

Review of Boise Front Low Temperature Geothermal Monitoring Data for Water Year 2013 (October 1, 2012 – September 30, 2013)

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EXECUTIVE SUMMARY

The total gross withdrawal from the four district heating systems in the Downtown Boise-East Boise area of the Boise Front Low Temperature Geothermal Resources Ground Water Management Area in Water Year 2013 (WY13) was 780.7 million gallons (mgal). This amount was 48.9 mgal more than the total gross withdrawal in Water Year 2012 (WY12). The net withdrawal for WY13 was 275.1 mgal, which was 12.5 mgal less than the net withdrawal in WY12. Thus, the gross withdrawal in WY13 was about 7% more than in WY12, and the net withdrawal was about 4% less. The State of Idaho Capitol Mall, the City of Boise and the Veterans Administration had increases in gross withdrawals, and the Boise Warm Springs Water District (BWSWD) had a decrease. BWSWD and the City of Boise both had decreases in net water withdrawal. About 65% of the water withdrawn in WY13 was re-injected, which is an increase of about 4% from WY12.

The BLM and Kanta wells are the key wells for analyzing water level¹ trends in the Downtown Boise-East Boise area. The City of Boise's BGL #1 and #2, and the BWSWD #1, #2, and #3 are also used for trend analyses. However, the water levels in the BWSWD wells are impacted significantly by winter time pumping in the BWSWD #1 and #2 wells.

Water level maximums and minimums changed slightly from WY12 to WY13. The maximum value for the BLM well increased 0.5 feet, and the minimum value decreased 0.2 feet. Kanta's maximum water level increased 0.2 feet, and the minimum value decreased 0.2 feet. The maximum water level for BWSWD #3 decreased 3 feet, and the minimum decreased 10 feet. The maximum water levels in BGL #1 and BWSWD #1 decreased 1.0 and 4.0 feet, respectively. The maximum water level in BGL #2 was the same in WY13 as in WY12, and the maximum in BWSWD #2 increased 1.0 feet.

The maximum water supply temperature values for the State of Idaho Capitol Mall and City of Boise systems were slightly higher in WY13 than in WY12: 0.3 degrees Fahrenheit (F) and 0.1 degrees F, respectively. The maximum temperature for BWSWD was essentially the same in WY13 as it was in WY12. The average winter (November through March) maximum water supply temperature for the Capitol Mall system was about 0.2 degrees F higher in WY13 than in WY12.

The total withdrawal of low temperature geothermal water in Stewart Gulch Ground Water District 63-S (GWD63-S) in WY13 was 195.0 mgal, which was 18.6 mgal more than in WY12. This equated to an increase of 11%, which is attributable to larger than usual withdrawals at the Quail Hollow Golf Course in WY13. Overall, ground water levels in GWD63-S wells showed a decreasing trend in WY13.

¹For flowing wells, pressure readings were converted to feet by multiplying each value by 2.31. The converted readings were then referenced to the measuring points by multiplying by -1. Thus, flowing wells have negative water level values since the Y ordinate is plotted as "Feet below measuring point".

DOWNTOWN BOISE-EAST BOISE

Withdrawals and Re-Injection

In WY13, gross and net withdrawals from the four Downtown Boise-East Boise district heating systems were 780.7 mgal and 275.1 mgal, respectively (Table 1 and Figure 1). The gross withdrawal was 48.9 mgal more in WY13 than in the previous water year. The net withdrawal was 12.5 mgal less in WY13 than in WY12. The gross withdrawal was 7% more in WY13 and the net withdrawal was 4% less in WY13, than their respective amounts in WY12. About 65% of the fluids were re-injected, which is 4% more than in WY12.

Table 1. Withdrawals¹ from the four district geothermal heating systems in the Downtown Boise-East Boise areas for Water Year 2013 (October 1, 2012 through September 30, 2013).

