain by the marble aquifer. The marble aquifer is a conduit-dominated aquifer that is recharged by surface water derived from lands not underlain by marble and by precipitation that falls on lands that are underlain by marble. Substantial recharge to the karst conduits occurs through sinkholes of which there are more than 50 known on campus. Many of the conduits are expected to be preferentially located along mapped major fracture zones (see DEIR Figure 3.10-4). It appears that most water that enters the aquifer is rapidly transported to one or more of 14 identified springs located west, south, and east of the campus. Flow rates of the springs vary widely as a direct result of precipitation events and stormwater runoff onto the marble.

Comment 3. The DEIR focuses on average hydrologic conditions rather than on conditions when water supplies are limited. While human demands for water on the University campus with a dramatically enlarged population will be relatively constant, the key issues is the adequacy of groundwater from the karst aquifer to supply adequate amounts of water under dry weather conditions without creating significant adverse impacts. Information in the DEIR does not adequately address this key issue.

Comment 4. A conclusion I reached in a report on a 1992 groundwater tracing study on the UCSC campus (Aley and Weber & Associates, 1994) related to extracting a relatively minor amount of water from WSW#1 to supply a greenhouse. That statement should not be viewed as suggesting that more than relatively small amounts of water can be extracted from this well under dry weather conditions without substantially reducing the flow rates of individual springs in the area.

At page 3.10-25 of the DEIR under the heading "Dye Trace Studies" a dye tracing study I directed in 1992 in cooperation with Weber & Associates is discussed. The statement is made: *"The study concluded that WSW#1 is hydraulically connected to major portions of the karst aquifer and that groundwater can be extracted from well WSW#1 without substantially reducing the flow rates of any individual spring in the area."* That statement in the DEIR fails to recognize that the dye tracing study conducted during the period January to March, 1992 and reported upon in 1994 (Aley and Weber & Associates, 1994) was conducted to assess potential impacts on springs of putting well WSW#1 into production to supply a greenhouse and perhaps some outside plants in the vicinity of the greenhouse. This is a relatively minor amount of water. The DEIR at page 3.17-20 shows an average daily water demand for a greenhouse as 62 gallons per day; I presume that is the same greenhouse.

Comment 5. UCSC failed to collect adequate spring flow data during the period 1984 through 2019. As a result, the University has no credible estimate of the rates at which water has been discharged from the karst aquifer during this 35 year period and how rapidly water that enters the aquifer is discharged through the springs. Adequate measurements would have shown whether or not the University could withdraw water from the karst aquifer at a projected mean rate of 113,700 gallons per day under dry weather conditions without depleting the aquifer and/or decreasing or eliminating flow from springs fed by the aquifer. The 113,700 gallons per day value is the projected demand for University activities located outside the service area for the City of Santa Cruz which the University contends could be met by extracting water from the on-campus karst aquifer.

Except for a 7-day duration pumping test at WSW#1 in February, 1989 at an apparent constant rate of 100 gpm; a 3-day duration pumping test at WSW#1 in November, 2007 at an average rate of 92.5 gpm; and pumping to develop wells; the only known discharges from the campus aquifer from 1984 to present have been through approximately 14 springs located generally east, south, and west of University property. The University did make occasional flow rate measurements during the period 1984 through 2019. The most consistent of these were made during the period from 1999 through 2019. During this period flow measurements were usually made on one day in March and one day in September of each year at 13 of the 14 springs for the period 1999 through 2008 and at 9 of the 14 springs for the period 2009 through 2019.

As shown in DEIR Table 3.10-5 the measured flow rates of all 14 springs vary widely. Seven of the 14 springs have intermittent flow with zero flow for an unknown number of days per year. Of the remaining 7 springs maximum measured flow at Bay Street Spring is 11 times greater than minimum measured flow; the ratio is 66 times greater at Messiah Lutheran Spring; 9 times greater at Pogonip Creek System; 272 times greater at Pogonip Spring#1; 53 times greater at Pogonip Spring#2; 714 times greater at Lower Cave Gulch; and 640 times greater at Wilder Creek Spring. This wide variation between maximum and minimum measured flow rates means that a disproportionate amount of the total annual flow from the springs occurs during a relatively few days of each year.

