



**TECHNICAL
MEMORANDUM**

August 6, 2010

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Kemp Ranch
P.O. Box P
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FROM: Earl LaPensee and Richard Slade
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RCS Job No. 395-INY02

RE: Well Construction Summary and Results of Aquifer Testing
Kemp Ranch Well
Kemp Ranch, Inyo County, CA

Introduction

This Memorandum provides a summary of well construction activities and the results of pumping tests performed for the recently constructed domestic-supply water well (known herein as the Kemp Ranch Well) for Kemp Ranch, located along the south side of Indian Springs Road in the Alabama Hills area in Inyo County, CA. Figure 1, "Well Location Map" illustrates the location of this new Kemp Ranch Well. Also shown on Figure 1 are the proposed boundaries of the 12 proposed 2.5 acre subdivision parcels, three Lot Line Adjustment (LLA) parcels, and a one acre fire lot (Lot A), within the 630-acre Kemp Ranch property. In addition, the location of existing domestic-supply and irrigation wells near the west border of the property are also shown on Figure 1. The recently constructed Kemp Ranch Well is located on LLA Parcel No. 2.

The Kemp Ranch Well was drilled, constructed, developed and tested between January 11 and March 8, 2010. A copy of the Inyo County Environmental Health Services drilling permit for the well and the signed and completed State of California Well Completion Report are presented in the Appendix to this Memorandum.

Summary of Well Construction

Pilot Hole Drilling

Reeve Drilling Inc (Reeve) mobilized a mud rotary drill rig to the proposed drill location between January 11 and 15, 2010. Following this, drilling of the pilot hole commenced on January 18 and was completed the next day, January 19, to a total depth of 200 feet below ground surface (ft bgs). Pilot hole drilling was performed using the direct mud (bentonite) rotary drilling method

using a 9-7/8" diameter drill bit. Shortly following completion of drilling, an electric log survey was conducted to a depth of 192 ft bgs; a copy of this electric log is provided in the Appendix.

The drill cuttings collected by the driller during drilling of the pilot hole were geologically logged by a geologist and the logged cuttings along with electric log were reviewed to evaluate subsurface geologic conditions. A copy of the geologic log is included in the Appendix. These tasks were performed to help determine the Final construction parameters for the new well. Review of the collected geologic samples revealed that sediments consisting of dark yellowish brown to light yellowish brown sand layers with minor gravels and cobbles were encountered between ground surface and the total 200-foot depth of the pilot borehole.

These geologic interpretations, along with the geologic log and electric log, were used by RCS to help develop a Final well construction schedule for the contractor. Table 1, "Final Well Design Schedule," provides a summary of the materials used in the well construction, the diameters of the well casings, the depths and type of the perforations, the type and gradation of the gravel pack used and the depth of the annular cement seal. This design was forwarded to Reeve by RCS on January 21, 2010.

Borehole Reaming

Reaming of the borehole to a final diameter of 15½ inches was performed between January 27 and February 1, 2010 using direct rotary methods. A "wiper pass" with the same drill bit was performed on February 2 to clear sediment fill from the bottom of the borehole.

Well Construction

Following completion of the "wiper pass", Reeve prepared for the installation of the well casing, gravel pack and cement seal, in accordance with the Table 1 parameters. These installation operations were performed, reportedly without incident, between February 3 and 5, 2010. Figure 2, "As-Built Well Diagram," provides a schematic of the newly-constructed well.

Mechanical Well Development

Following the completion of well construction, Reeve commenced mechanical development of the perforated sections of the casing to help remove heavy fluids, drilling muds, and fine-grained silt and sand from the gravel pack and the walls of the adjacent formation. The purpose of this development was to enhance the flow of groundwater from the formation into the well by the removal of clay, silt, fine-grained sand, and drilling muds that had been used during borehole drilling and reaming. Mechanical development of the well initially consisted of airlifting heavy fluids and sand from the entire casing using an open-ended single swab tool. The single swab tool was then replaced with a 10-foot long perforated section of pipe equipped with double swabs at either end. This tool was used to perform simultaneous swabbing and airlifting in 20- to 25-foot sections of the casing perforations. Also, a chlorine solution was applied to the well by Reeve to aid in breaking up the bentonite clays (from the drilling fluids) while swabbing was being performed. This development was conducted between February 8 and 16, 2010. Copies of the mechanical development sheets prepared by the onsite geologist are appended to this Memorandum.