System	Gross Withdrawals ¹ for WY13 (million gallons) and percent change from WY12 to WY13	Net Withdrawals ² for WY13 (million gallons) and percent change from WY12 to WY13
Boise Warm Springs Water District	240.1 (-3%)	240.1 (-3%)
Capitol Mall	88.5 (+23%)	0 (NC ³)
City of Boise	266.5 (+13%)	35.0 (-17%)
Veterans Administration	185.5 (+5%)	0 (NC ³)
Total	780.7 (+7%)	275.1 (-4%)

¹These numbers contain some degree of uncertainty which is typically associated with measurement equipment and methods. Therefore, the amounts are being reported in millions with one decimal place.

²Net Withdrawals equal Gross Withdrawals minus Injection amounts. ³NC = No change.

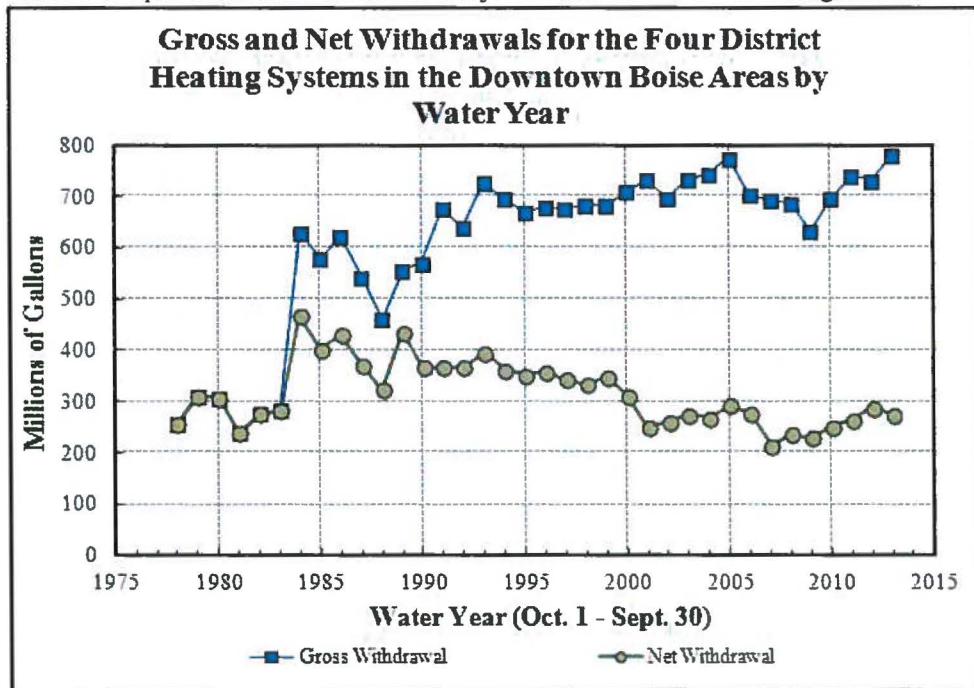


Figure 1. Gross and net withdrawals for the four district heating systems in the downtown Boise area for water years 1978 through 2013.

The State of Idaho Capitol Mall, the City of Boise and the Veterans Administration had increases in gross withdrawals in WY13, while the Boise Warm Springs Water District had a decrease. The State of Idaho Capitol Mall system had the largest change in gross withdrawals by percentage.

Water Levels in the BLM, Kanta, BWSWD, City of Boise, and Harris Ranch Wells

Historically, the BLM well has been the primary monitoring well for the Downtown Boise area. The BLM well is located near the City of Boise, Capitol Mall and VA wellfields. In WY13, the maximum value for the BLM well increased 0.5 feet, while the minimum value decreased 0.2 feet (Figure 2).

The Kanta well, located in the East Boise area, is another key monitoring well for the system because of its location near the BWSWD wellfield. Kanta's water levels trends are very similar to the trends in the BLM well (Figure 3). In WY13, Kanta's maximum water level increase 0.2 feet, and the minimum water level decreased 0.2 feet (Figure 3).