Approximately half of the flow rate measurements of springs were made during months (and especially March) when periods of high spring discharge are likely to occur and the other approximately half of the measurements were made during months (and especially September) when low discharges are likely to occur. The DEIR calculates average spring flow rates as the mean of all measured values. This is a specious value that has no technical credibility; the same applies to the statement that the springs discharge an average of 181 MGY. There is no way to recover the critical data on flow rates of the springs, especially flow rates during dry weather periods.

Continuous records of flow should have been measured from the 14 springs believed by UCSC to drain the karst aquifer during the period 1984 to 2019. Automatic monitoring equipment serviced monthly would have provided adequate information. This is not difficult; there are thousands of stream and spring flow rate measuring stations in the United States that routinely and continuously record similar information. Absent that information, the University lacks credible data for determining how much water could be withdrawn from the karst aquifer without lowering groundwater elevations in the aquifer and/or increasing the frequency and duration of zero or unacceptably low flow volumes from aquifer-related springs.

Comment 6. UCSC has failed to conduct adequate hydrogeologic investigations to characterize the campus aquifer and assess normal fluctuations in groundwater levels at multiple points in the aquifer.

The campus wells are identified on page 3.10-20. Water Supply Well#1 (WSW#1) is located on a major fracture near the southern end of the aquifer. Monitoring Well 1A is located 54 feet northeast from the water supply well and Monitoring Well 1B is located 37 feet west from the water supply well. The only other well on campus is the Upper Quarry Well which is located near the northern end of the marble deposit. At the time the Quarry Well was constructed the static water level elevation was 619 feet which is about 200 feet higher than the static elevation within WSW#1 at the time it was drilled. There is no indication in the DEIR that water levels are routinely monitored in the Quarry Well.

The marble aquifer underlies approximately 1,000 acres. Springs inferred (but not proven) to receive most or all of their water supplies from the campus aquifer are at elevations between 110 feet and 540 feet above mean sea level. An adequately comprehensive network of monitoring wells for routinely measuring water level elevations is a key part of understanding and managing groundwater basins. Given the size of the aquifer, the large elevational range indicated by the springs, and the proposed massive-scale development, one would expect a good comprehensive network of monitoring wells with multiple years of records that had been used as critical data for the DEIR. Unfortunately, that is clearly not the case.

Comment 7. UCSC conducted pumping tests of WSW#1 on two occasions and a test in 1989 indicated: that: "... the well is completed in a highly permeable karst aquifer, with the ability to provide a sustained pumping rate of 100 gpm without dewatering the well, or creating any pumping drawdown at identified spring locations over 2000 feet away". I disagree with the conclusions because they are contradicted by the data.

Although the well is located in a highly permeable *fracture zone* and did in fact maintain a pumping rate of 100 gpm for 7 days, this occurred when the flows from down gradient springs were 15 times greater than minimum measured flow rates from these springs for the period 1984-2019, indicating average rather than dry conditions. The data show that this is a highly permeable section of the karst aquifer. It is not true, however, that the *karst aquifer* as a whole, is highly permeable and that the pumping test shows aquifer resilience under dry weather conditions. This testing is not indicative of aquifer resilience during dry weather conditions, let alone over a large area, for four separate and independent reasons.

First, this is not a highly permeable karst aquifer. Highly permeable karst aquifers routinely have very low groundwater gradients, frequently only a few vertical feet per thousand horizontal feet. The steeper the gradient, the lower the overall permeability of the aquifer. The straight-line distance between the Quarry Well and WSW#1 is approximately 5,300 feet. Based on well completion data in the DEIR the difference in water level elevation between the two wells is about 200 feet; this represents 37.7 feet per 1,000 feet. This is a steep gradient, indicating the presence of barriers to groundwater movement rather than "highly permeable" conditions. Both wells are on mapped major fractures, and a continuous system of mapped fractures exists between the two wells. This steep groundwater gradient is inconsistent with "a highly permeable karst aquifer".

