

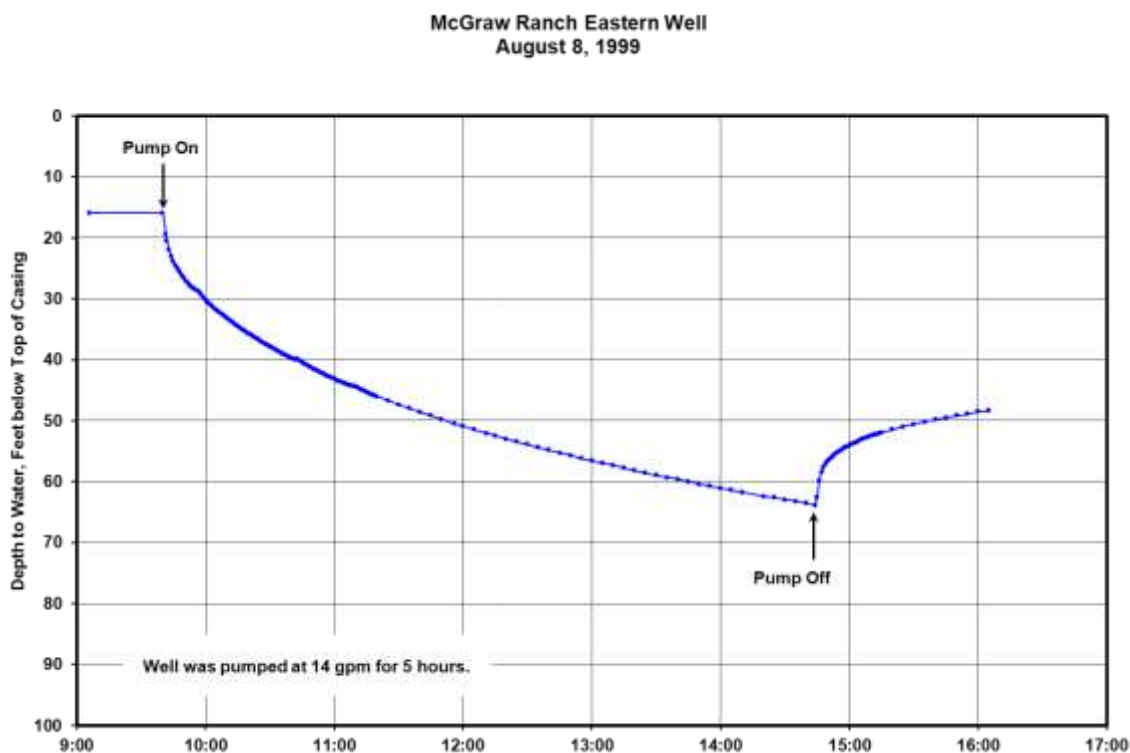
Analysis of Water Levels and Yield of the Well at McGraw Ranch Rocky Mountain National Park

Introduction

I first visited McGraw Ranch in December 1998. At that time we found two wells. Both had 6-inch steel casing at the surface. The “western” well was measured to be 185 feet deep. The second well was about 200 feet east of the first well, and thus I refer to it as the “eastern” well. The “eastern” well was measured to be about 160 feet deep. Because of their location and geologic setting, we can be reasonably certain that the wells obtain water from fractures in granitic bedrock.

Initial Testing

Testing in July 1999 showed that the western well would quickly be pumped dry. The eastern well was more reliable. The eastern well was test pumped at 14 gpm for 5 hours resulting in drawdown from a static level of 16 feet to 64 feet below ground surface; 48 feet of drawdown. A graph of the water level data from the August 1999 pumping test of the eastern well is shown below.