Five of the six maximum and minimum values for the three BWSWD wells decreased in WY13 (Table 2, and Figures 4 and 5). The changes in minimum values were significantly different than the maximum changes, and they varied between the wells (Table 2). The minimum values are less reliable because they are affected significantly by winter time pumping in BWSWD #1 and #2.

Table 2. Water level changes in the maximum and minimum values for the Boise Warm Springs Water District wells between WY12 and WY13.

	WY12_max (ft below MP)	WY13_max (ft below MP)	Change in Max	WY12_min (ft below MP)	WY13_min (ft below MP)	Change in Min
BWSWD#1 East	0 ft ¹	4 ft	-4 ft	162 ft	194 ft	-32 ft
BWSWD#2 West	2 ft	1 ft	+1 ft	160 ft	192 ft	-32 ft
BWSWD#3	26 ft	29 ft	-3 ft	111 ft	121 ft	-10 ft

¹The East well flowed for 2 days in August 2012. A value of zero was recorded on those two days because there was no way to measure the actual water levels above the top of the well.

A data transducer was deployed in the City of Boise's BGL #1 well in July 2011. Wellhead pressures for BGL #2 are measured by hand. The maximum water level for BGL #1 was 1.0 feet lower in WY13 based on the September readings in 2012 and 2013 (Figure 6). The minimum water level for BGL #1 declined at least 0.5 feet; the actual amount of decline cannot be determined because the water level was below the measuring point in the time period from early February to early April, 2013. BGL #2's maximum level was the same in WY13 as in WY12, based on the August readings in 2012 and 2013. BGL #2 had unexplainable water level spikes in either November or December in each of the last five years with higher values than the August maximum levels. The minimum level in BGL #2 decreased 2.9 feet, based on readings from March 2012 and January 2013.

The Harris Ranch wells are located 2.25 miles southeast of the East Boise area. Water levels in the Harris Ranch West and East wells showed slight decreasing trends in WY13 (Figure 7). This trend is most obvious in the datalogger data for the West well, with the

maximum value decreasing 0.6 feet from January 2012 to January 2013. The Harris Ranch wells have distinctly different water level signatures than the Downtown Boise-East Boise wells. The maximum values in the Downtown Boise-East Boise wells generally occur in late September; the maximum values in the Harris Ranch West well occur in January. The minimum values in the Downtown Boise-East Boise wells occur in January, while the minimum values in the Harris Ranch West well occur in November or December.

Water Supply Temperatures for the Capitol Mall, BWSWD and City of Boise.

The maximum water temperatures¹ for the State of Idaho Capitol Mall Production well, as determined on a monthly basis, were 0.3 degrees Fahrenheit (F) higher in WY13 than in WY12 (Figure 8). The average of the November-March maximum values in WY13 was about 0.2 degrees F higher than the average for WY12 (Figure 9).

The maximum and minimum temperatures for BWSWD were essentially the same in WY13 as they were in WY12 (Figure 10). The maximum water temperature generally occurs in August or September, and the minimum temperature occurs in November or December.

The City of Boise's maximum water temperature was slightly higher (0.1 degrees F) in WY13 than in WY12. The City's maximum temperature generally occurs in January. Non-winter minimum temperatures occur in the July-August time period. This minimum water temperature was about 1.5 degrees F higher in WY13 than in WY12 (Figure 11). In the winter months, the water temperatures are actually lower than in the July-August time period by 3 to 4 degrees F. The reason for the lower winter-time temperatures for the City and BWSWD systems is unknown.

¹Readings that are preceded by 8 hours of discharge rates over 300 gallons per minute are valid for considering as maximum values. Analysis is done on a monthly basis.