Second, the karst aquifer underlying UCSC is not homogeneous and isotropic. The term isotropic means that the hydraulic conductivity is the same in all directions. Isotropic conditions have been clearly demonstrated in the DEIR to <u>not</u> be present within the karst aquifer on the UCSC campus. Examples of data demonstrating the lack of isotropic conditions include Figure 3.10-4 illustrating the complex network of fractures and conduits and the location of a dry well drilled within 30 – 50 feet of a fracture zone. Most numerical solutions to pumping tests assume that the aquifers and aquitards under investigation are homogeneous and isotropic. If the assumptions of the equations are not reasonably well met, the equations are not valid and therefore a credible answer cannot be expected. That is the case here.

Third, the testing occurred during a period when flows from down gradient springs were 15 times greater than the minimum flows recorded over the last 35 years for those springs. These conditions are not representative of dry weather conditions when the flows in the down gradient springs are most vulnerable to interruption from pumping from the aquifer. The DEIR states that the 7-day pumping test conducted in 1989 occurred during a year of severe and prolonged drought. Still, the combined flow rates from the five springs monitored during the test were approximately 89% of the DEIR calculated combined average flow at the springs. It is the time of the 7 day test, rather than general conditions during the year, that are relevant to the test conditions. As a result, the test more appropriately characterized average rather than dry weather conditions. This is shown by the fact that the combined flow rates of the five springs during the pumping test were 15-fold greater than the minimum measured flow rates from these springs for the period 1984-2019.

A 72-hour pumping test was conducted at WSW#1 in November, 2007. Combined flow rates at measured springs were somewhat closer to low flow conditions. However, during the five day period when spring flows were monitored at three springs the total flow volume of the springs increased by 84% indicating that precipitation had occurred and resulted in significant recharge to the aquifer. The karst aquifer is clearly capable of rapid recharge. However, pumping tests conducted during appreciable recharge events do not enhance understanding of the storage component of the aquifer. While the results of the two pumping tests are similar, they do not demonstrate that sustained pumping of 113,700 gallons per day from the aquifer during dry weather periods would not have significant adverse impacts on spring flow or the aquifer.

The primary insights gleaned from the pumping tests relates to the transport ability of the karst aquifer within a few hundred feet of the extraction well under average flow conditions and not to the potential ability of this portion of the aquifer to yield water from storage under dry weather conditions. The DEIR data do not adequately characterize the storage component of the karst aquifer. Absent this information, the University lacks credible data for determining a sustainable volume of water that could be withdrawn from the karst aquifer without adverse impacts.

Fourth, the testing was limited to a small fraction of the total karst aquifer and the test results are unlikely to apply to the majority of the karst aquifer. As explained, the aquifer underlying the UCSC campus is neither homogeneous nor isotropic. Instead, it is highly fractured and contains both barriers to and conduits for groundwater movement. As noted above, examples of data demonstrating the lack of isotropic conditions include DEIS Figure 3.10-4 illustrating the complex network of fractures and conduits and the location of a dry well drilled within 30 – 50 feet of a fracture zone.

The DEIR states that the storage capacity within the saturated zone of the karst aquifer is estimated to be at least 3,000 acre-feet as demonstrated by aquifer pumping tests. The data do not support this conclusion. The pumping test data were collected from only 3 wells within a 60-foot radius (0.25 acres). The area sampled represents a minute fraction of the total area expected to be underlain by the marble aquifer. With this level of coverage, it is unreasonable to expect the data to be representative of the system. Furthermore, the matrix porosity of the marble is insignificant and does not produce water, indicating that all water storage is likely restricted to zones where fractures or conduits are present. Without an extended monitoring network across the karst aquifer to understand the lateral extent of the aquifer and the spatial and temporal variability of the groundwater table, a reasonable estimate of storage capacity cannot be made. Because such a monitoring network has not been created, the storage capacity of the aquifer is unknown.