Pumping Development

On February 16, 2010, a submersible test pump was mobilized to the site and was installed into the well the next day. Pumping development commenced on February 22, and was performed until February 26, 2010. Pumping rates during development ranged from 20 to 95 gallons per minute (gpm).

Prior to and during pumping development, water levels in the well were measured and recorded by the Reeve driller as well as the geologist; all monitored water levels were referenced to the top of a temporary sounding tube, the top of which was approximately 2.1 ft above ground surface. Thus, all water level measurements reported herein have been referenced to feet below reference point (ft brp).

Prior to the start of pumping development, the static water level (SWL) was measured to be at a depth of 27 ft brp. A total of 25 hours of pumping development was performed on the well; a copy of the well development sheets from February 25 and 26 and field notes by the geologist for the previous days of development activities are appended to this Memorandum.

During pumping development, pumping water levels ranged from a depth of approximately 40 ft brp to as deep as 72 ft brp. However, on February 25, the electronic tape water level sounder became stuck in the well and thus it was not possible to continue measuring water levels near the end of pumping development.

Measurement of the sand content, as reported by the geologist, revealed that the amount of sand produced in the very early stages of pumping ranged from 1 to 2 percent (%). However, by the end of pumping development, the sand content was reported by the geologist to be at concentrations of trace amounts to not detected.

Pumping (Aquifer) Test of Well

The pumping test (aquifer) test was conducted in the new well in accordance with the RCS-prepared Aquifer Testing Workplan, dated November 2009, that had been previously approved by Inyo County. On March 2, 2010, a geologist was onsite to install an automatically-recording water level pressure transducer which recorded water level measurements at 1-minute intervals during the entire monitoring period. The entire test period was designed to include at least two days of background water level monitoring prior to the pumping test, monitoring of water levels during the pumping portion of the test and also the monitoring of water level recovery for an additional day following the pumping portion of the aquifer test. In addition to a water level transducer, a barometric pressure transducer was used to measure fluctuations in the barometric pressure during the test. After testing was complete, the automatically-collected water level data were corrected using the barometric data, so that the effects of barometric pressure changes on the device were not reflected in the water level measurements. Manual water level measurements, using the electronic water level sounder, were also collected periodically during the pumping test by the geologist to help corroborate the automatically-collected transducer water level data.

Pumping Test

An approximately 12-hour (720-minute) pumping test was performed in the new Kemp Ranch Well on March 5, 2010 at an RCS-recommended nominal pumping rate of 75 gpm. The pre-test static water level (SWL) for this test was measured at a depth of approximately 28.6 ft brp. As shown on Figure 3, "Plot of Water Levels During Pumping Test," water levels in this well, prior to beginning this pumping test, appeared to have been stable. Figure 3 also shows that water levels were beginning to stabilize after approximately 8 hours of continuous pumping during this test.

The final pumping water level in the well at the end of the pumping test was at a depth of 68.2 ft brp. This represents a maximum water level drawdown of 39.6 ft. The overall average pumping rate during the 12-hour test, as determined from the totalizer flow meter dial, was 75 gpm. Thus, the current specific capacity of the new well, based on this pumping test, is calculated to be approximately 1.9 gpm/ft ddn.

Upon startup of testing, the water was observed by the geologist to be clear. Only trace amounts of sand were observed within the first 15 minutes of testing, and after this time, no additional sand was observed by the geologist throughout the remainder of the test. No entrained air or odors were reportedly observed by the geologist in the pumped discharge during this pumping test.

At the end of the 12-hour pumping test, before the pump was shut down, a final wellblend water sample was collected by the geologist. This sample was then delivered by RCS to American Analytics Laboratory in Chatsworth, California, for analysis of California Administrative Code (CAC) Title 22 general minerals. The results of these laboratory tests of the final wellblend water sample are listed on Table 2, "Results of Laboratory Analysis of Final Wellblend" and included in the Appendix. Testing for a complete suite of all remaining Title 22 analytes, including inorganic chemicals, organic compounds and radiological constituents, was not performed at this time.

Each of the listed constituents on Table 2 was found to occur at concentrations below its respective and applicable, current California Department of Public Health (CDPH) and US Environmental Protection Agency (EPA) Primary and Secondary MCLs. Listed below is a summary of selected key constituents:

- Electrical Conductance (EC) was detected at a concentration of 110 micromhos per centimeter ($\mu\text{mhos/cm}$).
- pH was detected at 6.90.
- Total dissolved solids (TDS) was detected at 71 mg/L; the Secondary Maximum Contaminant Levels (MCL) for this constituent for domestic use are 500, 1000, and 1500 mg/L for the recommended, upper, and short term levels, respectively. Hence, the TDS of the local groundwater meets these standards.
- Total hardness (TH) was only 31 mg/L.
- Iron (Fe) and manganese (Mn) were each reported as not detected and thus were below their respective MCLs of 0.3, and 0.05 mg/L for domestic use.



