Watermaster's Report
Water District 63-S (Stewart Gulch)
October 1, 2017 to September 10, 2018

Michael W. McVay, P.E., P.G.

Withdrawals

The combined total withdrawals in Stewart Gulch Ground Water District 63-S (WD63-S) in Water Year 2018 (WY18) were 201.6 mgal, which was 23.5 mgal more than in WY17 (Figure 1 and Table 1).

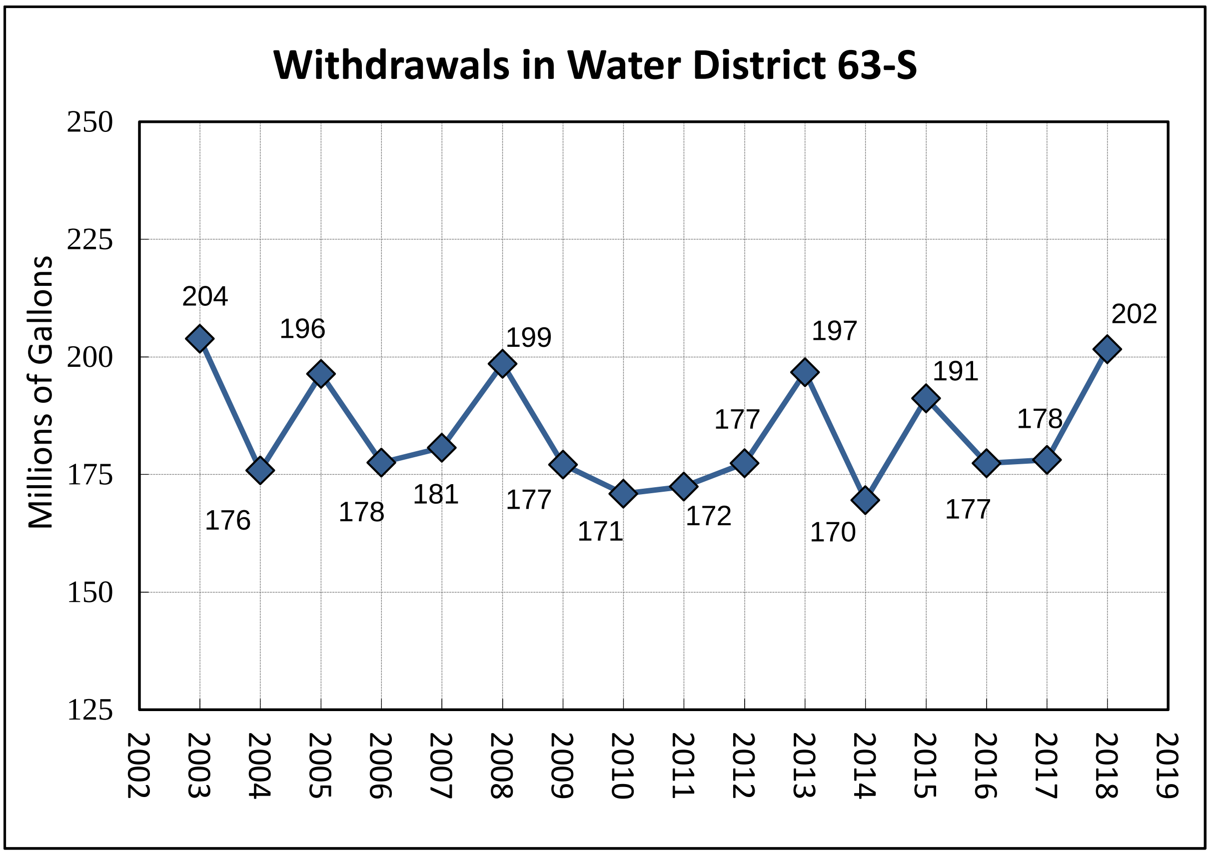

Figure 1. Low-temperature geothermal withdrawals in WD63-S for Water Years 2003-2018.

Combined district withdrawals increased 13% from WY17 to WY18. Withdrawals increased in the Terteling Company, Inc. (TTCI) Garden Center, Edwards Greenhouse, and Terteling Ranch. Quail Hollow withdrawals decreased in WY18 (Table 1). Terteling Ranch and Edwards Greenhouse accounted for 93% of the increased district withdrawals.

Table 1. Withdrawals[1] in WD63-S for Water Year 2018 (October 1, 2017 through September 30, 2018).

