STONY CREEK GROUNDWATER RECHARGE INVESTIGATION, 2005 GLENN COUNTY, CALIFORNIA

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This summary report was prepared by the Department of Water Resources, Northern District, Groundwater Section, on behalf of the Glenn County Department of Agriculture. It was prepared under the direct supervision of Dan McManus, Chief of the Northern District Groundwater Section, Professional Geologist No. 6162, and was written by Kelly Staton, Professional Geologist No. 7501, in accordance with the provisions of the Geologist and Geophysicists Act of the State of California.

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INTRODUCTION

In the summer and fall of 2005, surface water levels in Lower Stony Creek and groundwater levels in the Stony Creek Fan alluvium were measured in order to evaluate the recharge potential of the aquifer. Increased recharge could provide improved water supply reliability to water users in the area along Stony Creek. Additional work was also conducted to determine the optimal flow rate from Black Butte Reservoir into Lower Stony Creek at which the most favorable levels of recharge could be achieved.

Stony Creek flows through the northern part of Glenn County, from the Coast Range in the western part of the county, east across the valley floor to the confluence of the Sacramento River. Stony Creek is informally divided into two reaches, Upper and Lower Stony Creek. Upper Stony Creek is the portion of the creek flowing from its headwaters in the Coast Range to Black Butte Reservoir. Lower Stony Creek is the roughly 25 mile section of the creek flowing from Black Butte Reservoir to the Sacramento River. The Lower Stony Creek reach was further subdivided into four reaches using surface water flow cross-sections sites as subdivisions. The study area is located along Lower Stony Creek (Stony Creek), as shown in Figure 1. Groundwater wells and surface-water cross-section sites are also shown in this figure.

PREVIOUS STUDIES

A similar study was performed in 2003 using cross-section sites and groundwater wells along the same stretch of Stony Creek (*Stony Creek Groundwater Recharge Investigation, 2003, Glenn County, California, CA DWR, 2005).* The results from the 2003 study suggest that flows in Stony Creek of about 100 cubic feet per second (cfs) have the greatest potential for recharging the Stony Creek Fan aquifer. Flows in excess of 100 cfs tend to move too fast to adequately recharge the aquifer, resulting in more water being discharged from the creek into the Sacramento River, than is absorbed into the aquifer.

Using data from the 2003 study, a groundwater model was developed in 2004 to further examine the relationship between rates of flow release from Black Butte Reservoir and groundwater recharge (*Conjunctive Use Releases for the Stony Creek Fan, Lee G. Bergfeld, UC Davis, 2004).* Modeling results indicate:

- The rate of flow release from Black Butte Reservoir is the most important factor for maximizing recharge efficiency,
- lower release rates are more efficient than higher release rates,
- theoretically, groundwater may be recharged more efficiently utilizing pulse release flows, and
- pulse flows are less efficient with respect to dam operations.

In October 2004 and March 2005 two aquifer performance tests were performed within the Stony Creek Fan alluvium to determine the transmissivity and hydraulic conductivity of the aquifer material *(Stony Creek Fan Aquifer Performance Test, Glenn County, California, Township 22 North, Range 3 West, Section 24, March 2005, California Department of Water Resources, in cooperation with Glenn County Department of Agriculture; Stony Creek Fan Aquifer Performance Test, Glenn County, California, Township 21 North, Range 2 West, Section 1, October 2004, California Department of Water Resources, in cooperation with Glenn County Department of Agriculture*). Results from the tests suggest that the Stony Creek Fan alluvium is very transmissive and that groundwater levels in shallow wells less than one mile away from the test production well showed influence from the pumping well.

