Watermaster's Report
Water District 63-S (Stewart Gulch)
October 1, 2018 to September 30, 2019

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Withdrawals

The combined total withdrawals in Stewart Gulch Ground Water District 63-S (WD63-S) in Water Year 2019 (WY19) were 183.7 million gallons (mgal), which was 17.9 mgal less than in WY18 (Figure 1 and Table 1).

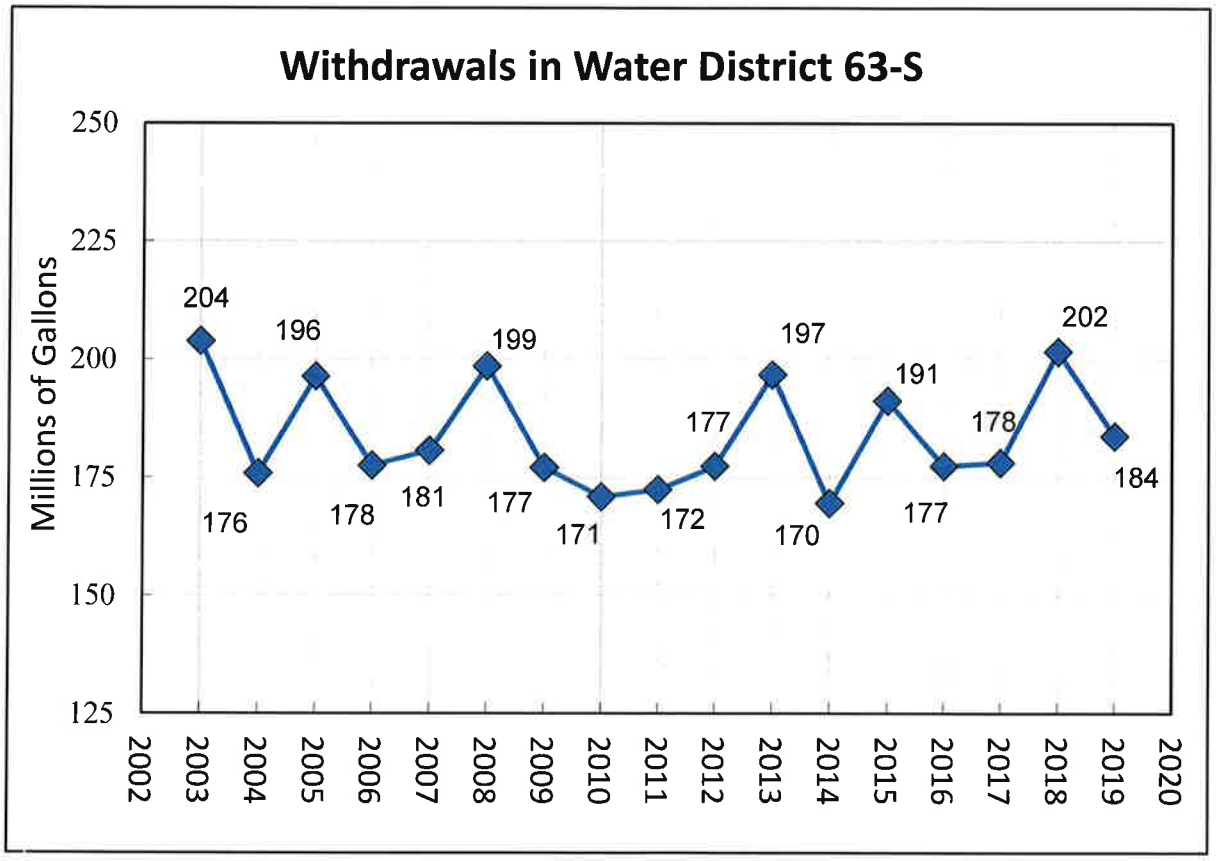

Figure 1. Low-temperature geothermal withdrawals in WD63-S for Water Years 2003-2019.

Combined district withdrawals decreased 9% from WY18 to WY19. Withdrawals decreased in the Edwards Greenhouse (Edwards), Niznik, Quail Hollow Golf Course (Quail Hollow), and Terteling Ranch wells. Terteling Company, Inc. Garden Center (TTCI) withdrawals increased in WY19 (Table 1). Terteling Ranch and Edwards accounted for 80% of the district 63-S withdrawals.

Table 1. Withdrawals[1] in WD63-S for Water Year 2019 (October 1, 2018 through September 30, 2019).

Well	Withdrawals in WY19 (millions of gallons)	Change from WY18 (millions of gallons)	Percent Change from WY18
TTCI Tiegs (Triangle)	0	0	0
TTCI Silkey (Shed)	26.5	+5.04	+23%
TTCI House (Office)	4.80	+1.13	+31%
Edwards Greenhouse	40.3	-14.9	-27%
Terteling Ranch Windsock	86.1	-7.70	-8%
Terteling Ranch Pool	21.0	-1.21	-5%
Quail Hollow (Tee Ltd) Upper[2]	0.00	-0.0002	-100%
Quail Hollow (Nibler) Lower	0.00	-0.18	-100%
Niznik (Whitehead)	4.92	-0.09	-2%
Total	**183.7**	**-17.9**	**-9%**

[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.
[2]WY18 withdrawals in Quail Hollow Upper totaled 0.0002 mgal.