Well	Withdrawals in WY18 (millions of gallons)	Change from WY17 (millions of gallons)	Percent Change from WY17
TTCI Tiegs (Triangle)	0	0	0
TTCI Silkey (Shed)	21.5	+1.5	+8%
TTCI House (Office)	3.7	+0.1	+2%
Edwards Greenhouse	55.1	+6.1	+13%
Terteling Ranch Windsock	93.8	+15.7	+20%
Terteling Ranch Pool	22.3	+0.5	+2%
Quail Hollow (Tee Ltd) Upper	<0.1	<0.1	0
Quail Hollow (Nibler) Lower	0.2	-0.1	-32%
Niznik (Whitehead)	5.0	-0.3	-5%
Total	**201.6**	**+23.5**	**+13%**

[1]These numbers contain some degree of uncertainty which is typically associated with measurement equipment and methods. Therefore, the amounts are being reported to within 100,000 gallons..

Withdrawal Centers

The ownerships and locations of the wells allow them to be grouped into three withdrawal centers: 1) Edwards-TTCI-Niznik, 2) Quail Hollow, and 3) Terteling Ranch. This is a useful approach for summarizing the withdrawals in localized areas within WD63-S (Appendix A and Table 2), and allows for the visual assessment of the both the relative magnitude and withdrawal trends for each of these sub-district areas (Figure 2).

Table 2. Three withdrawal centers in WD63-S and changes from WY16 to WY17.

Withdrawal Center	Number of Wells	Change from WY17 (millions of gallons)	Percent Change from WY17
Edwards Greenhouse-TTCI-Niznik	5 (4 in use; 1 unused)	+7.5	+10%
Quail Hollow	2	-0.1	-32%
Terteling Ranch	2	+16.1	+16%

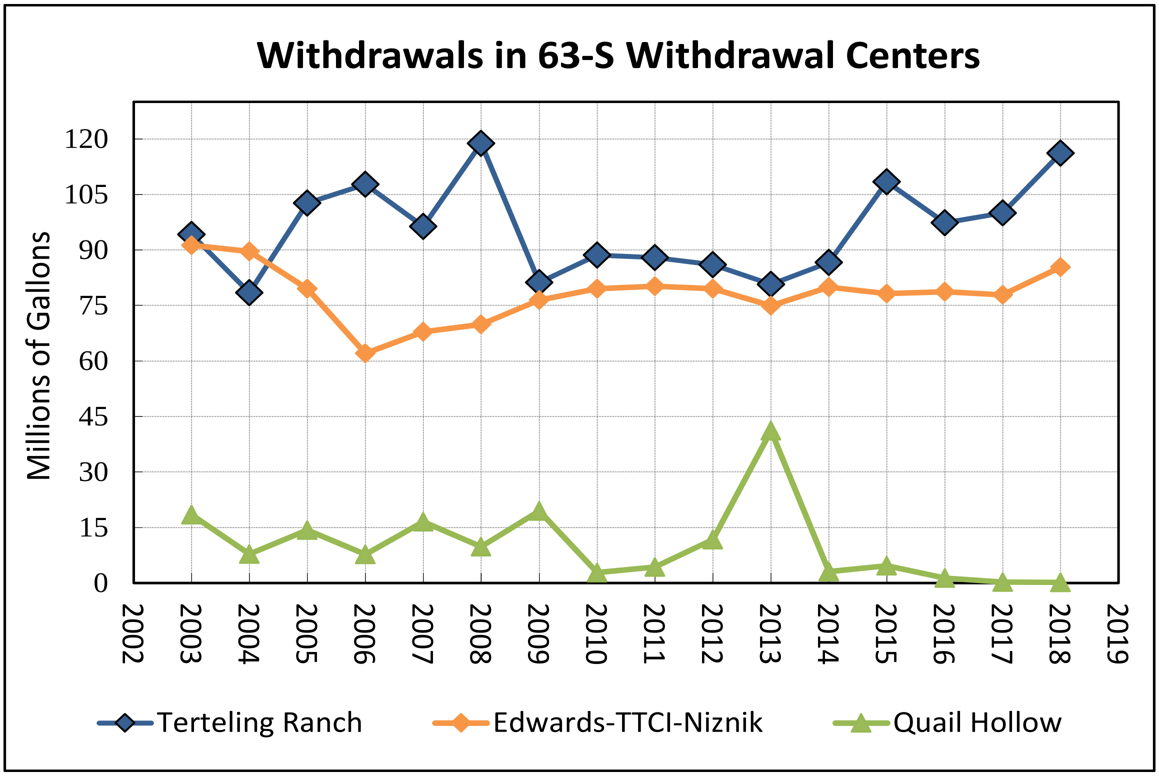

Figure 2. WD63-S withdrawals grouped by withdrawal center for WY08-WY18.

Statistical trends provide a technically defensible assessment of withdrawals over time. The trend in combined withdrawals for WD63-S is not statistically significant, which indicates withdrawals in the district have not consistently increased or decreased since WY03 (Table 3).

Table 3 shows that there is no statistically significant trend in withdrawals for the Edwards Greenhouse-Terteling Garden Center-Niznik withdrawal center for WY03 – WY18.