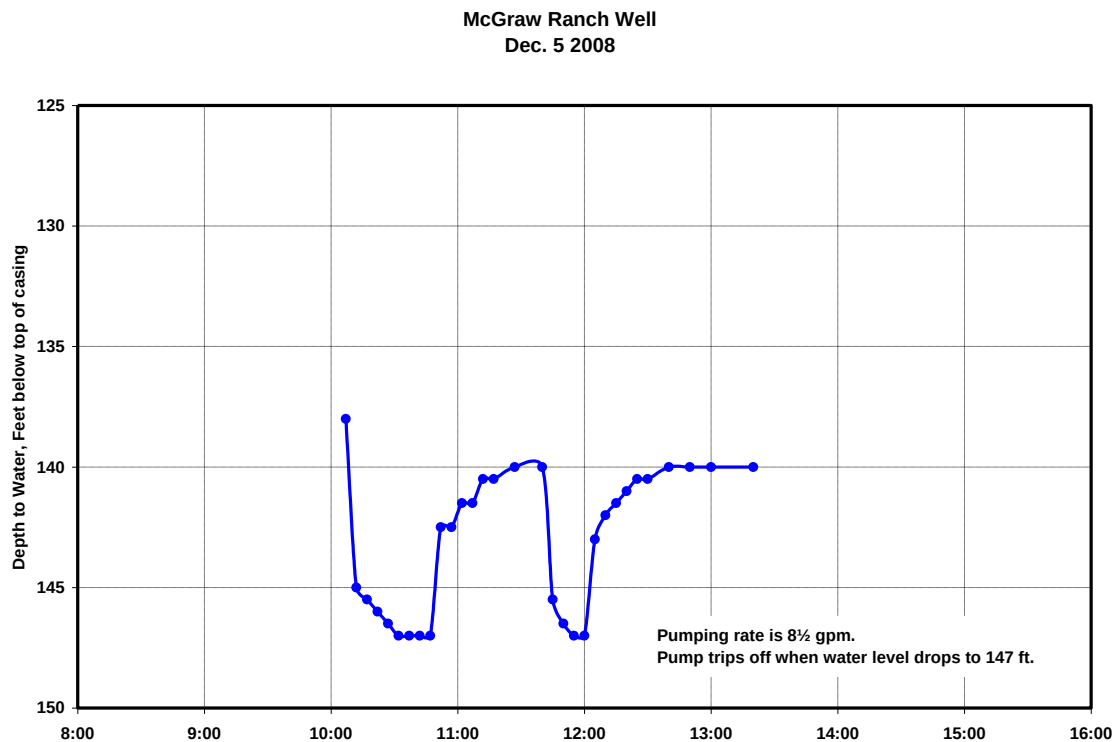


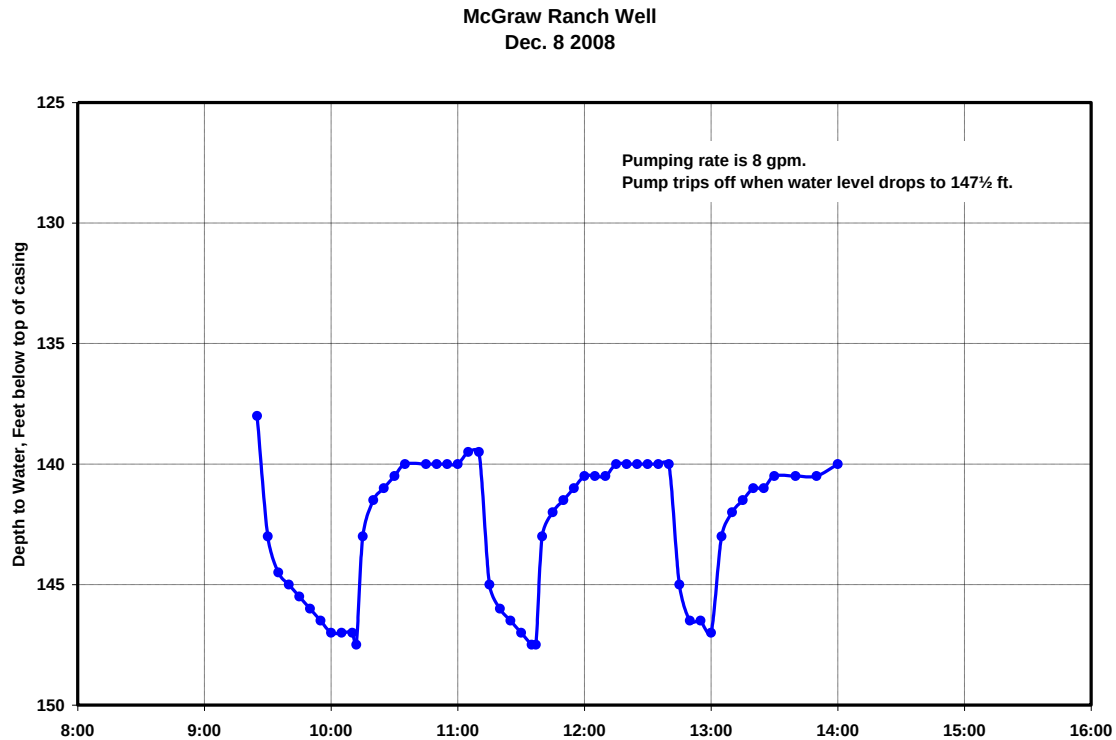
In retrospect, we can see that the recovery rate was slow and that it would have taken quite a long time to recover to even 40 feet from the top of the casing. Thus, the initial static water level of 16 feet below ground surface is probably only representative of conditions after many years with no pumping.