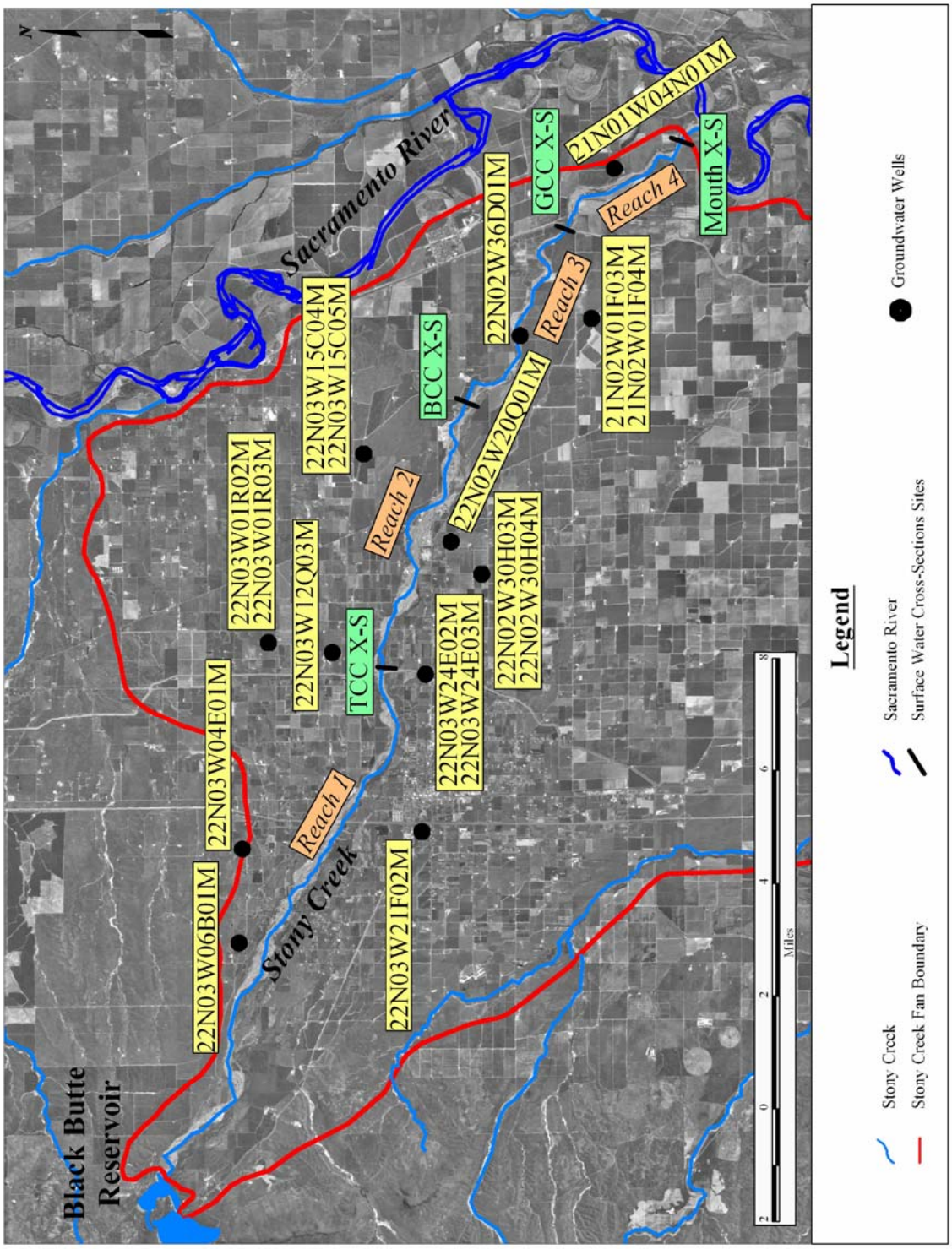

Figure 1. Location Map of Study Area Showing Groundwater Wells and Surface Water Cross-Section Measurement Sites.

DATA COLLECTION

Surface water flow and groundwater level measurements were collected weekly, from July 1, 2005 through October 27, 2005. Data collection sites used in the 2003 study were reviewed and only the sites showing a groundwater level response to changing flows in Stony Creek were used in the current study. Surface water level measurements were taken at four cross-section sites along Stony Creek, identified as (Tehama-Colusa Canal (TCC), Baldwin Construction Company (BCC), Glenn-Colusa Canal (GCC) and Stony Creek Mouth (SC Mouth), seen in Figure 1.