The Quail Hollow withdrawal center diverts the smallest volume of low-temperature geothermal water; however, it is the only withdrawal center with a statistically significant trend since WY03. Withdrawals from the Quail Hollow area have declined at an average rate of 850,000 gallons/year (Table 3).

Despite the visible increase in withdrawals in the Terteling Ranch area since WY13, there are not enough data to assess the statistical significance over this period. However, there is no statistically significant trend from WY03 – WY18 in this withdrawal center (Table 3).

Table 3. Combined and sub-district withdrawal trends in WD63-S for WY03 – WY18.

Withdrawal Center	Trend (mgal/year)[1]	p-value[2]	Statistically Significant
Combined total WD63-S	-0.09	0.9	NO
Edwards Greenhouse, Terteling Garden Center, Niznik	-0.03	0.9	NO
Quail Hollow	-0.85	0.01	YES
Terteling Ranch	+0.54	0.5	NO

[1] Trends and significance have been calculated using the statistical approach known as the Mann-Kendall test.

[2] P-values less than 0.05 indicate the trend is significant at the 95% confidence interval.

Water Levels

Groundwater levels generally dropped in WY18. The shallowest (peak) water levels in the Tiegs well declined 1.5 feet, and the deepest (minimum) water levels in the Tiegs well rose 2.4 feet (Figure 3).

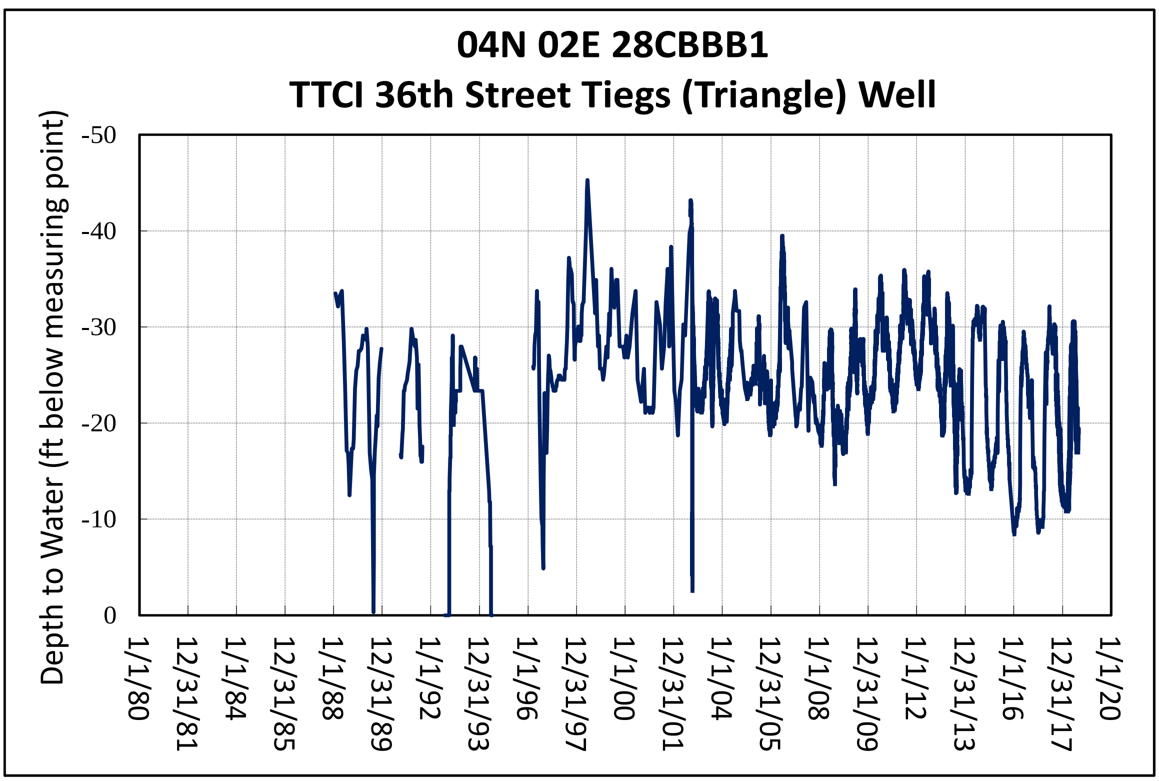

Figure 3. Water-levels for the TTCI 36th Street Tiegs (Triangle) well.

There was a significant data collection gap in the Edwards Greenhouse well from October 2017 to August 2018. This issue has been corrected and regular data collection has resumed. This data gap precludes a WY17 to WY18 water-level change analysis.