A permanent pump was installed in the eastern well and it became the water-supply source for facilities at McGraw Ranch. There was no water-level monitoring at the well until production problems began to occur in late 2008.

Water problems in 2008-09

In December 2008 it became apparent that there were problems with the production from the well. The water level was repeatedly measured and the static water level was always around 138-140 feet below the top of the casing, more than 100 feet lower than it was in 1999. When the well was pumped, the water level would be drawn down to the pump intake after about 20-40 minutes (pumping rate of 8 gpm) and the pump would shut off. Pumping tests were conducted on December 5 & 8, 2008 in an attempt to determine the problems. Graphs of data from those tests are shown below.





The December 2008 pumping tests showed that the water level is drawn down to the level of the pump intake (about 147-148 feet) in less than an hour. The pump starts to suck air and the pump controller senses the amperage change and trips off to protect the pump. The water level recovers to about 140 feet fairly quickly, but each subsequent pumping period takes less time before the water level is drawn down and the pump trips off.

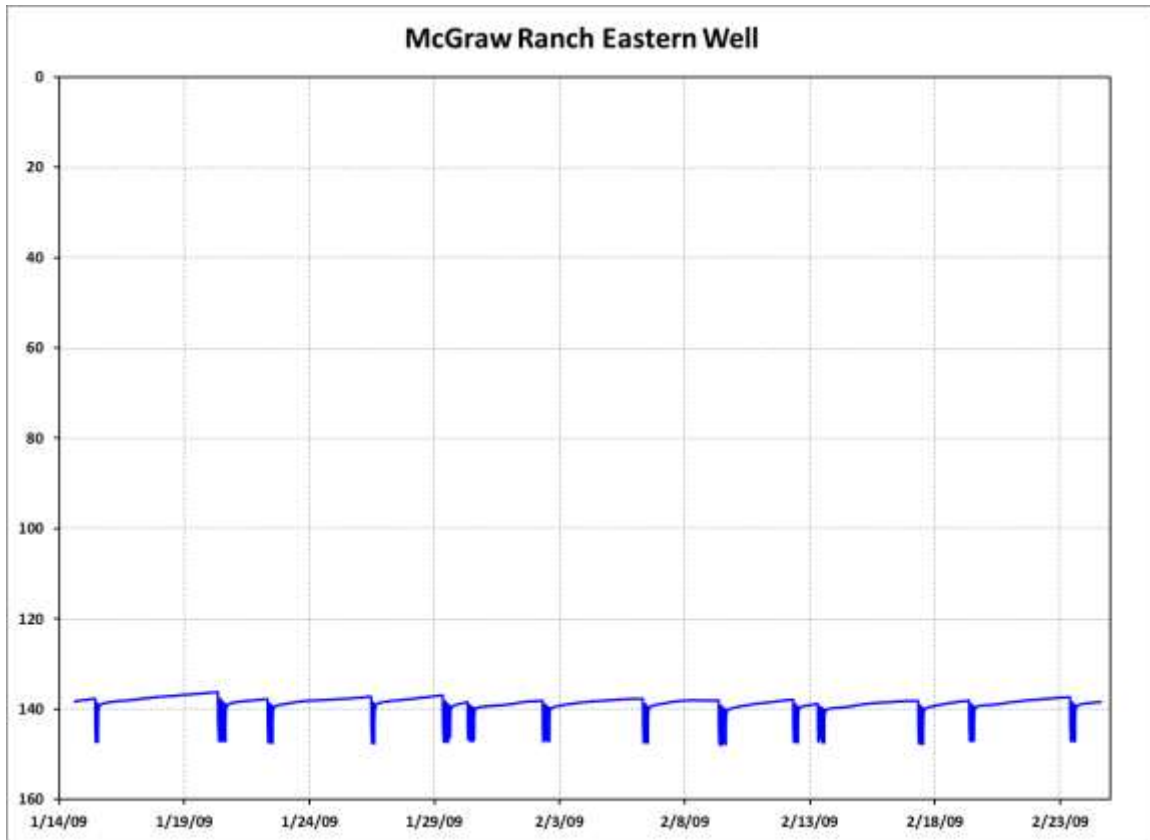
Based on the measurements of November and December 2008, we concluded that the static water level was around 138 feet below the top of the casing. But there was no way to determine how or when the static water level had declined from about 16 feet below ground surface in 1999 to about 138 feet below ground surface in 2008.

