**Technical Memorandum**

**Date:** 20 January 2022

**From:** Neil D. Currie

**To:** Geoff English
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**SUBJECT: Pumping Testing Wells 4A, 5A, 6A**

Per your request Cleath-Harris Geologists (CHG) has conducted pumping test for three alluvial wells which lie along San Luis Obispo Creek within the Avila Village Development (Figure 1). This effort was part of an assessment of the viability of switching from water supplied by the state to water supplied by groundwater resources along San Luis Obispo Creek. This memo serves to only analyze the operational capacity of the existing wells, and does not include an analysis of the long-term yield of the source (San Luis Creek).

## Background

Wells 4A, 5A, and 6A are part of the San Miguelito Mutual Water Company water system in Avila Beach California. Wells 5A and 6A are completed in the alluvium of San Luis Creek and Well 4A is primarily completed in the alluvium and but has some minimal penetration (less than 10 feet) into the underlying bedrock shales. Due to this, Well 4A shows elevated levels of iron and manganese in its produced water. Individual Well 4A has a pumping rate of 90 gallons per minute (gpm), Well 5A pumps at a maximum of 110 gpm, and Well 6A pumps at a maximum of 170 gpm. When pumping in combination, Wells 5A and 6A produce 240 gpm and with all three well pumping a maximum rate of 300 gpm can be achieved. Pumps in all wells are set at a depth of approximately 36 feet below ground surface (13 feet below mean sea level (msl)).

## Hydrogeology

The wells all produce from alluvium which lies along San Luis Obispo Creek. This alluvium is composed of interbedded sands, gravels, silts and clays that have been transported into place by the creek. Thickness is generally less than 60 feet, and the alluvium rests unconformably on the underlying bedrock. This unit is saturated with static levels approximately correlating to the water levels in the creek.

**Pumping Tests**

Four pumping tests were conducted on the alluvial well field operated by San Miguelito Mutual Water Company. These included a test with all three wells pumping at a combined 300 gallons per minute, and a pumping test of each of the wells individually. For each test, pumping occurred for four hours and water levels were monitored in wells 4A, 5A, and 6A.

*Background on Pumping Tests*

A pumping test is a test in which a well is pumped at a controlled (fixed) rate and the response of the aquifer is monitored by measuring water levels in one or more wells. Pumping tests are a tool used in hydrology to help better characterize aquifer parameters including, storage, transmissivity, and well efficiency. They can be used to help identify the source (or sources) of recharge (for example storage versus a constant head source). Pumping tests can also help to identify boundary conditions which may affect the aquifer's performance including faults or changes in lithology which may impact the aquifers ability to transmit water to the well.

When water infiltrates the aquifer as percolation of precipitation it is held within the empty spaces in the aquifer (pores) which act as aquifer storage which can then be accessed through a well. As the well pumps this storage is emptied creating a drawdown of water levels. Under gravity, water then flows through the aquifer from regions away from the well where water levels are higher towards the well where water levels are lower. After the pump is stopped water will continue to flow toward the well (the low point), but as water is no longer being removed, water levels will rise (recover) until they reach an equilibrium where there is no longer a low point for water to flow to (static conditions). Unless there is recharge, this new static water level will be lower than the initial static level reflecting the change in stored water.

When water levels from a pumping test are plotted these behaviors can be observed. When the well is turned on there is an initial period of significant drawdown (initial instability). This period can be short or long depending on the well design or aquifer parameters, but is generally less than 10 minutes in length. As water begins to flow into the well the graph shows a steady linear decline when plotted in a semi-log format. This slope will remain constant provided the well is pumped at a stable rate, there is sufficient storage is available to provide water to the well and provided there are no geologic restrictions (changes in formation or faulting) impede the flow of water into the well. If the pumping rate increases, or if the well can no longer draw from storage due to dewatering, or if a boundary condition impedes water flow to the well, the drawdown will continue to plot linearly, but the slope of that curve will increase. Water drawn from storage (recharged by percolation of precipitation) always shows this linear drawdown behavior.

A second source of recharge is possible for wells. This type of source is termed a constant head boundary. A constant head boundary is a surface water source (usually a lake, stream, or sea) that is capable of recharging water removed from an aquifer at a one to one rate. In the case of a stream this recharge is via streambed percolation (subflow). This type of recharge is characterized in a pumping test plot as a flat decline curve (no change in water level over time). If the well is very near to the constant head source the graph of the pumping test will show and initial instability (steep drawdown) followed by a flat drawdown curve. If the well is at a distance from the constant head boundary, it will show an initial sharp drawdown (instability), followed by a traditional drawdown curve (declining at a constant log-linear rate) as the well draws from storage, and then as the constant head provides recharge to the aquifer the decline curve will go flat. This flat slope is always associated with a constant head (surface source of water).

*Pumping 4A*

A pumping test for Well 4A was conducted on 15 October 2021. During this test, Well 4A was pumped for four hours at a rate of 90 gallons per minute. During this test, wells 5A and 6A were monitored for drawdown. A summary of this test is included in Figure 2. During the test with only well 4A, both observation wells experienced drawdown. The pump was started at 8:57 AM (1 minute on Figure 2) and then experienced an issue and was restarted at 9:01 AM (4 minutes on Figure 2). Both pumping wells and the observation wells stabilized into a log linear drawdown after 11 minutes and then flattened after 100 minutes. The flattened drawdown curve indicates that when Well 4A was pumped, the aquifer was recharged from a constant head boundary (San Luis Obispo Creek). Over the four hour pumping test, total drawdown in the pumping well (4A) was 1.7 feet. The drawdown in the observation wells after four hours was 1.7 feet for Well 5A and 2.56 feet for Well 6A. Well 4A showed a specific capacity of 53 gpm/foot of drawdown.