- Fluoride (F) was detected at <math><0.50\text{ mg/L}</math>.
- Nitrate as N was reported to be 0.32 mg/L; the Primary MCL for this constituent is 10 mg/L.

Analysis of Test Data

Important aquifer parameters such as transmissivity (T) can be determined using data collected during pumping tests. Transmissivity is a measure of the rate at which groundwater can move through an aquifer system, and therefore is essentially a measure of the ability of an aquifer to transmit groundwater to a pumping well. Transmissivity is expressed in units of gallons per day per foot of aquifer width (gpd/ft). Another aquifer parameter, storativity (S), is a measure of the volume of groundwater taken into or released from storage in an aquifer for a given volume of aquifer materials; storativity is dimensionless and has no units. Storativity calculations can only be made using water level drawdown data, if any, monitored in observation wells during a pumping test and not by water level drawdown data acquired solely from the pumping well. Because no other wells could be monitored during the subject pumping test, i.e., no additional water level observation wells were available during the pumping test, aquifer storativity could not be calculated from the pumping test data.

Water level drawdown data and recovery data for the Kemp Ranch Well were input into the software program AQTESOLV (version 4.5 Professional). Numerous analytical solutions were then utilized to determine transmissivity values using an automatic curve fitting procedure. The solutions utilized consisted only of unconfined aquifer solutions; no confined aquifer solutions were used. Note that RCS geologists did analyze a few “confined solutions” during the work, but those solutions were not deemed valid and they are not presented herein.

Also, certain assumptions must be made about the aquifer when using these solutions. In general, for the solutions below, the assumptions include: the aquifer has an infinite areal (lateral) extent; the pumping well fully penetrates the aquifer system(s); and water is instantaneously released from storage with the decline of hydraulic head. Also, for the purposes of this analysis, the assumption is made that the aquifer is 160 ft thick. This was determined by taking the known distance between static water level at the time of the pumping test (about 30 ft) and the bottom of the perforations (190 ft) in the Kemp Ranch Well. Also, since storativity cannot be calculated for this well, it is assumed that steady-state conditions apply to the aquifer system.

Using the water level data shown on Figure 3, RCS geologists used the AQTESOLV software package to perform automatic curve-fitting procedure. Below is a list of the two different curve-fitting solutions used, the resulting transmissivity value, the figure number on which the water level data and fitted-curve are presented, and additional assumptions about the aquifer inherent in the solution.

- Theis (1935) – Figure 4A, “Pumping Test Analysis, Theis Unconfined Aquifer Solution, Kemp Ranch Well.” – Using the Theis solution, a transmissivity value of 4,170 gpd/ft is calculated for these data. The Theis solution assumes numerous conditions, including the aquifer is isotropic (the same in all directions). Also note that RCS used both the confined and unconfined Theis solutions, but there were no differences in the resultant transmissivity value determined by either solution.

- Cooper-Jacob (1946) – Figure 4B, “Pumping Test Analysis, Cooper-Jacob Unconfined Aquifer Solution, Kemp Ranch Well.” – As shown on the figure, the solution should be a relatively good fit of the data for the drawdown portion of the pumping test. A transmissivity value of 4,320 gpd/ft is calculated. The Cooper-Jacob solution also assumes that the aquifer is isotropic.

Based on the information presented above, and for the purposes of this report, a transmissivity value of 4,200 gallons per day per foot of aquifer width (gpd/ft) will be assigned to the aquifer system into which the Kemp Ranch Well is constructed.

Theoretical Water Level Drawdown

Using the data and aquifer parameters collected during the construction and testing of the Kemp Ranch Well, a theoretical water level drawdown analysis was conducted for the future pumping of this well. This analysis, which was performed using the PUMPIT (v4.2) software package, was used to determine theoretical distance-drawdown values that might possibly be created while pumping Kemp Ranch Well in the future at its normal operational pumping rate. When pumping a well, a region of temporary water level drawdown is created around the well (known as a cone of depression). Once pumping is ceased, water levels within this cone of depression will begin to recover back to their pre-pumping static water levels. Hence, the purpose of making these theoretically-predicted drawdown calculations is to provide estimates of the possible amount of temporary water level drawdown that might be induced in any existing or future wells constructed either on or near the property, as a result of the future pumping the Kemp Ranch Well at its normal operational rate and for various continuous durations of time. Certain assumptions about the aquifer are inherent in the PUMPIT software package, such as: the aquifer is homogeneous and isotropic; the wells all fully penetrate the same aquifer system(s); and the aquifer is of infinite lateral (areal) extent. Further, steady state conditions were assumed for the pumping well. That is, a radius of influence (R_o) of 1000 ft was assumed prior to performing the water level drawdown calculation. In essence, it is assumed that there is no drawdown interference from the Kemp Ranch Well while pumping at a radius of 1000 ft from the wellhead.

