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Solutions for Land and Water Resources

January 13, 2010

Mr. Keith Wimer
Los Osos Sustainability Group
[redacted]

Subject: Review of Cleath-Harris Geologists' July 2009 Memorandum "Flow Model Conversion and Urban Area Yield Update" (Corrected Version February 4, 2010)

Dear Mr. Wimer:

I reviewed the subject report and compared the development and results of the SEAWAT model with the results of previous studies that characterized seawater intrusion and basin yield (Cleath & Associates 2003, 2005, 2006 and Michael Brandman Associates 2008). I also contacted Spencer Harris by telephone, and he was able to provide additional information and responses to our key questions and areas of concern.

Actions are urgently needed to prevent further seawater intrusion, and they should be accompanied with monitoring and contingency measures. Because basin yield is uncertain, an adaptive management approach is needed that recognizes this uncertainty and incorporates appropriate margins of safety to prevent further intrusion in the event the expected effectiveness of the initial actions prove incorrect.

The SEAWAT model represents a step forward in more than two decades of effort towards developing models and quantitative tools to evaluate groundwater yield and quality in the Los Osos basin. The SEAWAT model flow components retain the same basic inputs (recharge and pumping rates) as the earlier "equivalent freshwater head model" that was completed in 2008 and employed for the wastewater project environmental impact report (Michael Brandman Associates, 2008). Although the reports present calibration statistics comparing simulated and measured historical water levels and salinity concentrations, they do not indicate how those statistics translate into uncertainty (i.e., potential errors) in simulated future scenarios. In all scenarios considered, groundwater use is nearly equal to the estimated basin yield. Therefore, this uncertainty in simulation results translates into a direct risk of continued overdraft and further need to reduce demand, augment supplies, or both.

In the recent SEAWAT modeling, some of the sources of uncertainty affecting safe yield estimates include the following:

1. The projected safe yield conditions are substantially different from the historical conditions used to calibrate the model in terms of the spatial distribution of groundwater extraction and recharge. Whenever a model is used to simulate conditions that deviate substantially from the calibration period, there is inherent uncertainty in the results. In this case, the "current conditions" safe yield scenario assumes that nearly two-thirds of the existing groundwater pumping from the lower aquifer (1,062 AFY) would be shifted to the upper aquifer. This change in annual upper and lower pumping rates represent a substantial redistribution of pumping stresses in the basin. While the model predicts that this increase in upper aquifer pumping can be implemented without incurring seawater intrusion, this upper aquifer pumping level has never been experienced in the basin historically nor have any of its effects been measured. Simulated pumping increases in the upper aquifer above the estimated safe yield resulted in simulated sea water intrusion at some wells (Spencer Harris, personal communication, January 5, 2010). Hence, little to no margin of error exists to accommodate the uncertainty in upper aquifer yield relative to the proposed pumping rate.

2. Recent salinity measurements in deep wells show that the model underestimates the rate of movement of the saltwater front. The chloride concentration in the Palisades well reached 250 mg/L in early 2009, indicating the seawater front advanced approximately 4,500 feet in 8 years since it first arrived at the Pecho well in 2001. In contrast, the SEAWAT model projected that the seawater front would move only about 2,000 feet over the next 50 years—less than half the distance in more than six times the period of time—as shown by Figures A-7 and A-5 of the subject memorandum. The main cause for this error is probably the assumption that the saltwater front advances uniformly through the entire cross-sectional area of the model. However in reality—as was described in the 2005 seawater intrusion report (Cleath and Associates 2005)—almost all groundwater flow is through sand lenses with relatively small cross-sectional area. For example, if permeable sand deposits comprise 10% of the basin deposits, the saltwater interface would advance approximately 10 times faster than the rate simulated by the model. Hence, fundamental uncertainty exists in the hydraulic connection between saltwater and individual wells, which translates into uncertainty in the rate of seawater advance and sustainable distribution of pumping between the shallow and deep zones. If monitoring data indicate that additional pumping shifts between the lower and upper aquifers are necessary to prevent seawater intrusion in the lower aquifer, it could exceed the ability of the upper aquifer to support production without inducing intrusion into the upper-aquifer.

3. There is uncertainty in the estimates of recharge (inflows) and pumping rates (outflows) specified as input to the model. The subject memorandum does not present the sensitivity of the yield estimate to the relative uncertainties in these flows. Specific flows that typically have relatively large uncertainty and could substantially influence the yield estimate for the Los Osos basin include:

a. Some previous studies estimated that private domestic wells extract 180-200 AFY, with little to no increase in private pumping since 1985 (Yates and Wiese 1988; Woodward-Clyde Consultants 1997; San Luis Obispo County 2007; Cleath-Harris Geologists 2009). Other studies estimated substantially lower private pumping rates, in the range of 71-88 AFY (URS Corporation 2000; Cleath and Associates 2002; Yates and Williams 2003; Michael Brandman & Associates 2008). There was no systematic chronological shift from one estimate to the other, and details supporting these estimates were presented only minimally if at all. Therefore, it appears there is uncertainty of at least 100 AFY in the amount of private domestic pumping used in the SEAWAT model. Because private domestic pumpers compete with municipal purveyors for yield, a larger estimate of private domestic pumping would result in a reduction in the expected yield that is available to the water purveyors.