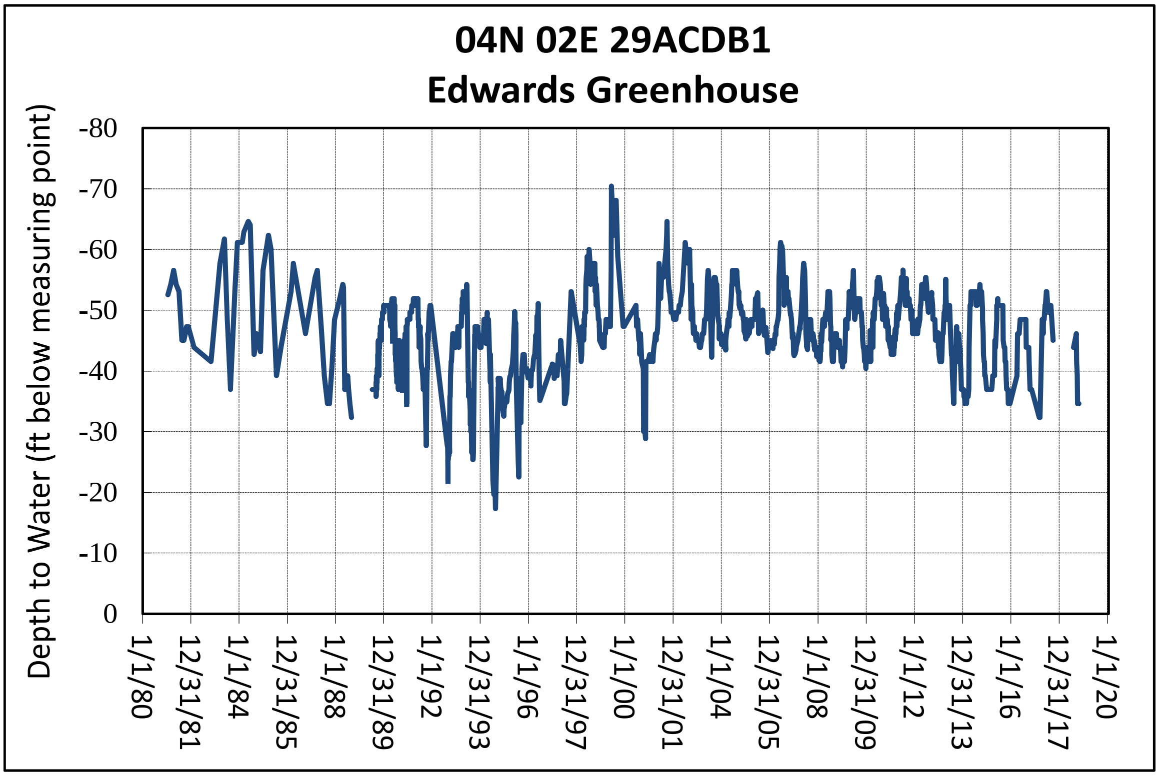

Figure 4. Water-levels for the Edwards Greenhouse well.

There was a significant data collection gap in the Quail Hollow wells from early 2016 to early 2017 due to staff changes and miscommunication. This issue has been corrected and regular data collection has resumed. Because of the data gap, WY18 water levels have been compared to WY15.

The peak water level in the Upper well dropped 5 feet from WY15 to WY18, and the minimum water level dropped 5.4 feet (Figure 5). The peak water level in the Lower well dropped 7.3 feet from WY15 to WY18, and the minimum water level dropped 3.1 feet (Figure 6). Despite the reduction in Quail Hollow withdrawals, the Quail Hollow wells appear to be responding to the increase in combined WD63-S withdrawals.

For comparison, peak and minimum water levels in the Tiegs well dropped 1.1 and 2.1 feet, respectively, from WY15 to WY18.