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 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 WY18 to WY19.

Withdrawal Center	Number of Wells	Change from WY18 (millions of gallons)	Percent Change from WY18
Edwards-TTCI-Niznik	5 (4 in use; 1 unused)	-8.79	-10%
Quail Hollow	2	-0.18	-100%
Terteling Ranch	2	-8.90	-8%

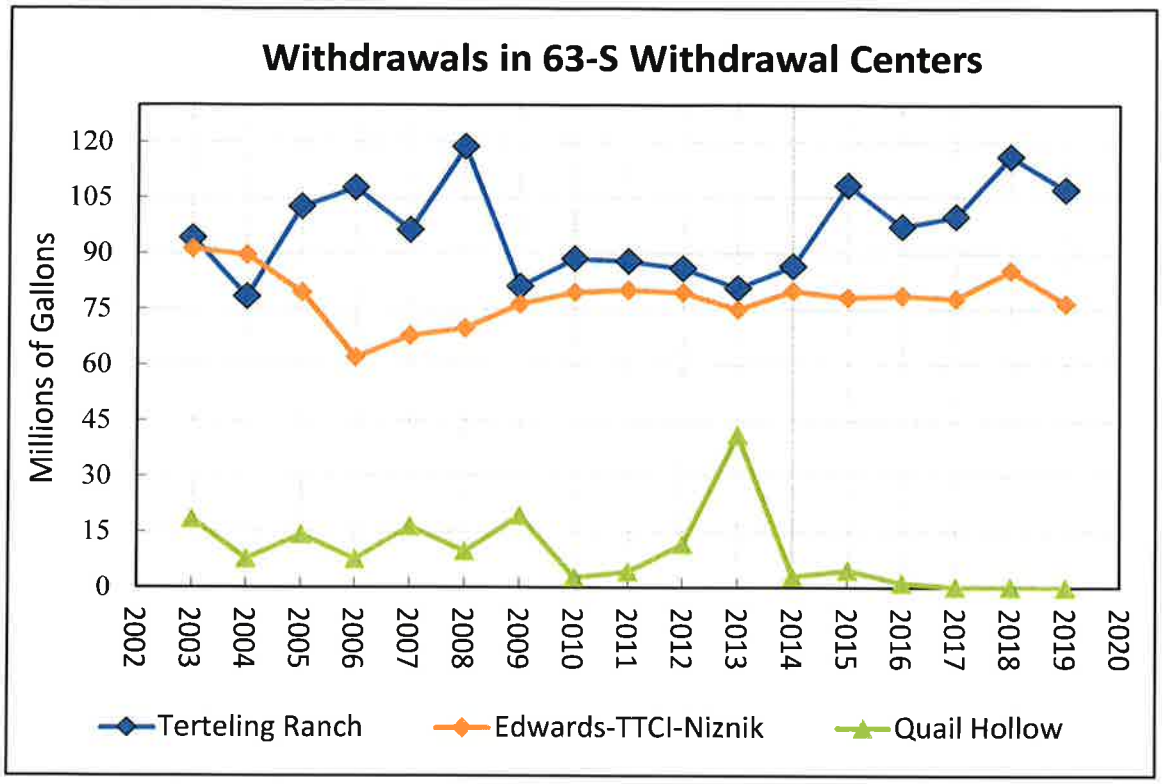

Figure 2. WD63-S withdrawals grouped by withdrawal center for WY08-WY19.

Statistical trends provide a technically defensible assessment of changes over time. Statistical significance indicates that there is a non-zero trend in the data at the chosen confidence interval, and the calculated trend is the best linear representation of changes over time. Lack of statistical significance indicates that the trend cannot be considered different than zero (at the chosen confidence interval), and the calculated trend does not represent changes over time. A confidence interval of 95% has been used to determine statistical significance for all District 63-S trends.

The trend in combined withdrawals for WD63-S is 0.00 mgal/year; however, the trend is not statistically significant. This is a unique situation in which the calculated trend is zero, and the statistical test indicates the trend is not statistically different from zero.

There is no statistically significant trend in withdrawals for the Edwards-TTCI-Niznik withdrawal center for WY03 – WY19 (Table 3).

The Quail Hollow withdrawal center has diverted the smallest volume of low-temperature geothermal water since 2003, and no withdrawals were reported in WY19. It is the only withdrawal center with a statistically significant trend during the WY03 – WY19 period due to the reduction from 18.5 mgal in WY03 to nothing in WY19. Withdrawals from the Quail Hollow area have calculated trend 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. The increasing trend of 750,000 gallons/year for the longer WY03 – WY19 period is not statistically significant (Table 3).

Table 3. Combined and sub-district withdrawal trends in WD63-S for WY03 – WY19.