Apparently the water table had recovered to higher levels by Summer 2009, as the well was able to meet the demand throughout the summer. Also, water use in 2009 was less than in 2008 (see graphs later in this report), never rising above 10,000 gallons per month.

Groundwater level monitoring since 2009

A datalogger was installed in the well in January 2009. Unfortunately, the datalogger was programmed to record at 5-minute intervals. The memory filled after 45 days and it then stopped logging. We did not discover this until we returned to download data in September 2010. Also, there was a miscommunication regarding who was going to periodically download the data and as a result, no data retrieval occurred. Partly this

situation occurred because the well was keeping up with production demands, so there was no crisis. The datalogger was restarted in September 2010. A graph of water level data during January and February 2009 is shown below.

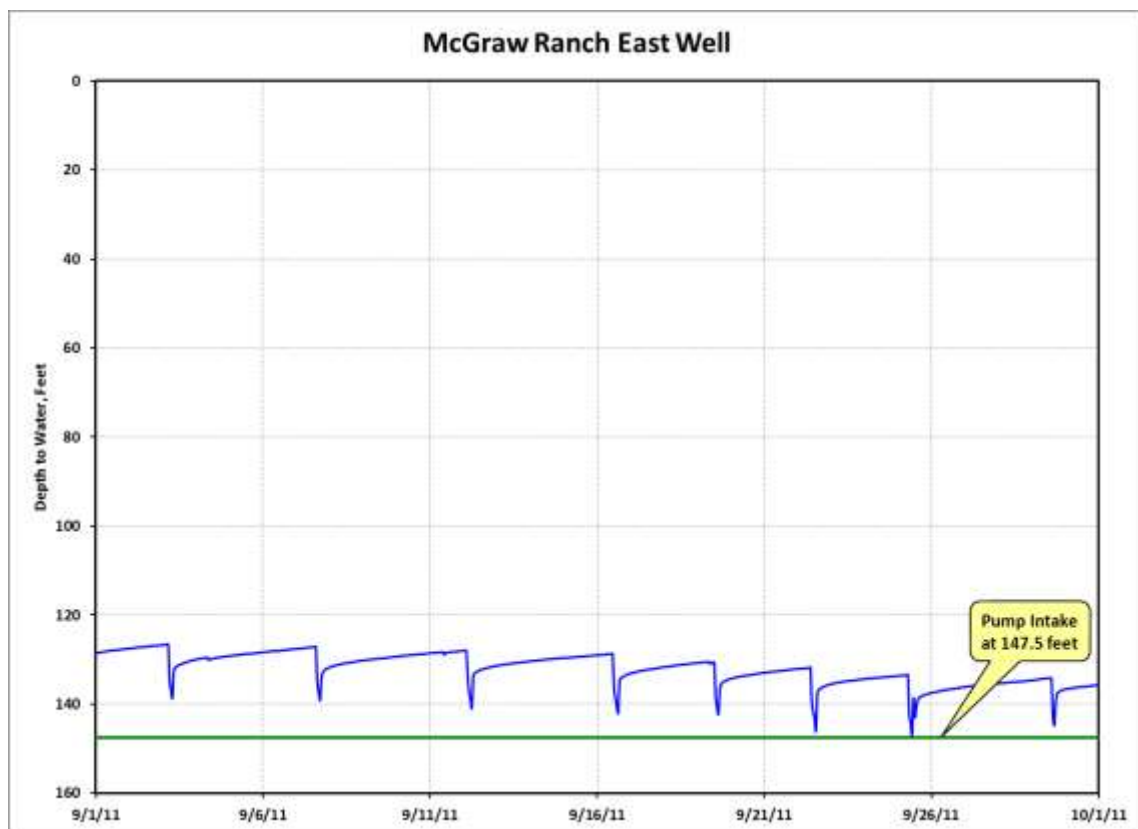
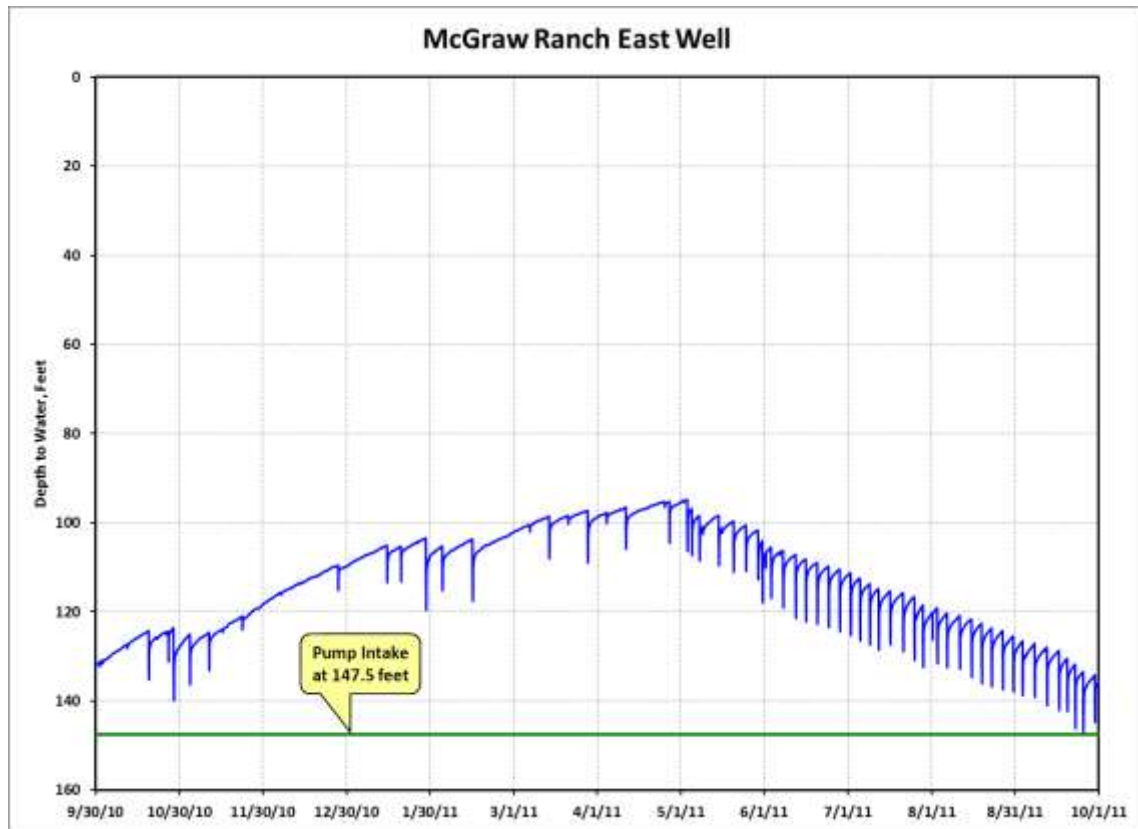