*Pumping 5A*

A pumping test for Well 5A was conducted on 14 October 2021. During this test Well 5A was pumped for four hours at a rate of 110 gallons per minute. During this test, wells 4A and 6A were monitored for drawdown. A summary of this test is included in Figure 3. Both pumping wells and the observation wells stabilized into a log linear drawdown after 11 minutes and then flattened after 143 minutes. The flattened drawdown curve indicates that when Well 5A was pumped the aquifer was recharged from a constant head boundary (San Luis Obispo Creek). Over the four hour pumping test, total drawdown in the pumping well (5A) was 12.15 feet. The drawdown in the observation wells after four hours was 1.75 feet for Well 4A and 1.75 feet for Well 6A. Well 5A showed a specific capacity of 9 gpm/foot of drawdown.

*Pumping 6A*

A pumping test for Well 6A was conducted on 13 October 2021. During this test, Well 6A was pumped for four hours at a rate of 170 gallons per minute. During this test, wells 4A and 5A were monitored for drawdown. A summary of this test is included in Figure 4. Both pumping wells and the observation wells stabilized into a log linear drawdown after 10 minutes and then flattened after 100 minutes. The flattened drawdown curve indicates when Well 6A was pumped, the aquifer received recharge from a constant head boundary (San Luis Obispo Creek). Over the four hour pumping test, total drawdown in the pumping well (6A) was 10.17 feet. The drawdown in the observation wells after four hours was 4.76 feet for Well 4A and 4.89 feet for Well 5A. Well 6A showed a specific capacity of 17 gpm/foot of drawdown.

*Combined Pumping Test*

A pumping test for all three wells was conducted on 12 October 2021. During this test, Wells 4A, 5A, and 6A were pumped for four hours at a combined rate of 300 gallons per minute. All wells were monitored for drawdown during this test. A summary of this is included in Figure 5. All pumping wells stabilized into a log linear drawdown after 6 minutes and then had a flat drawdown after 125 minutes. The flattened drawdown curve indicates that when all the tested wells were pumped, the aquifer received recharge from a constant head boundary (San Luis Obispo Creek). From 35 to 70 minutes, the treatment plant underwent a backwashing cycle which increased backpressure on the system, lowering pumping rates and temporarily raising water levels as is visible in Figure 5. Over the four hour pumping test, total drawdown in the pumping well 4A was 9.87 feet. Total drawdown in pumping well 5A was 9.75 feet and total drawdown over the four hour test was 11.7 feet for pumping well 6A. Due to meter configuration, pumping rates on individual wells were not available for this test. The recording transducers were not installed for this combined test.

*Creek Response*

San Luis Obispo Creek was monitored in two locations, one upstream of the well field which was located in the creek near the San Luis Bay Drive bridge, and one downstream of the well field which was located in the creek near the tennis courts (Figure 1). Each transducer was placed approximately 18 inches below the water surface in the creek to monitor relative water level changes. Total water depth at the location of the transducer placements are approximately 4.5 feet. A summary of this data is included in Figures 6. An increase in transducer depth on this figure corresponds to a rise in creek level as the depth of the tranducer is constant after placement.

No discernible changes in creek weter level due to the well pumping were observed during the pumping tests. However, the flat drawdown curves (no decline over time) observed in the pumping test show that during pumping the aquifer was recharged from subflow in San Luis Obispo Creek. During the duration of the test, creek flows show significant changes related to other factors (e.g., evapotranspiration, upstream pumpage/diversions, and wastewater discharge to the creek). The absence of discernible changes in creek water like reflects either that the magnitude of sub-flow recharge related to pumping is much less than other factors causing the signal to be lost in the background changes, and/or that the sensitivity of instrumentation was insufficient to detect the changes, rather than the absence of recharge via sub-flow.

## Summary and Conclusions

During the four pumping tests, the pumped wells all had flat drawdown curves that indicate the presence of a constant head boundary. Given the proximity and flow, this boundary is San Luis Obispo Creek. While no changes in creek water levels due to pumping were observed, this is most likely the result of noise or instrumentation sensitivities rather than the absence of recharge from the creek. The flat drawdown curves observed in the pumping tests are characteristic of recharge from the creek rather than from percolation/precipitation held in storage. This means that provided there is sufficient flow in the creek to recharge at the pumped rate, these wells could be pumped for extended periods of time.

For use as water supply facilities, these wells can pump at a combined rate of 300 gallons per minute. Individually well 4A pumps 90 gpm, Well 5A pumps 110 gpm and Well 6A can pump 170 gpm. In assessing the water supply needs, the system should have the capacity to supply water needs on the highest demand day with the highest producing well not functioning. In this scenario, Well 6A would be offline. The remaining two wells could supply approximately 200 gpm, or 288,000 gallons per day. If this quantity is insufficient to meet water demands during periods of maximum water demand, or if increased system reliability is required, additional alluvial wells would be needed. Water produced from alluvial wells ultimately comes from San Luis Creek and the stream would have reduced flows equivalent to pumping rates.

If you have any further questions or concerns, please feel free to contact our office.

Cordially

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