Withdrawal Center	Trend (mgal/year)[1]	p-value[2]	Statistically Significant
Combined total WD63-S	0.00	1.00	NO
Edwards Greenhouse, Terteling Garden Center, Niznik	-0.04	1.00	NO
Quail Hollow	-0.85	0.00	YES
Terteling Ranch	+0.75	0.30	NO

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

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

Water Levels

Groundwater levels in District 63-S generally rose in WY19. The shallowest (peak) water levels in the Tiegs well rose 8.7 feet, and the deepest (minimum) water levels in the Tiegs well declined 3.0 feet (Figure 3). The peak water level is a better indication of aquifer conditions because minimum water levels may be influenced by pumping. There was a significant data collection gap in the Tiegs well from the end of August 2018 to the middle of December 2018 due to equipment failure. This issue has been corrected and data collection has resumed. Analysis of WY18 to WY19 water-level changes have been evaluated despite the gap because the absence of data was not concurrent with typical peak or minimum water level dates.

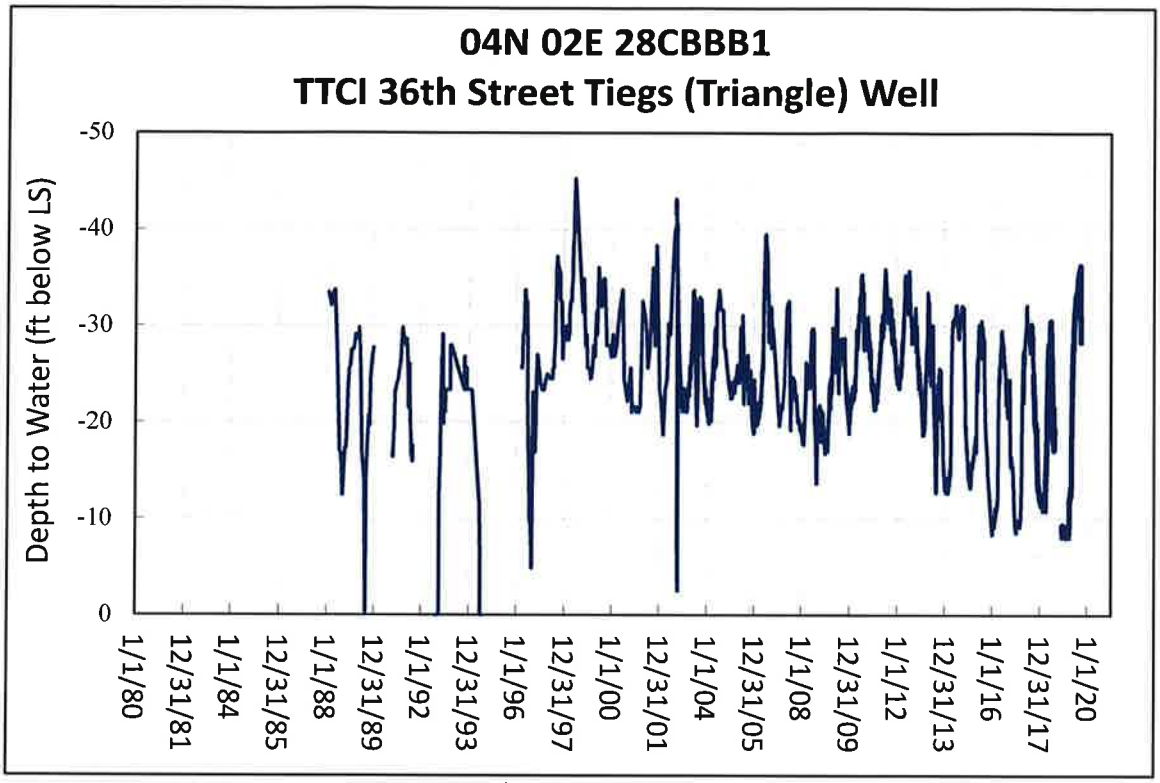

Figure 3. Water-levels for the TTCI 36th Street Tiegs (Triangle) well.

Changes in groundwater levels from WY18 to WY19 in the Edwards well cannot be accurately assessed because there was a significant data collection gap from October 2017 to August 2018 (Figure 4). This issue has been corrected and regular data collection has resumed. This data gap precludes a WY18 to WY19 water-level change analysis.