Groundwater level measurements were taken in seventeen groundwater wells, also shown in Figure 1. Seven of the wells were active domestic or irrigation purposes and ten were inactive, dedicated observation wells, see Figure 1. Nine of the ten observation wells have continuous data recorders installed in them and record data on a daily basis. These wells are identified by the Public Land Survey system and assigned a State Well Number by the California Department of Water Resources. The State Well Numbering system identifies a well according to the township, range, section, forty acre subdivision and survey baseline meridian. For example, well 22N02W15C05M is located in township 22 north, range 2 west, section 15 and is the fifth well in subdivision C using the Mount Diablo meridian baseline. Figure 1 also shows the location of the surface water cross-section sites and groundwater well sites used in the study.

HYDROGEOLOGY

The study area geology is composed of the Stony Creek Fan alluvium and the underlying Tehama Formation. The Stony Creek Fan alluvium is a broad alluvial fan in Glenn County extending about 26 miles north to south and about 14 miles east to west. The alluvium is composed of sediments deposited by Stony Creek. These geologically young sediments are derived from the Coast Ranges to the west and consist mainly of metamorphic and sedimentary gravel and sand with interbedded clay and silt layers. The alluvium is exposed at the ground surface, and has an average thickness of about 50 to 80 feet. Thickness in various parts of the fan can reach depths of up to about 120 feet. The Stony Creek Fan aquifer is recharged primarily by precipitation in the late fall, winter and spring months, surface water irrigation in the summer and early fall months, and flow in Stony Creek year-around.

Aquifer performance tests on the Stony Creek Fan alluvium indicate that the transmissivity is about 400,000 gallons per day per foot and the average hydraulic conductivity is about 3,625 gallons per day per square foot. Draw-down data in the aquifer test production wells indicate a specific capacity of about 50 gallons per minute per foot of drawdown, implying that the aquifer is very porous and able to transmit significant volumes of water to wells.

The older Tehama Formation lies below the Stony Creek Fan alluvium and is composed of metamorphic and sedimentary deposits also derived from the Coast Ranges. These sediments consist predominantly of clay and silt with discontinuous layers of sand and

gravel. These sand and gravel layers compose the water-bearing aquifers of the Tehama Formation. The overall permeability of this formation is low to moderate, with localized areas of high permeability associated with the water-producing sand and gravel zones.

FINDINGS

The Stony Creek Fan alluvium is a very transmissive aquifer with the potential for two to three feet of increased seasonal groundwater storage through recharge. Groundwater level hydrographs indicate that recharge occurs fastest in the portion of the aquifer adjacent to the creek. Data also indicate that increased aquifer recharge and storage is available in areas where Stony Creek is a losing stream. Surface water flow and cross-sectional area calculations show that at each of the measurement sites the cross-sectional area does not increase significantly with higher flows in the creek. This data suggests that lower sustained flows in Stony Creek may be more beneficial for recharging the Stony Creek Fan aquifer than higher flows.

Surface Water Flow and Cross-Sectional Area.

Surface water flow and cross-sectional area calculations show that the relationship between flow in the creek and the cross-sectional area measurement is not necessarily a one-to-one relationship. Over the study period, flows ranged from about 50 cfs to about 350 cfs, as shown in Figure 2. The cross-sectional area at the surface water measurement sites did not increase significantly with higher flows of around 200 to 350 cfs. Conversely, cross-sectional area also did not decrease significantly at lower flows of around 50 cfs.

The previous study indicated that flows of around 100 cfs in Stony Creek were most beneficial to recharge in the Stony Creek Aquifer. Over the course of this study, flow was measured only once in the 100 cfs range (135 cfs). The remainder of the time flows were either under 60 cfs or from 200 to 350 cfs. Because the flow release schedule was different from the 2003 study, it is hard to come to the same conclusions for optimal flow in Stony Creek that would best recharge the aquifer. However, data in this study suggest that lower flows are more beneficial than higher flows in Stony Creek. In other words, at higher flows water is moving too fast to adequately recharge the adjacent aquifer. Water that would be otherwise beneficial to the Stony Creek Fan aquifer is lost downstream to the Sacramento River.