The site was visited on October 4, 2011 to measure the water level in the well and download the data. The measured water level was 136 feet below ground surface. I downloaded a full year of hourly data at that time. A graph of the data is shown below.

The data show that the static water level in the well increased through the autumn, winter, and early spring; probably in response to infiltration of recharge into the fractured rock aquifer, and partly due to the decreased pumping during that time. Pumping increased starting around May 1. The water level decreased steadily from May to October; from 95 feet to 135 feet below ground surface.

More detail is provided in the graph that shows water level data and the response to pumping during the month of September 2011.

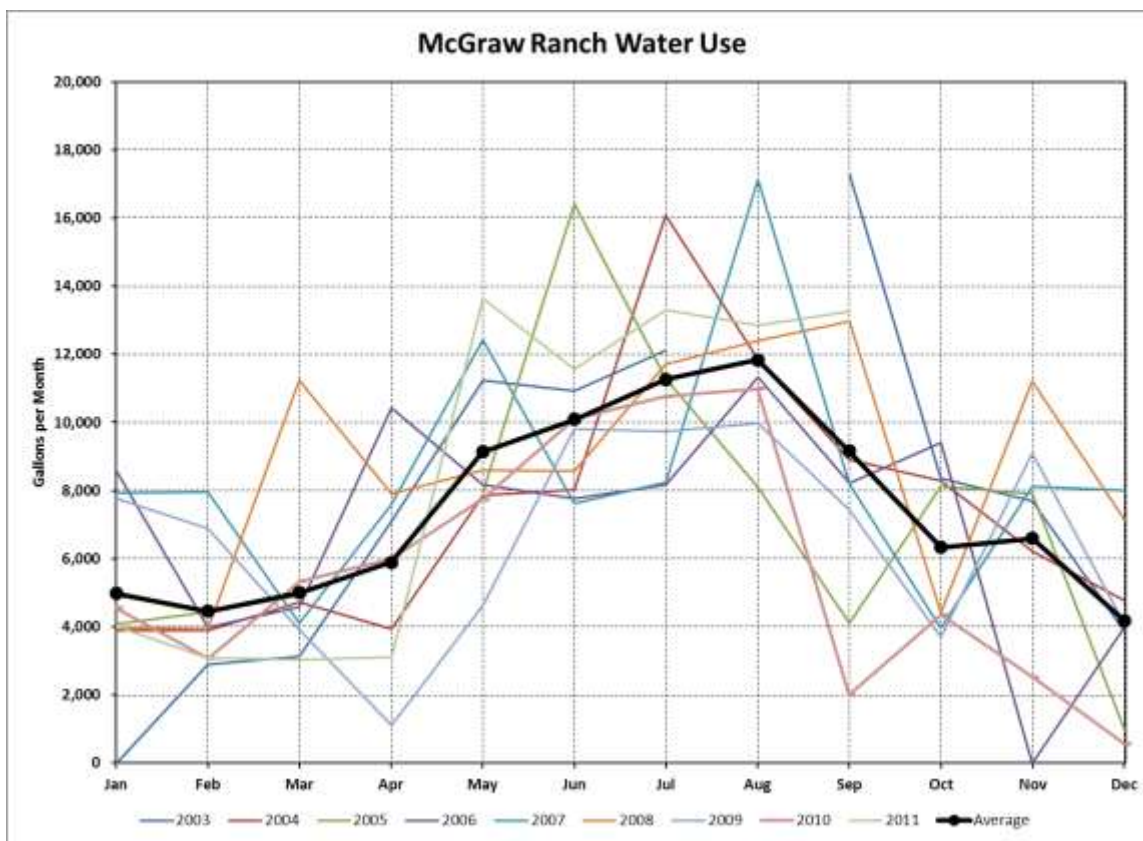