b. The soil moisture budget method used to estimate rainfall recharge includes a number of parameters that are not well quantified. Two parameters that can substantially affect the average annual recharge estimate are the rainfall-runoff coefficient and the depth of the root zone for various types of vegetation. In similar water balance studies, the range of uncertainty in these parameters has been shown to correspond to a +/- 40 % variation in estimated recharge (Yates and Wiese 1988; Yates, Feeney and Rosenberg 2005). This can translate directly into a similar uncertainty in estimated aquifer yield.

c. My understanding is that Willow Creek flows are not gauged, and the ET estimate for riparian vegetation is uncertain due to coastal fog effects and unknown “crop coefficients” for natural plant species. Uncertainty in creek flow and riparian ET estimates translate directly into uncertainty in the simulated leakage from the perched aquifer to the upper aquifer and, hence, similar uncertainties in estimated aquifer yield.

d. Streambed permeability influences the simulated quantity of flow between the stream and aquifer. For example, a low permeability can decrease the amount of percolation from high winter flows while having little effect on total groundwater discharge into the lower reaches of the creek. This would shift the simulated average annual net recharge from the creek, which contributes directly to the estimated aquifer yield. This source of uncertainty is further obscured by the use of steady-state simulations.

e. The model simulates a steady-state flow regime, which can underestimate seawater intrusion impacts. During droughts, water levels typically decline as a result of the reduction in rainfall recharge and corresponding increase in groundwater pumping, causing a relatively rapid advance of the saltwater interface. This could potentially contaminate key production wells and require that they be removed from service for a period of months or perhaps years. Even a temporary loss of pumping capacity could jeopardize the reliability of the community water supply system. Furthermore, the subsequent retreat of the saltwater interface when water levels rise during a sequence of wet years can be slower than the advance during droughts, because the rate of movement is driven more by the density difference between freshwater and seawater. So the average interface location under transient analysis might be farther inland than under steady-state analysis, possibly requiring a reduction in the estimate of basin yield.

4. Mitigation of impacts to riparian, marsh and aquatic habitats could require an allocation of basin yield that is currently not considered. The wastewater project's Draft Environmental Impact Report presented a biological analysis that overlooked one of the largest potential impacts, which is a substantial reduction in groundwater discharge to Willow Creek and wetlands in the Los Osos Creek estuary and along the Morro Bay shoreline (Michael Brandman Associates 2008). This impact results from the planned decrease in septic system percolation, not the increase in upper aquifer pumping. For example, current estimates indicate septic percolation recharge to the perched aquifer is presently about 631 AFY and groundwater outflow from the perched aquifer to streamflow and riparian ET along Willow Creek is 552 AFY. As a result of the proposed sewering, the septic system percolation decreases to 36 AFY and outflow to streamflow and riparian ET decreases to 35 AFY (a 93% reduction). Sewering would similarly decrease upper aquifer outflow to marshes around the perimeter of the urban area. If this impact is eventually evaluated and deemed to significantly impact Morro Bay shoulderband snail, steelhead trout or other sensitive species or habitats, some form of mitigation will be necessary. If mitigation includes replacement flows, that allocation of water could compete for basin yield with other water users. Thus, this issue is a source of uncertainty in the amount of yield available to water users.

The proposed management actions to address the saltwater intrusion problem do not increase basin yield, but shift the location of groundwater extraction. For example, pairing shallow and deep wells at major pumping locations provides the opportunity to adjust the proportion of water pumped from the upper and lower aquifers but it does not increase yield. Furthermore, there are limits to this strategy because of uncertainty in the capacity of the upper aquifer to support additional extractions and the possibility of seawater intrusion occurring in the upper aquifer.

Saltwater intrusion can severely affect Los Osos basin water quality, which presently is the sole source of potable water in the basin. Intrusion requires years to decades to reverse and remediate. Therefore, any prudent water management plan must include margins of safety that consider the uncertainty in estimated basin yield, monitoring, and an adaptive management strategy that includes contingency actions that can be implemented should the proposed plan not work.

Monitoring actions need to focus on the movement of the freshwater-saltwater interface in the upper and lower aquifers. Monitoring wells located between active upper aquifer production wells and Morro Bay, and lower aquifer production wells and the present interface location can detect the continued inland migration of saltwater before impacting production wells. Monitoring wells will be particularly important in the upper aquifer, where large changes in the water balance (decreased septic recharge and increased pumping) create an increased saltwater intrusion risk. Potential impacts of sewering on riparian, marshland and aquatic organisms along Willow Creek and bay fringe marshes should also be monitored with appropriate mitigation measures ready for implementation. Contingency measures can include any actions that decrease demand, increase overall basin yield, or decrease seawater intrusion.

In summary, there is substantial uncertainty in the basin yield. Because the consequences of saltwater intrusion are severe and difficult to reverse, I conclude that a responsible water management plan must incorporate margins of safety that consider the uncertainty in estimated basin yield. This can include proactive measures to prevent intrusion (such as water conservation) and should include a monitoring program to detect any continued saltwater intrusion and contingency actions to ensure Los Osos maintains a reliable water supply.

Sincerely,

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