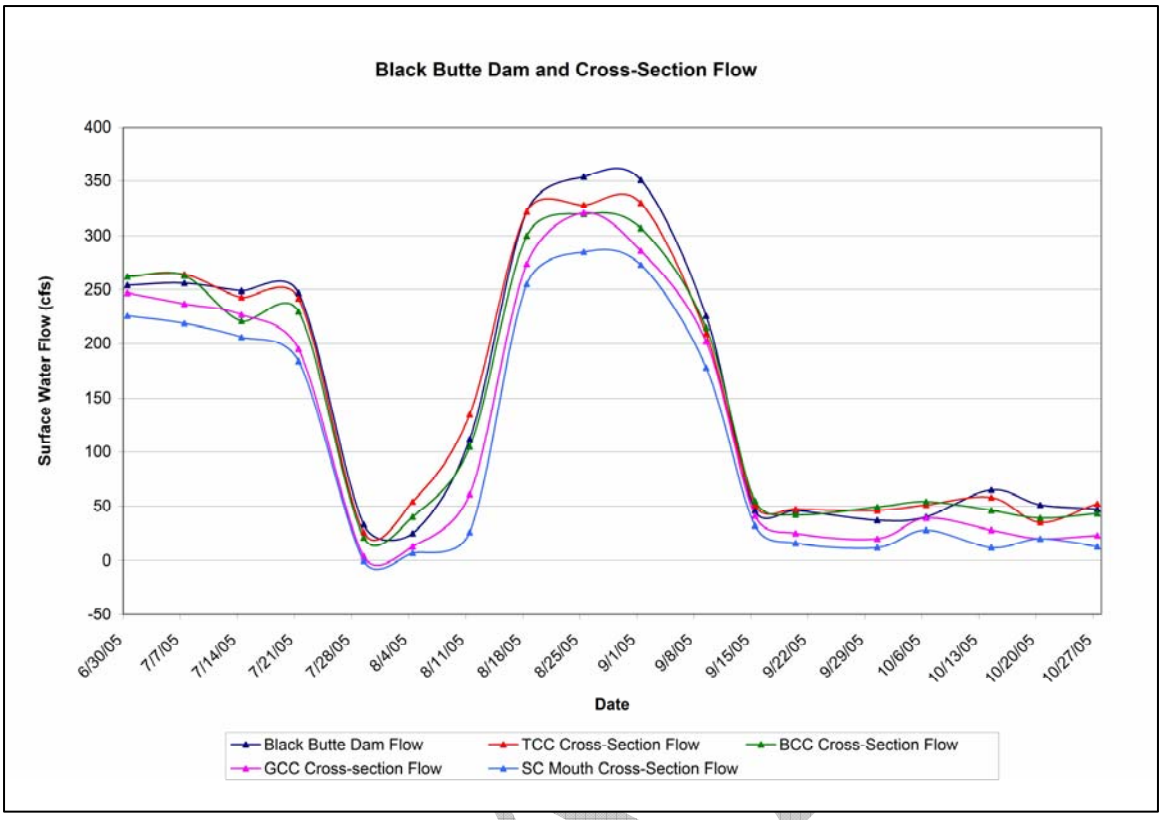

Figure 2. Surface Water Flow at Black Butte Dam and the Four Cross-Section Sites along Stony Creek.

Recharge in Gaining or Losing Areas of Stony Creek.

Data suggests that areas in the Stony Creek Fan alluvium with the highest potential for additional storage may be in areas adjacent to the losing reaches of Stony Creek. The areas where recharge and storage potential are lowest correspond to the gaining reaches of Stony Creek, where the aquifer is full.

Stream loss data from the surface-water cross-section measurements indicate that the stretch of Stony Creek from Black Butte Reservoir to TCC is a gaining stream, becoming a losing stream between TCC and BCC down-stream to the SC Mouth. The gaining sections of the stream seem to correlate with areas within the service boundaries of Orland Unit Water User's Association (OUWUA). OUWUA provide surface water for flood irrigation, which in turn serves also as a water supply source for groundwater recharge to the underlying aquifer during the irrigation season.

Losing reaches along Stony Creek correspond to locations where groundwater serves as the predominant supply source for agricultural demand by independent pumpers.

Groundwater levels commonly decline in relationship to increasing agricultural demand. Groundwater level hydrographs associated with agricultural pumping in the shallow Stony Creek Fan alluvium show a greater seasonal fluctuation than groundwater levels associated with agricultural use in the deeper aquifers.

Groundwater Level Hydrographs.