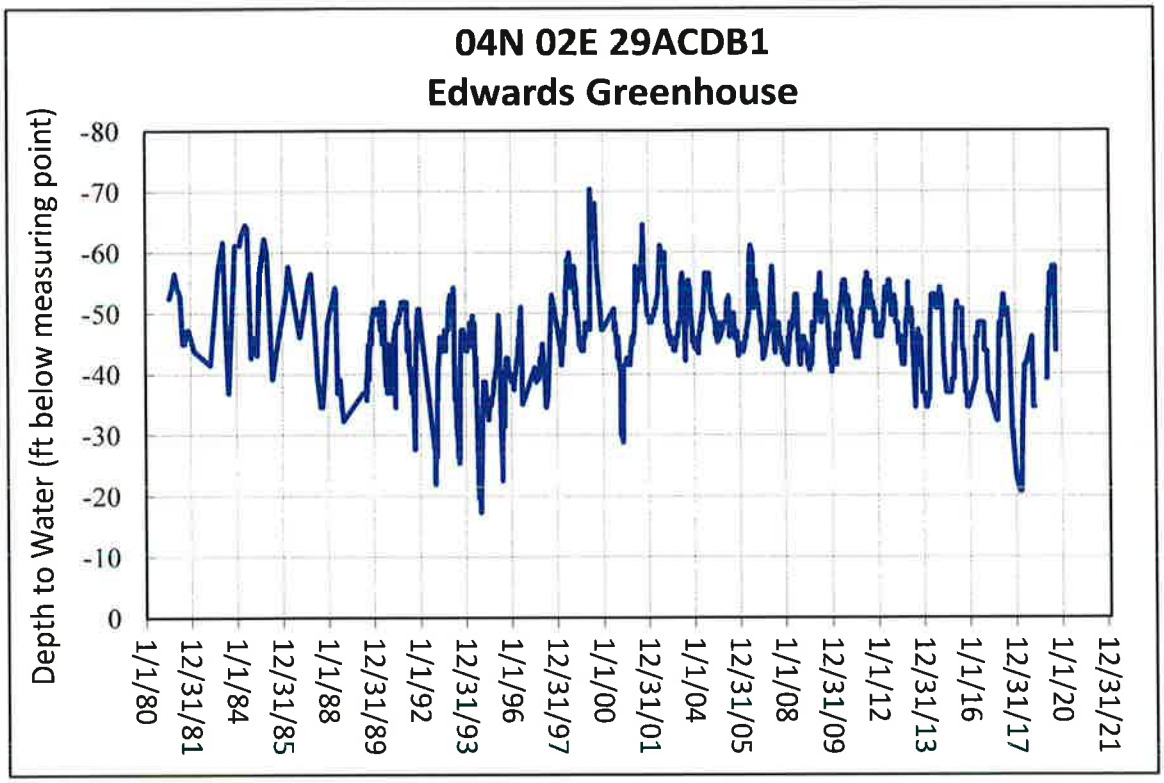

Figure 4. Water-levels for the Edwards Greenhouse well.

Water levels in both of the Quail Hollow wells rose from WY18 to WY19. The peak water level in the Upper well rose 4.0 feet, and the minimum water level rose 2.6 feet (Figure 5). The peak water level in the Lower well rose 8.3 feet from WY18 to WY19; however, the minimum water level dropped 2.2 feet (Figure 6). Peak water levels are a better indication of aquifer condition because the minimum water levels may be influenced by nearby pumping.

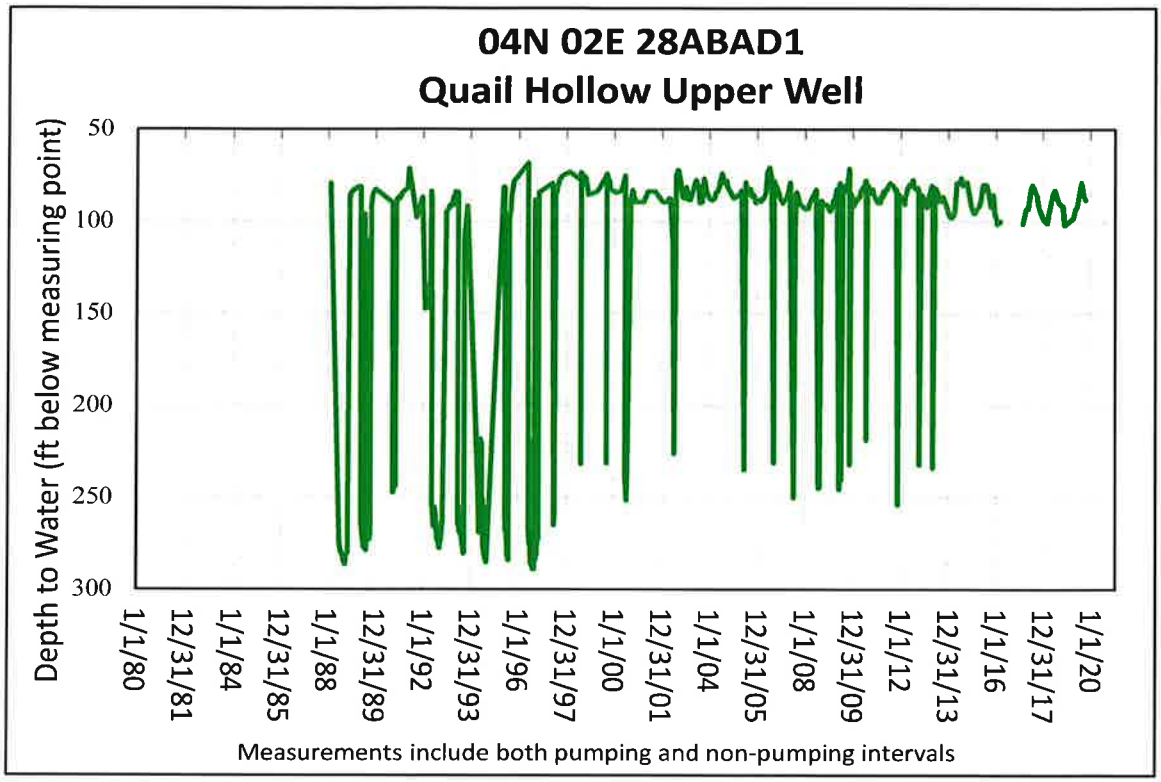

Figure 6. Water level hydrograph for the Quail Hollow Upper well.