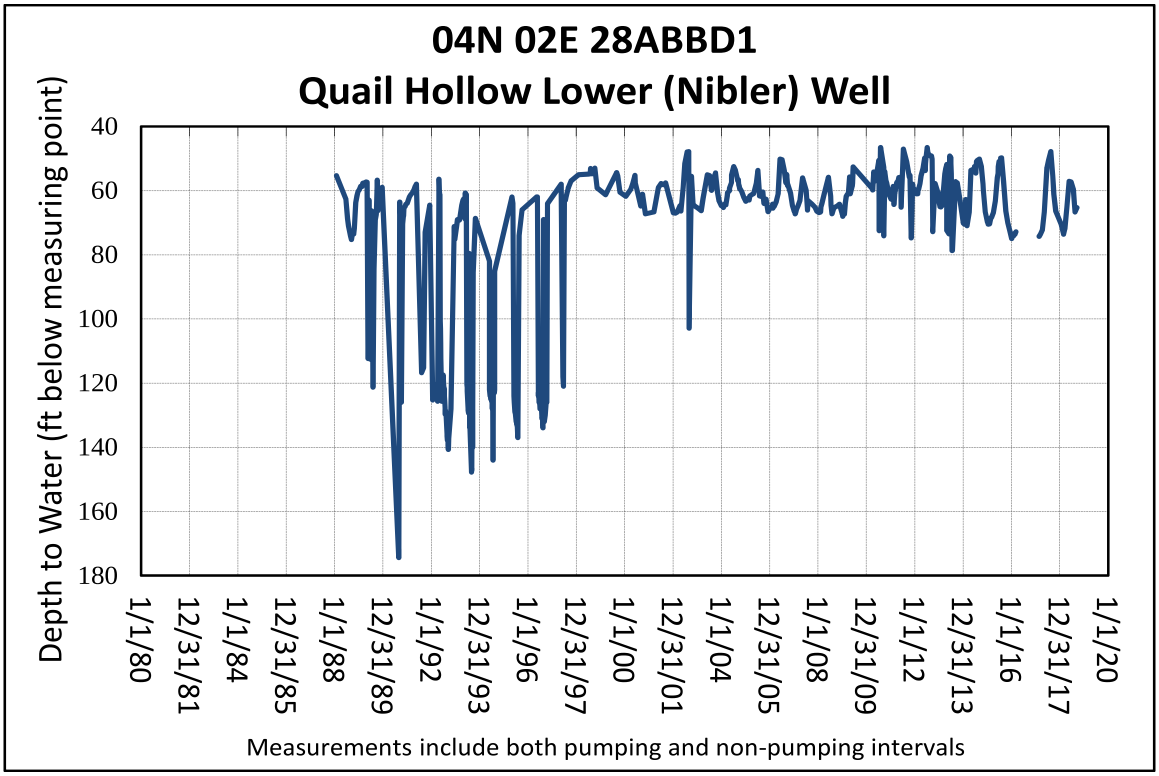

Figure 5. Water level hydrograph for the Quail Hollow Lower well.

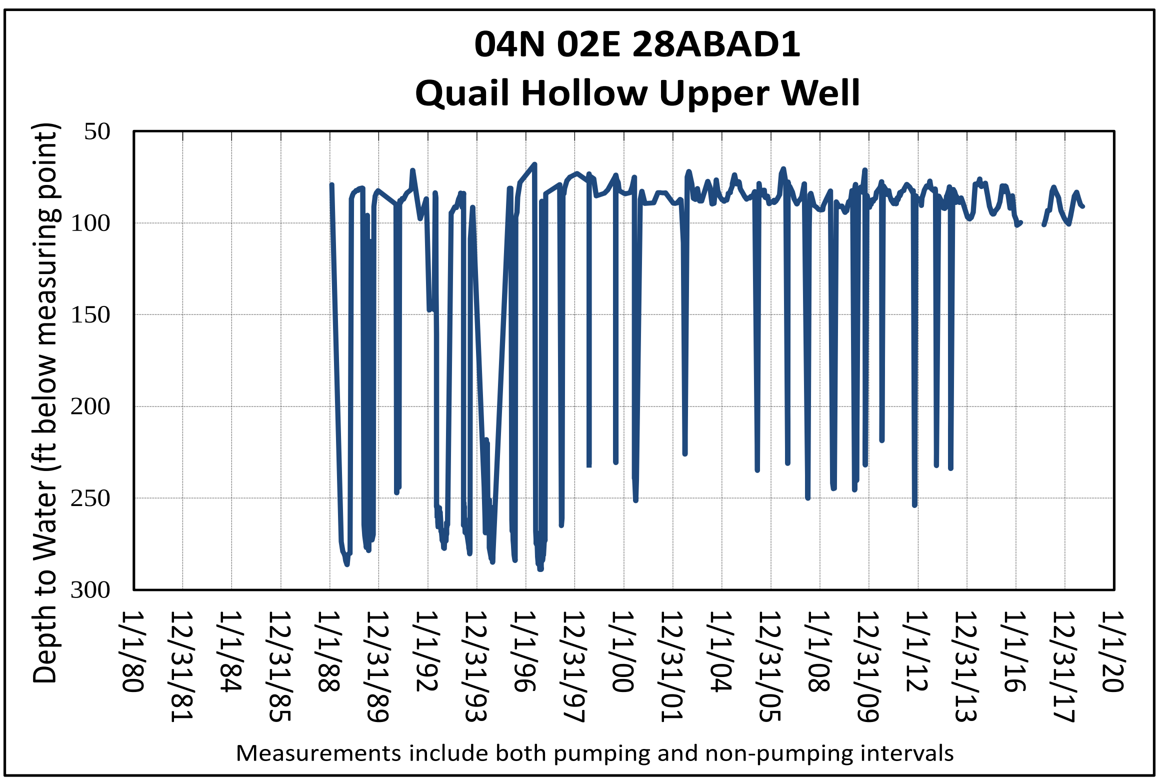

Figure 6. Water level hydrograph for the Quail Hollow Upper well.