I am hesitant to predict what might happen in the near future, other than to guess that this is probably a typical pattern. I should also emphasize the obvious; that the water level during pumping is perilously close to the level of the pump intake by the end of the summer. Water levels are likely a little higher or lower in wet or dry years.



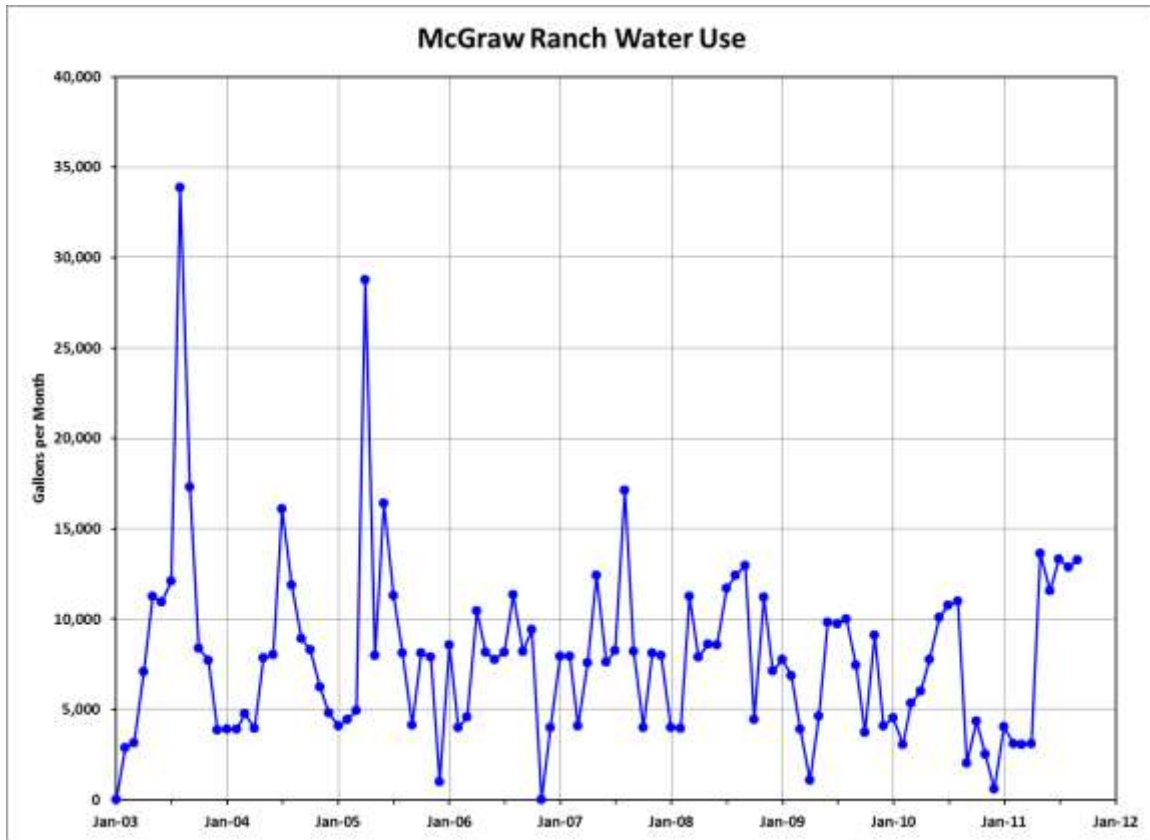
It appears that the cumulative effect of pumping through the entire summer causes a gradual decline of the groundwater level. Although we only have good data for one complete year, it appears that the current well is producing at about the maximum capacity for the summer season. Any increase in demand will likely cause a steeper water level decline and supply problems late in the high-use season. We might also surmise that the problems observed in 2008 might be related to drier than normal conditions, resulting in less recharge to the local aquifer.