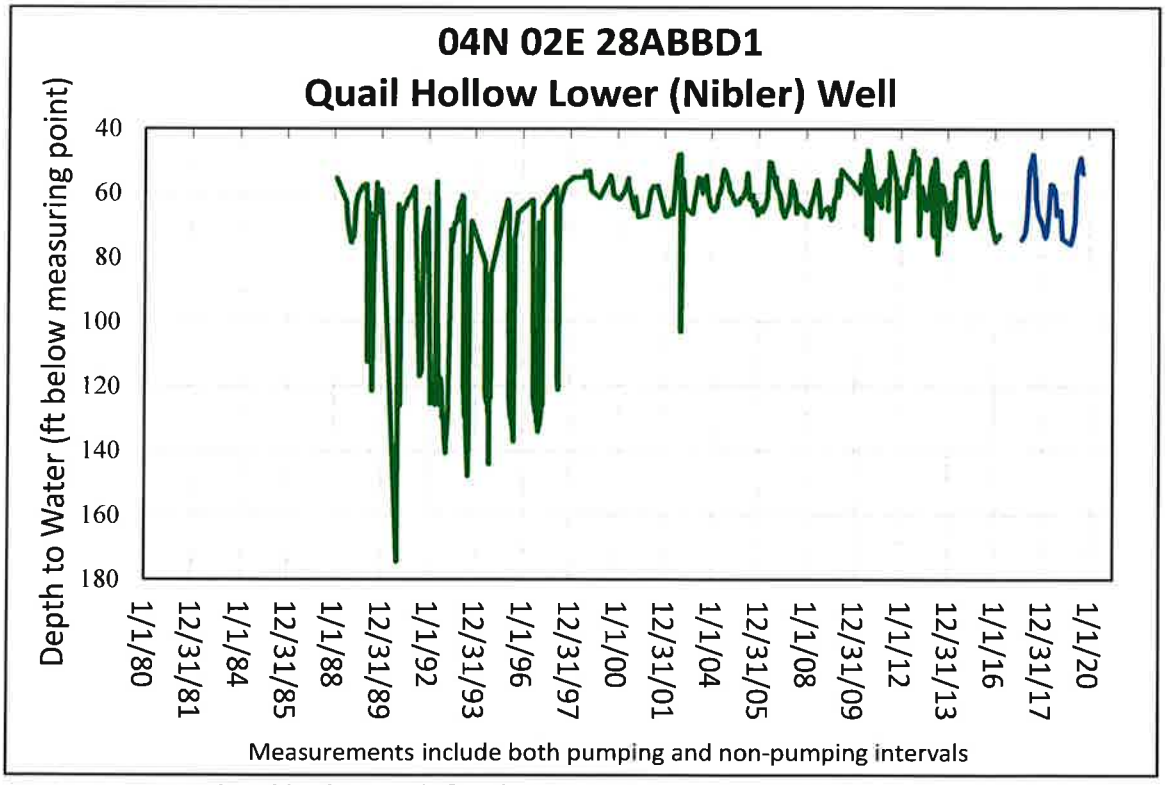

Figure 5. Water level hydrograph for the Quail Hollow Lower well.

Analysis of Withdrawals and Water Level Trends

Water levels have cycled up and down over the past 16 years, with higher withdrawal rates generally resulting in lowered water levels. Figure 7 illustrates this inverse relationship between water-year withdrawals and peak water-year water levels in the Tiegs well, which is used an indicator of WD63-S aquifer conditions because it is somewhat centrally located and it is unused.