Analysis of Withdrawals and Water Level Trends

Water levels have cycled up and down over the past 10+ years, with higher withdrawal rates generally resulting in lowered water levels. Considering the Tiegs well as an indication of WD63-S aquifer conditions, Figure 7 illustrates the inverse relationship between water-year withdrawals and peak water-year water levels.

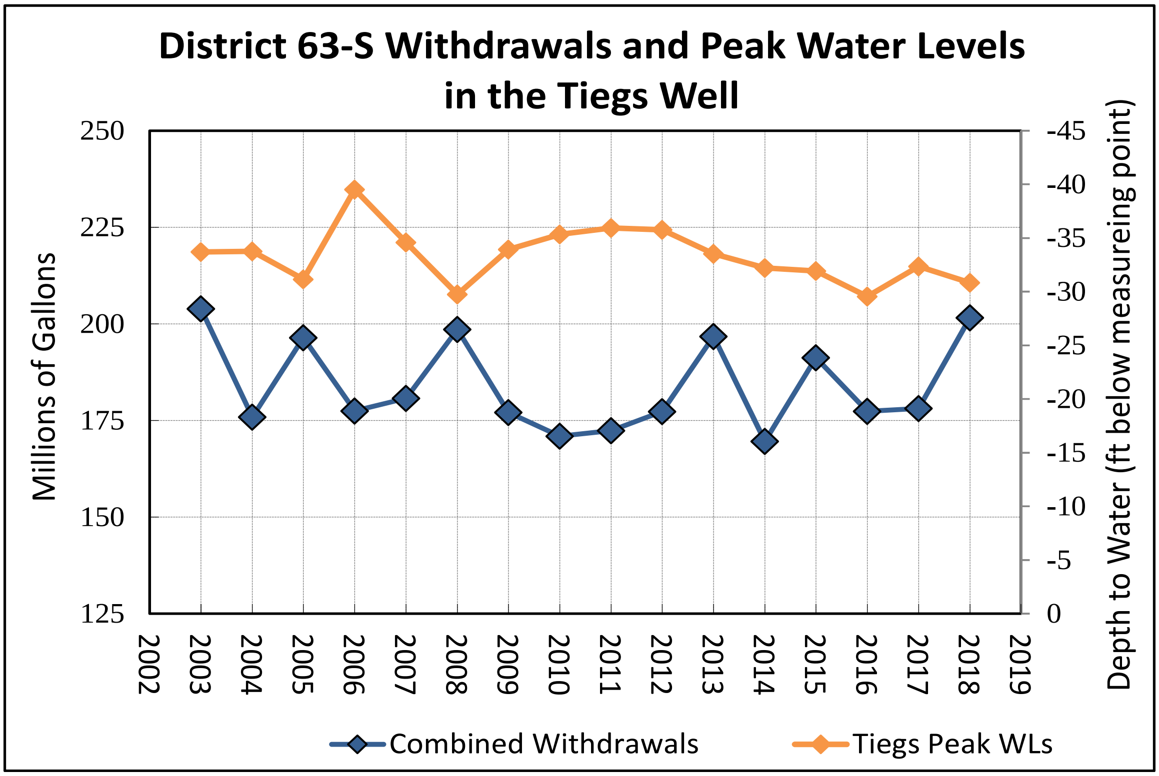

Figure 7. WY03 – WY18 water-year combined 63-S withdrawals compared to peak water levels in the Tiegs well.

The inverse relationship between withdrawals and water levels is plainly visible until WY13. After WY13, the relationship is less direct. The change in this relationship may be due to:

- Timing of local or regional withdrawals that result in peak water levels which are not reflective of regional water-year production.
- Changes in withdrawals from hydraulically connected wells that are located outside of the district.

Despite the lack of an increasing trend in the combined withdrawal volume, the minimum water levels in the Tiegs well, the peak and minimum water levels in the Edwards Greenhouse well, and the peak and minimum water levels in the Quail Hollow Upper well exhibit downward trends (Figures 8-10 and Table 4).