Groundwater level hydrographs were developed using groundwater surface elevation well data, outflow data from Black Butte Dam and cross-section flow data at the corresponding measurement sites. Well construction and hydrograph data indicates that groundwater recharge related to changes in Stony Creek flow occurs primarily in the shallow portion of the aquifer associated with the Stony Creek Fan alluvium, and within about one mile of Stony Creek. Wells constructed in the deeper portions of the aquifer associated with the Tehama Formation, and/or in wells that were over a mile from Stony Creek, did not show a discernible correlation that could be directly correlated between changing groundwater levels and alternating flows in the creek. Groundwater hydrographs of wells measured in the study are presented in Appendix A.

An observable response to changing flows in Stony Creek was seen in well 22N02W36D01M, south of Stony Creek. This well is constructed in the Stony Creek Fan alluvium and is located within about 350 feet from the creek. As seen in Figure 3, the graph of the groundwater surface elevation data follows the pattern of surface water flows at the GCC cross-section site and with the outflow from Black Butte Dam into Stony Creek. Although the data points generally follow the same sequence, it can be noted on the graph that when surface water flow drops by 300 cfs, the groundwater surface elevation drops only about a foot. This suggests that high flows are not necessarily advantageous in recharging the aquifer and that lower flows may recharge the aquifer more efficiently.

Figure 4 shows a hydrograph of a well, 22N03W24E03M that is also constructed in the Stony Creek Fan alluvium, but is about a mile south of Stony Creek. This monitoring well hydrograph shows a distinct pumping signature of a nearby domestic well. It also shows that groundwater surface elevations decline throughout the study period with no obvious influence from rising and falling surface water levels in Stony Creek.

In contrast, another well, 22N03W12Q03M, which is constructed in the Stony Creek Fan alluvium and is about a mile north of the creek, shows an increase in groundwater surface elevations as flow in the creek declines. This hydrograph is shown in Figure 5, and seems to be in opposition to the previous well shown in Figure 4. This illustrates the fact that there are many factors that can affect the groundwater levels and recharge to an aquifer.

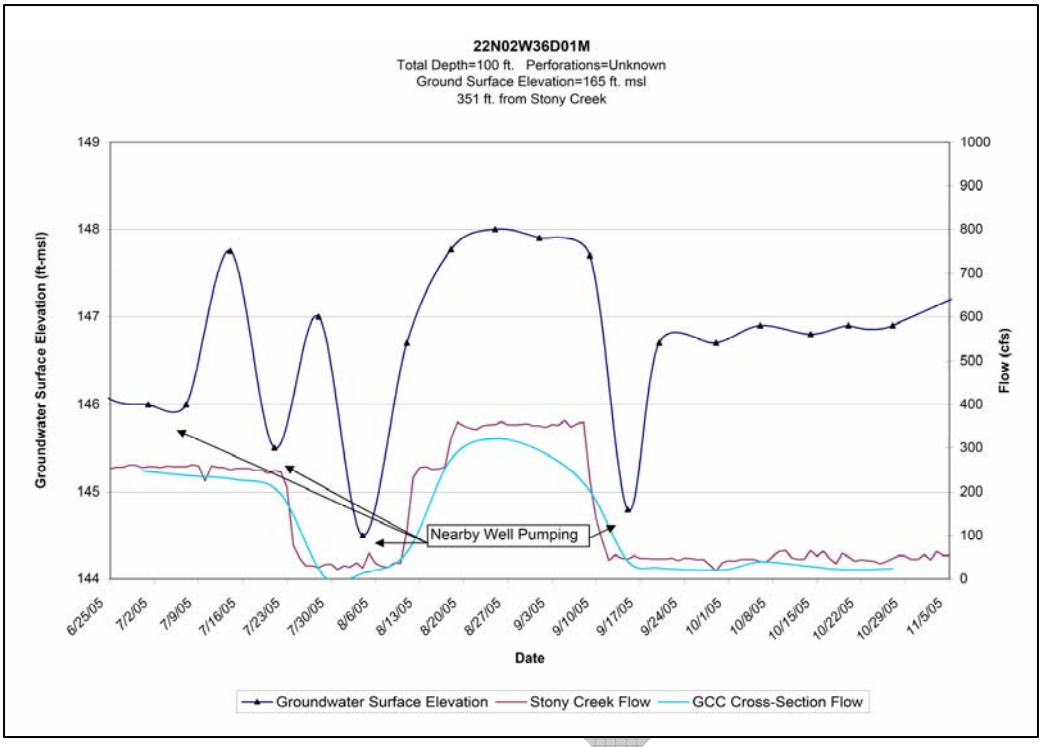

Figure 3. Groundwater Surface Elevation Hydrograph vs. Flow in well 22N02W36D01M.