Theoretical Impacts on Offsite Wells

Using the PUMPIT software, the theoretically-predicted water level drawdowns were then calculated for other known or assumed well locations that might be at distances of 340 ft, 570 ft, and 670 ft from the Kemp Ranch Well. These distances correspond to the neighboring property to the east, the nearest known offsite well to the north, and another offsite well to the northwest. Calculations of theoretical drawdown were made for four durations of continuous pumping: 1 day, 30 days, 90 days, and 180 days. In all simulations, a pumping rate of 75 gpm was used; this is the same rate at which the recent pumping test was performed. In reality, the future pumping rate and pumping duration of the Kemp Ranch Well during normal usage is currently unknown but can be reasonably assumed to be at a lower rate and for a less continuous period, in part, because there may be other onsite water-supply wells in the future to be constructed and developed at possible future subdivisions of the Kemp Ranch property.

Table 3, “Theoretical Water Level Drawdown Calculations,” shows the results of the PUMPIT calculations, using the transmissivity value determined from our curve-fitting procedures. The

computer simulation assumes that the Kemp Ranch Well will be pumped for each of the pumping durations mentioned above continuously, 24 hours per day, 7 days a week. RCS does not recommend ever pumping a well for such a continuous period without periodically allowing for periods of non-pumping and water level recovery. Typically, a maximum 12-hour to 18-hour per day operational pumping period could be recommended for future pumping of the Kemp Ranch Well.

Recommended Pump Rate and Pump Depth Setting

Table 4, "Recommended Pumping Rate and Pump Depth Setting," presents our recommended pump depth setting and final pumping rate for a new permanent pump in the new Kemp Ranch Well. The information shown in the table is based upon the results of measurements performed during the recent pumping test and, therefore, represents our opinion of a potential pumping rate and resulting pumping water levels that may occur in the new well in the future. We also understand that future pumping practices will likely require operational rates to be significantly less than 75 gpm, and more realistically on the order of 5 to 10 gpm. This well will chiefly be used as a private domestic well and pumping rates higher than that mentioned above are not common for this type of use. Therefore, at greatly reduced pumping rates, we would expect pumping water levels in this well to be significantly shallower than those observed during the pumping test.

Table 4 also shows the additional factors that were considered for our assessment of the pump depth setting for the future permanent pump. These factors are:

- A future 15% decline in the specific capacity, to a value of approximately 1.6 gpm/ft ddn, at a pumping rate of 75 gpm. This decline will be caused by normal plugging of the perforations as the well ages and as the perforations become partially closed by, possibly, calcium carbonate or other chemical precipitates. Additional plugging will likely also result from bacterial growths/slimes, such as iron-related bacteria (IRB).
- An estimated additional water level decline of 50 ft due to drought conditions over time in the region.

Thus, based on the above considerations, we recommend that the intake for the permanent pump in the Kemp Ranch Well be set at a depth of approximately 135 ft bgs. This places the pump within a blank section of casing from 125 ft to 140 ft bgs. It is important that regular measurement and recording of static water levels, pumping water levels and pumping rates be conducted, in order to permit ongoing calculations of the specific capacity of the well over time. When a 15% decline in specific capacity has been calculated to have occurred in the well relative to its current value of 1.9 gpm/ft ddn, it is recommended that well/pump rehabilitation be performed. Prompt response to either gradual or abrupt declines in the specific capacity is important to maintain the efficiency and use of the new well.

After the permanent pump has been properly installed in the well, the well should be pumped for at least 3 to 4 hours and, just before shutting the pump off, a new set of groundwater samples should be collected and properly delivered to a State-certified laboratory for testing of all Title 22 constituents (general minerals, general physical parameters, inorganic chemicals, radiological constituents, and various organic chemicals). Depending on the results of this



testing, a decision can be made as to which constituents in the groundwater, might require treatment for domestic use, if applicable.

If you have any questions regarding this Memorandum, please call us.