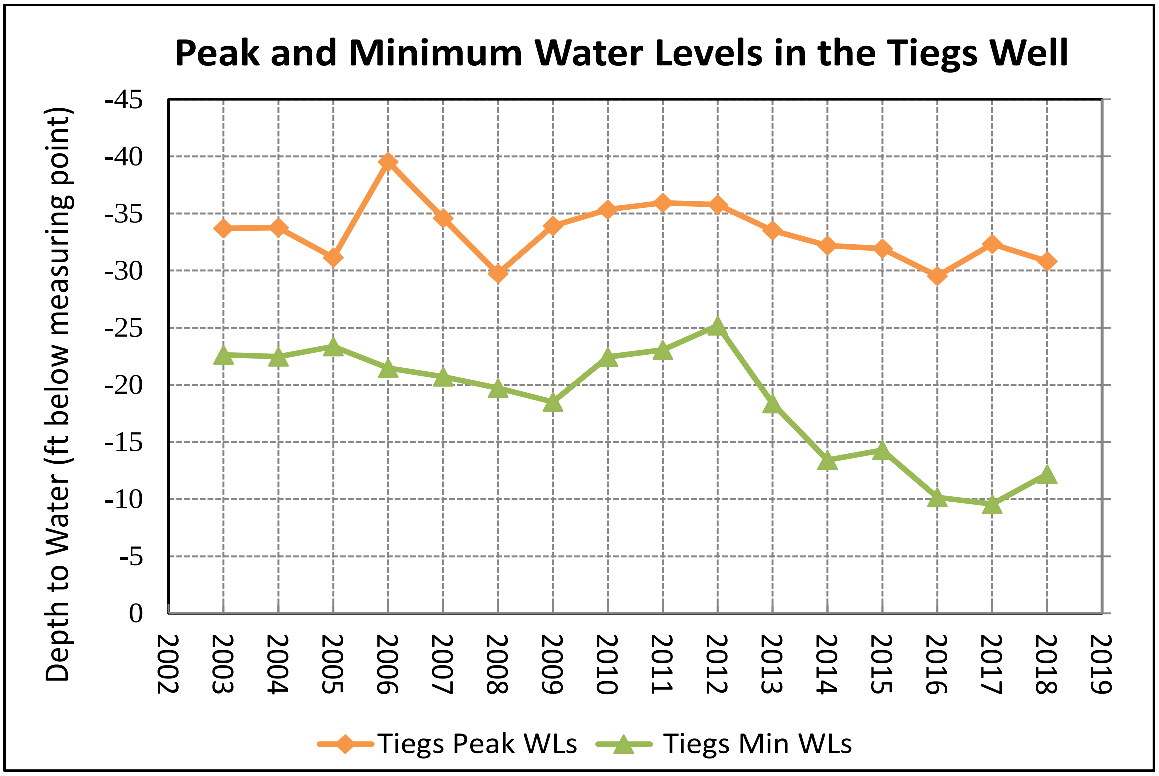

Figure 8. Water-year peak and minimum water levels in the Tiegs well.

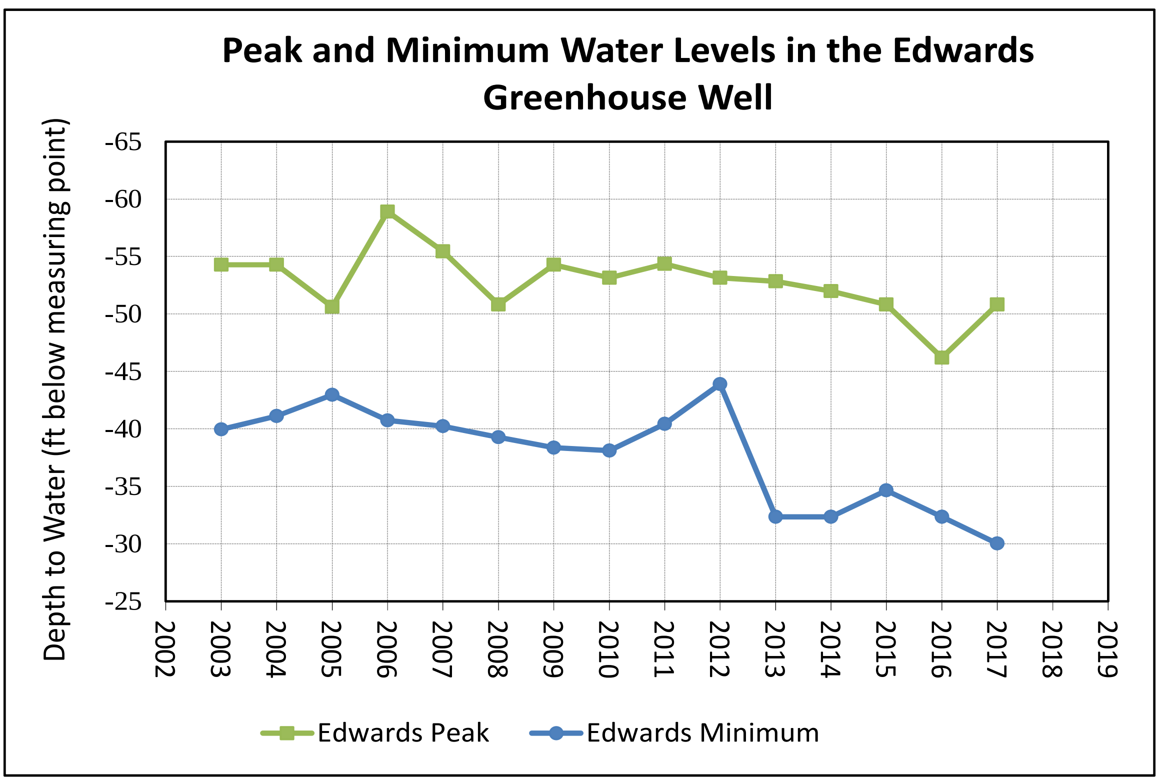

Figure 9. Water-year peak and minimum water levels in the Edwards Greenhouse well.