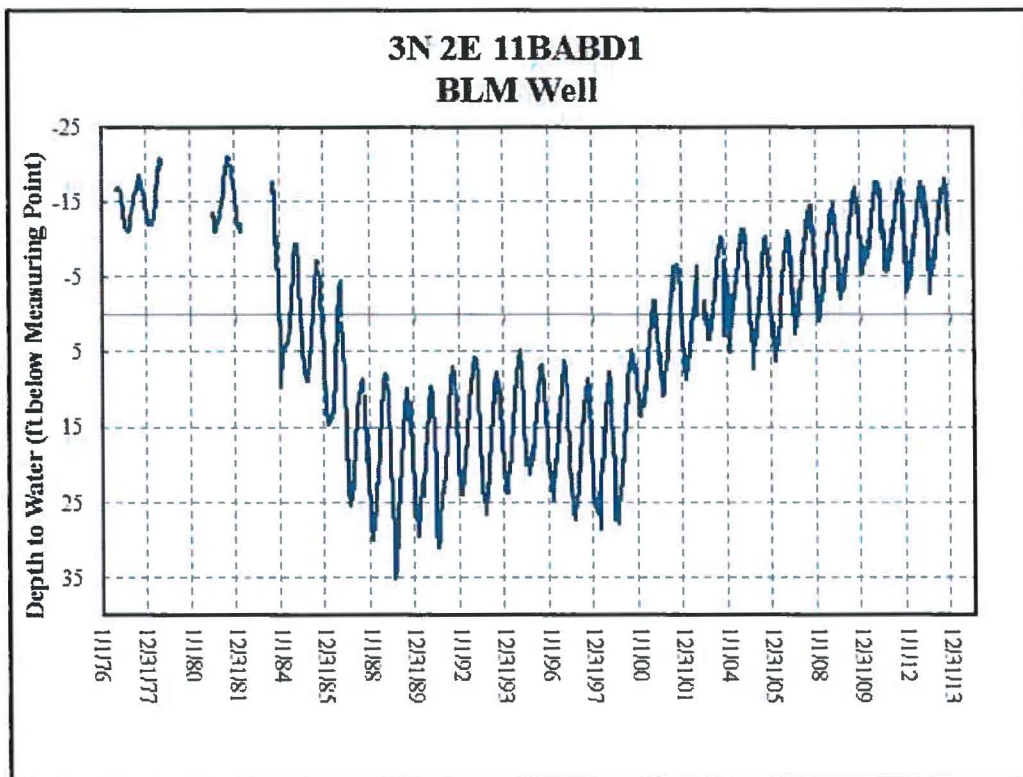


Figure 2. Water level hydrograph for the BLM well.