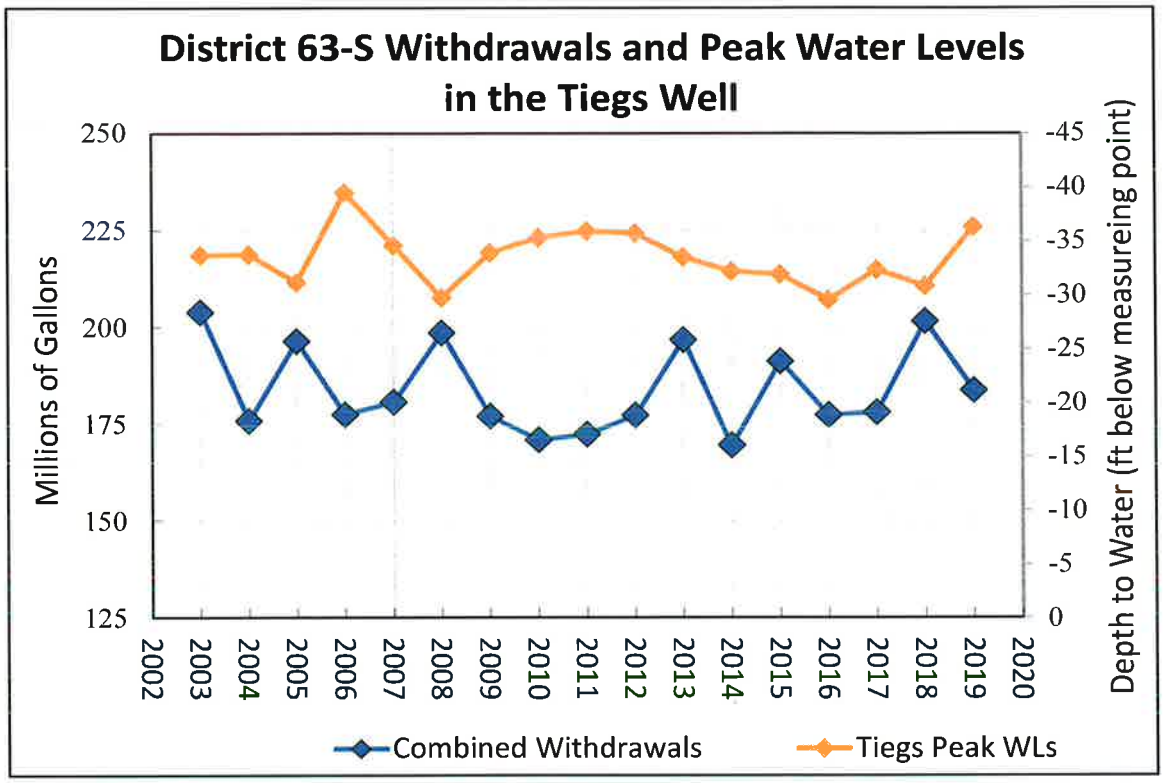

Figure 7. WY03 – WY19 water-year combined 63-S withdrawals compared to peak water levels in the Tiegs well.

The inverse relationship between withdrawals and water levels is plainly visible from WY03 to WY13. From WY13 to WY17, the relationship is less direct; however, an inverse relationship resumes after WY17. 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
- Spatial changes in the relative magnitudes of withdrawals between the withdrawal centers (e.g., an increase in withdrawals at one or more of the withdrawal centers in combination with a decrease in withdrawals at one or more withdrawal centers)
- Changes in withdrawals from hydraulically connected wells that are located outside of the district, or
- A combination of the above listed factors.

Despite the lack of 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 statistically significant downward trends (Figures 8-10 and Table 4).

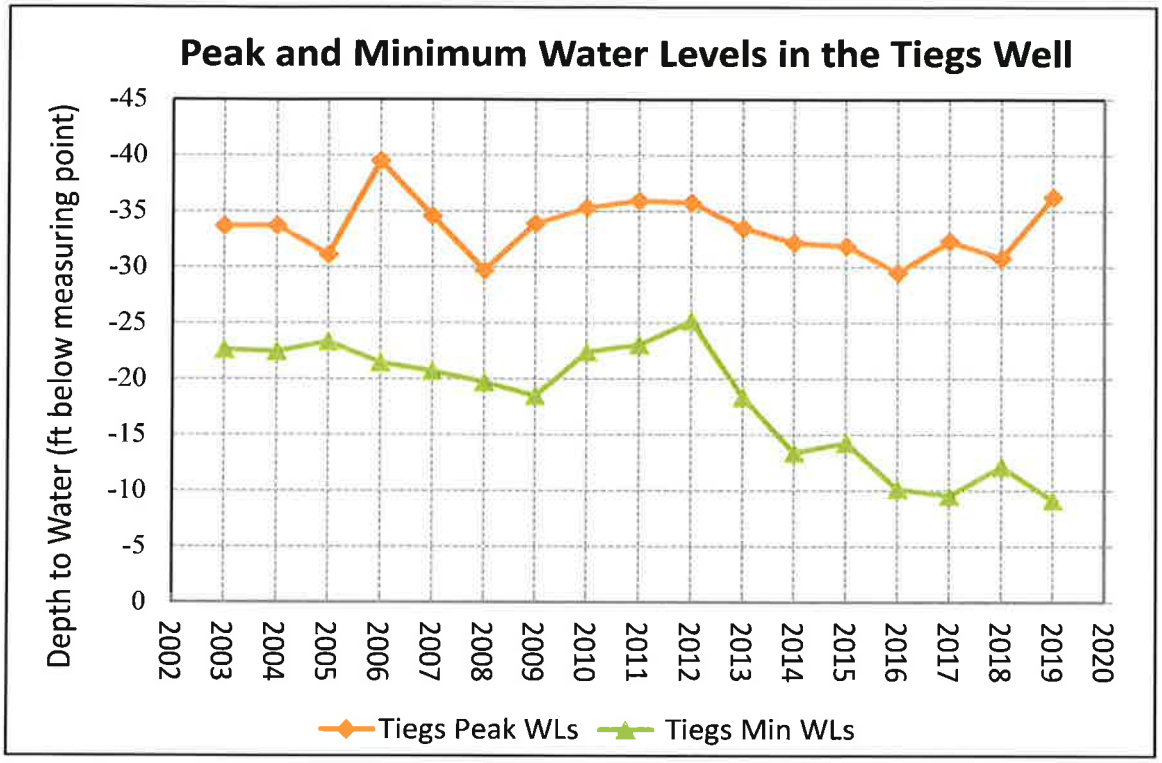

Figure 8. Water-year peak and minimum water levels in the Tiegs well.