Comment 8. There is a steep groundwater gradient between the Quarry Well and WSW#1. In addition, 14 springs presumed to receive water from the marble aquifer are located west, south, and east of the marble aquifer and at a maximum elevational difference among the springs of 430 feet. These factors suggest that the karst aquifer is unlikely to function as a single aquifer and is likely divided into multiple compartments each of which is associated with one or more springs. If this is the case then it enhances the risk that groundwater extraction during dry weather periods will result in significant adverse environmental impacts.

Determination of compartment boundaries in karst aquifers typically involves groundwater tracing with tracer dyes. Only limited tracing has been done at the University. Potentiometric head maps are also useful in this work.

Comment 9. The marble aquifer beneath the campus provides three beneficial environmental services and maintenance of these services necessitates very careful protection and management. These environmental services are:

- **Detains surface runoff by conveying it into and through the karst groundwater system.**
- **Supplies water to springs and watercourses that border the campus. Some of these apparently provide habitat for the federally threatened Red-legged Frog.**
- **Provides buoyant support for unconsolidated materials located above karst cavities.**

Previous discussions have adequately covered the environmental services except the last one listed. The discussion in the DEIR of catastrophic sinkhole collapse and land subsidence in areas underlain by the marble aquifer fails to evaluate the risk of these events if limited water availability were to result in pumping of the marble aquifer supplies. Under natural conditions the springs are the only points where water is extracted from the marble aquifer. When water levels in particular compartments of the aquifer become so low that associated springs cease flowing there will be no further lowering of the aquifer unless there is some component of deeper seepage. Pumping of wells has the potential to lower water levels substantially below those that ever naturally occurred.

Investigation of human-induced sinkholes (called collapse dolines in the DEIR) has been a substantial part of my practice and I have seen well over a thousand of them. Many are induced by pumping that substantially lowers groundwater levels. Important factors in collapses are groundwater levels declining to elevations lower than those that naturally occurred, the presence of open voids in the underlying bedrock, and a very irregular karst bedrock surface existing beneath overlying soils, alluvium, colluvium, or residuum.

Catastrophically formed sinkholes most commonly occur when groundwater levels that naturally supported overlying unconsolidated material decline to the point that the unconsolidated material has lost the buoyant support previously provided by groundwater. Heavy groundwater pumping by a marble quarry near Opelika, Alabama induced the formation of over 200 sinkholes at points up to about 7,000 feet from the quarry. Sinkholes formed in a county highway, beneath a bridge abutment, under an electric transmission tower, beneath a natural gas pipeline, and beneath a parked truck. Sinkhole depths can range from a few feet to depths somewhat below the top of the underlying soluble rock. At the University those depths can be over 100 feet.

Irregular bedrock surfaces above solutional features are favorable sites for sinkhole collapses because they make it relatively easy for pieces of undissolved rock to bridge underlying cavities. DEIR page 3.7-18 states: *"Boring data from prior investigations for the campus for the last decade show a variation in the elevation of the marble surface of more than 100 feet over a horizontal distance of 10 feet or less."* These are the kinds of situations that can result in land subsidence or collapse.

Comment 10. There is insufficient information available on the marble aquifer to conclude that it is capable of providing a daily volume of 113,700 gallons of water to extraction wells that would serve the University during dry periods without causing significant environmental problems. Those environmental problems include cessation of flow from springs and an increased risk of land subsidence or sinkhole collapse on University property.

The hydrogeologic information that UCSC management has developed and supplied in their DEIR is woefully inadequate for characterizing the small and unquestionably complex karst aquifer at the University. Expansion of the University is clearly not a new idea for University management and it is concerning that University management has not funded investigations to gather hydrogeological information essential for this major project.

Submitted by:

Thomas Aley, PHG & PG
Senior Hydrogeologist and President
Ozark Underground Laboratory, Inc.

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