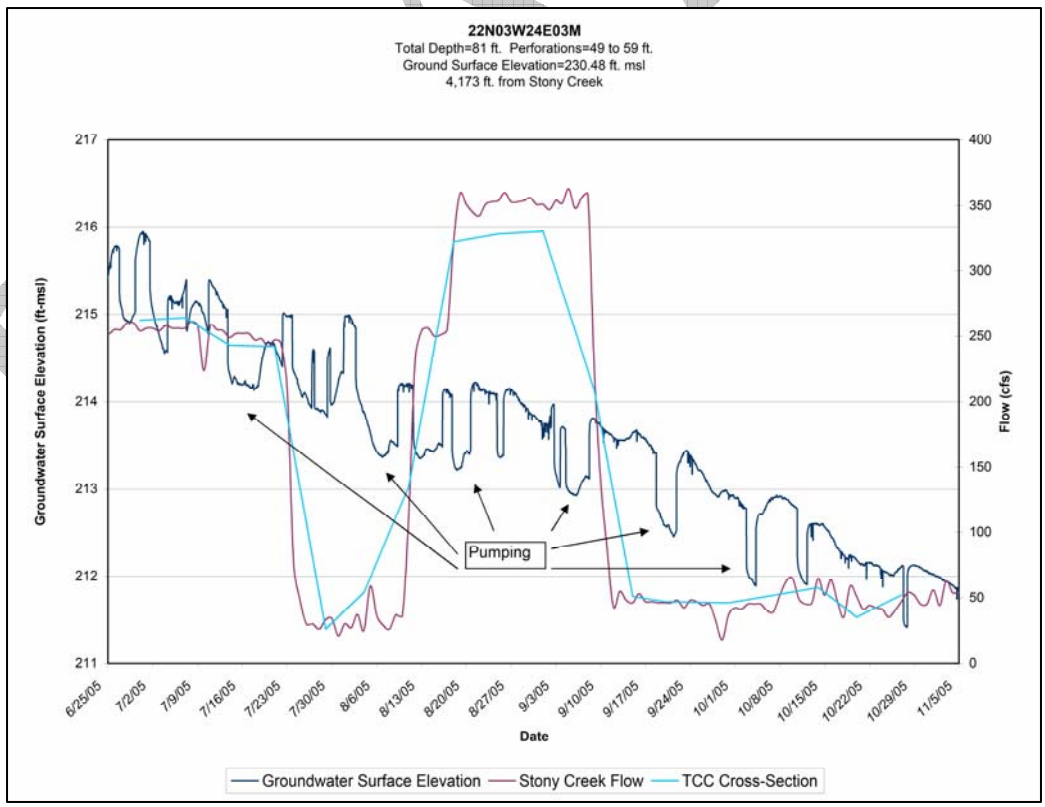

Figure 4. Groundwater Surface Elevation Hydrograph vs. Flow in well 22N03W24E03M.