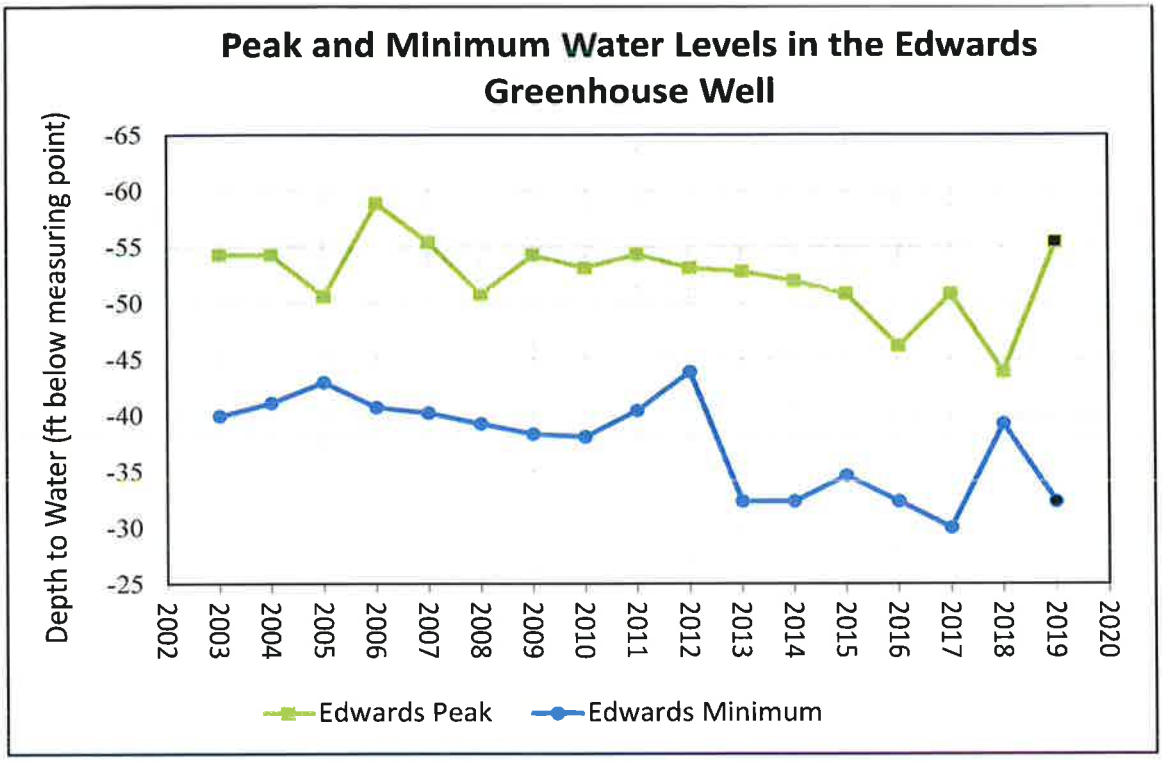

Figure 9. Water-year peak and minimum water levels in the Edwards Greenhouse well. The WY19 data points may not represent the true peak and minimum water levels because of missing data.

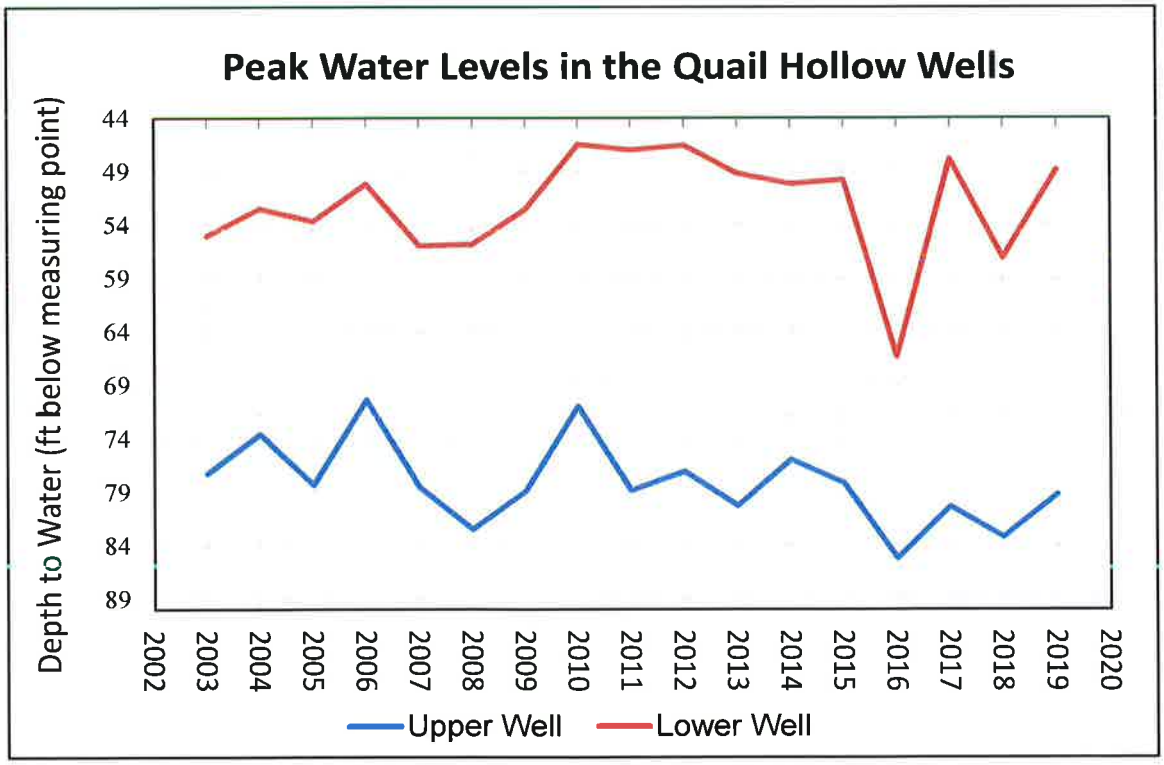

Figure 10. Water-year peak water levels in the Quail Hollow wells.