Water use at McGraw Ranch

Water use data for facilities at McGraw Ranch were provided by Dave Paquette. As would be expected, peak water use occurs from May-September with the average peak demand near 12,000 gallons per month. Low-season use is around 4,000-5,000 gallons per month. The highest values for monthly use, greater than 14,000 gallons, occurred in 2003, 2004, 2005, and 2007; and may be related to construction activities or some other one-time occurrence that required more water for a short duration. Two outliers were removed prior to plotting these data. Both outliers showed water use greater than 25,000 gallons per month.



Perhaps it is more illustrative to look at a chronological graph of water use at McGraw Ranch. In recent years, the peak season water demand is generally between 10,000-15,000 gallons per month. The low-season demand is generally around 3,000-4,000 gallons per month.



A demand of 15,000 gallons per month is an average of about 500 gallons per day. Previous graphs in this report suggest that the well is not capable of sustaining that amount of production for more than a few months. If the ranch was fully occupied and/or drier than normal conditions persisted for a few months, the well will likely begin to run dry again.

Increasing the water supply

Eventually a more reliable water supply will be needed at McGraw Ranch. Production from the existing well cannot be increased. There is reportedly an old pump in the bottom of the well that cannot be retrieved. Thus, the existing pump cannot be lowered and the well cannot be deepened.

The western well might be hydrofracked to increase its yield. There is a well fracking company in Ft. Collins that specializes in low-yield, domestic water wells in the Front Range area. If the yield could be increased to just a few gpm, it would probably be sufficient to supplement the yield from the existing well. After fracking, the well could be

equipped with a DC pump and solar panels to pump water at a low rate throughout the day. If it only produced 2 gpm for 4 hours per day, the total yield would be nearly 500 gallons, sufficient to meet the entire demand at McGraw Ranch. For more info on fracking see <http://www.well-improvement.com/hydrofracturing.html>

The eastern well (the current supply well) is probably not a candidate for fracking. Its current yield of 5-10 gpm is probably too large for fracking to be effective. However, we should consult with the expert before we dismiss this as an option.

Drilling a new well will be much more expensive than fracking the existing wells. Drilling a new well is also risky. The only geologic formation underlying the area is granite. Yield from a well drilled in granite is entirely dependent on the number of fractures encountered and the water-bearing nature of those fractures. Some fractures may be dry, some may be rather prolific producers of water. There's a good chance that a new well would need to be fracked to obtain a useable yield.

If a new well is the preferred option, it should be planned to drill to 250 feet. Preliminary cost estimates for constructing a well in bedrock are about \$100 per foot for drilling and surface casing. The majority of the well could be completed as an open borehole with no casing.

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