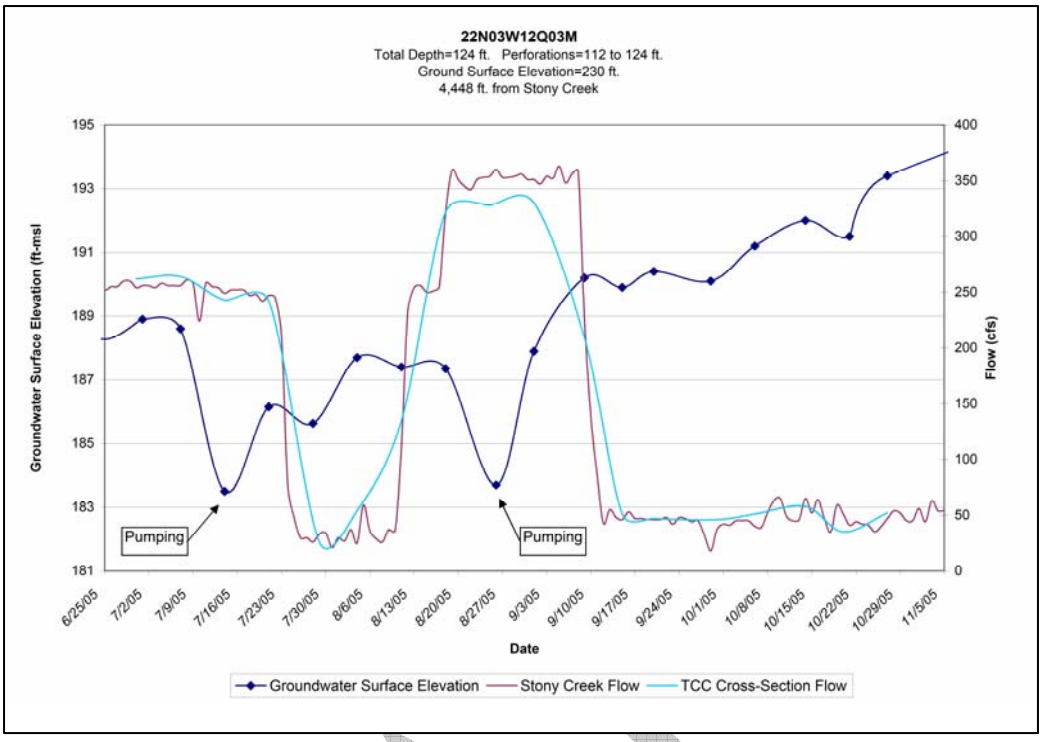

Figure 5. Groundwater Surface Elevation Hydrograph vs. Flow in well 22N03W12Q03M.

Recharge to an aquifer can be affected by many variables such as water usage, crop type, irrigation practices, air temperature, precipitation and/or evapotranspiration, among others. Also, other factors such as the timing of crop harvest and changes in applied water demand can influence groundwater levels in an aquifer.

For instance, irrigation of almonds typically stops in early August, if the irrigation source is groundwater. This allows groundwater levels to recover regardless of the flow in Stony Creek. Typically, a more detailed water budget analysis is required to help account for many of the above-mentioned variables. Attempts to correlate wide-scale changes in groundwater levels with changes in surface water flow without a more detailed analysis could be misleading. Additional data are needed to adequately evaluate the relationship between groundwater levels in the various aquifer systems and surface water flow in the creek.

CONCLUSIONS

The Stony Creek Fan alluvium is very transmissive aquifer with a reasonable potential for additional seasonal groundwater storage through recharge. Groundwater level hydrographs indicate that greater fluctuations in groundwater levels suggest the possibility that the aquifer may be less full and have more available storage space for additional recharge. Hydrographs with minor fluctuations in groundwater levels suggest that the aquifer may have less capacity for additional recharge and storage. Further investigation is needed to adequately determine the variables affecting aquifer storage capacity.

In addition, areas in the fan with the highest potential for additional seasonal recharge and storage are in areas adjacent to Stony Creek where it is a losing stream. The lowest potential for seasonal recharge and storage associated with increasing flows in Stony Creek are in areas where Stony Creek is a gaining stream, agreeing with the findings from the groundwater hydrographs. Furthermore, cross-sectional area and flow data suggest that lower flows may be more beneficial for recharging the Stony Creek Fan alluvium than higher flows.

A detailed water budget is needed to adequately assess the recharge and storage capacity of the Stony Creek Fan alluvium and aquifer system. A future project to assess the conditions of the aquifer system would entail the measurement and collection of data over at least one water year, in areas such as:

- Groundwater inflow and outflow
- Surface water inflow and outflow
- Precipitation
- Crop type, water usage
- Groundwater pumpage
- Evapotranspiration
- Seepage from surface water
- Groundwater underflow into aquifer
- Artificial recharge from irrigation

These data would then be compiled and analyzed to characterize the groundwater recharge and storage capacity of the Stony Creek Fan alluvium. A time-frame for a project such as this would more than likely be a two year process.