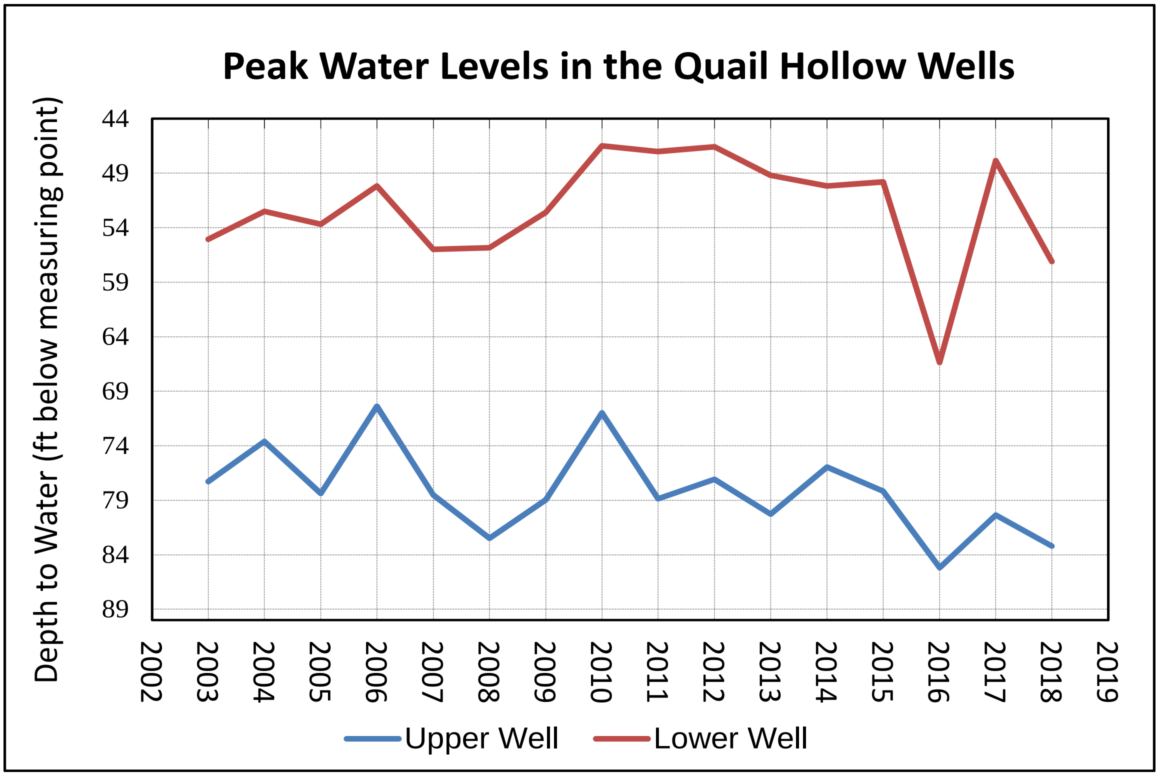

Figure 10. Water-year peak water levels in the Quail Hollow wells.

Table 4. Water-level trends in district 63-S wells for the period WY03 – WY18.

Water Level	Trend (ft/year) [1]	p-value[2]	Statistically Significant
Tiegs Peak Water Levels	-0.20	0.16	NO
Tiegs Minimum Water Levels	-0.80	0.00	YES
Edwards Peak Water Levels[3]	-0.39	0.02	YES
Edwards Minimum Water Levels[3]	-0.73	0.00	YES
Quail Hollow Lower Peak Water Levels[4]	+0.24	0.65	NO
Quail Hollow Upper Peak Water Levels[4]	-0.35	0.04	YES

[1] Trends and significance have been calculated using the statistical approach known as the Mann-Kendall test.

[2] P-values less than 0.05 indicate the trend is significant at the 95% confidence interval.

[3] Trends in the Edwards well were calculated for WY03 – WY17 due to lack of data in WY18.

[4] Only peak water levels were analyzed due to pumping impacts to the minimum water levels.

The downward trends in water levels may be due to:

- Measured withdrawals exceeding aquifer recharge.
- Unmeasured withdrawals within the district.
- Well construction or monitoring equipment issues.
- Withdrawals from hydraulically connected wells located outside of the district.
- Changes in the timing, duration, and/or frequency of withdrawals.

Although the declining water-level trends in the Tiegs well, Edwards Greenhouse well, and Quail Hollow Upper well are small, they are statistically significant.

Respectfully submitted,

Michael McVay, Water District 63-S Water Master

APPENDIX A

Figure A-1. Well locations within WD63-S