Table 4. Water-level trends in district 63-S wells for the period WY03 – WY19.

Water Level	Trend (ft/year) [1]	p-value[2]	Statistically Significant
Tiegs Peak Water Levels	-0.14	0.51	NO
Tiegs Minimum Water Levels	-0.88	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]	+0.25	0.46	NO
Quail Hollow Upper Peak Water Levels[4]	-0.30	0.04	YES

[1] Trends and significance have been calculated using the Mann-Kendall statistical 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 – WY18 due to lack of data in WY19.
[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

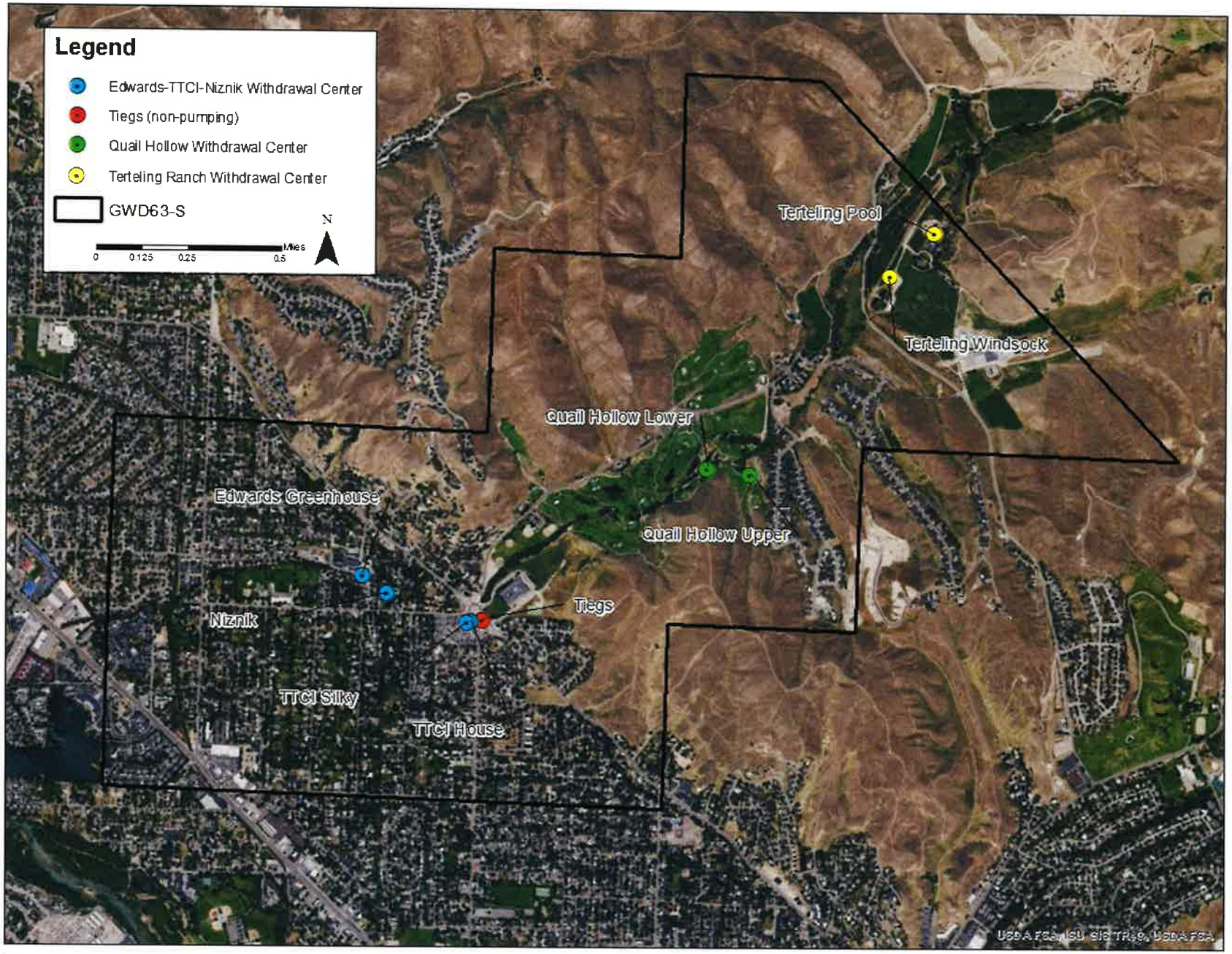

Figure A-1. Well locations within WD63-S