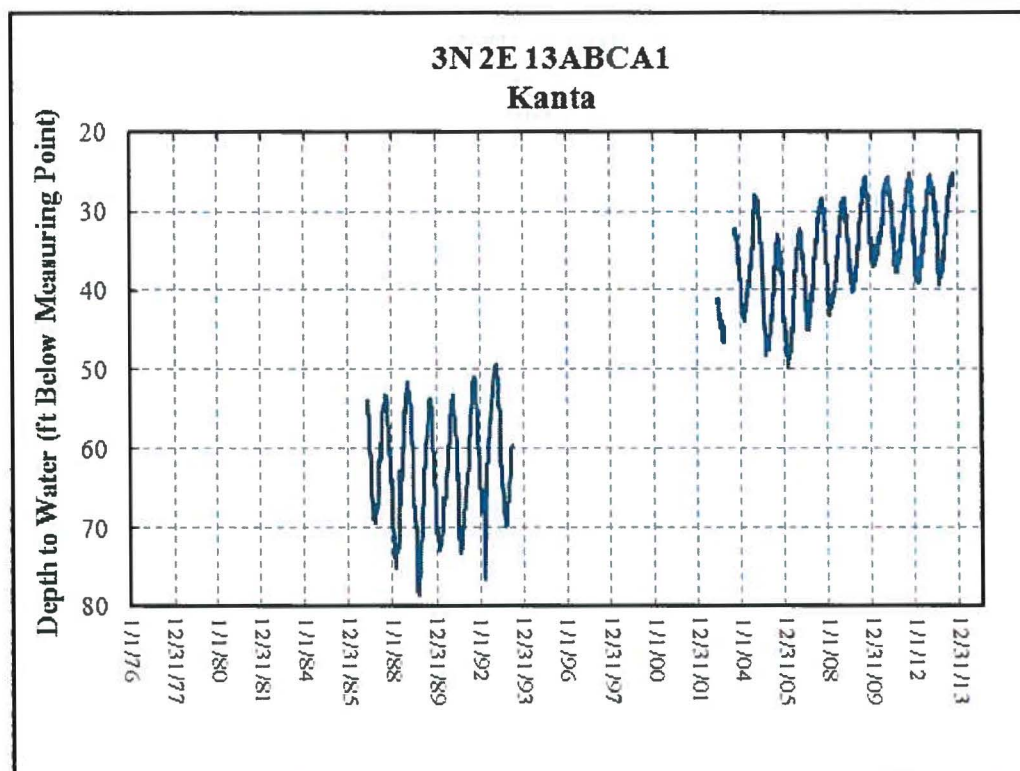


Figure 3. Water level hydrograph for the Kanta well.

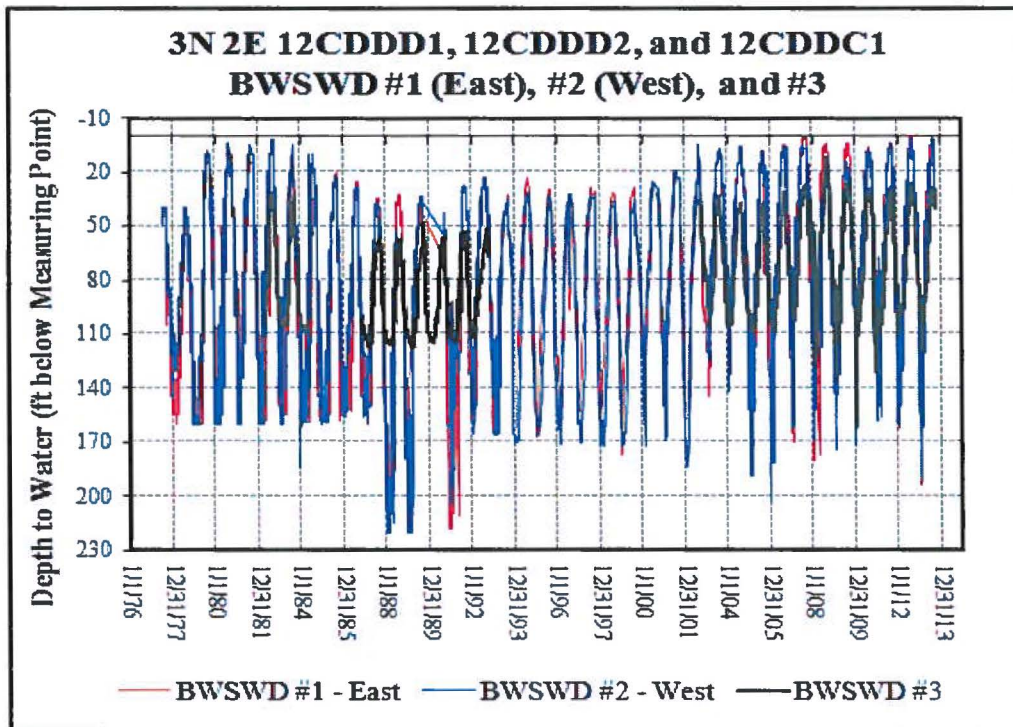


Figure 4. Water level hydrographs for the Boise Warm Springs Water District (BWSWD) wells.

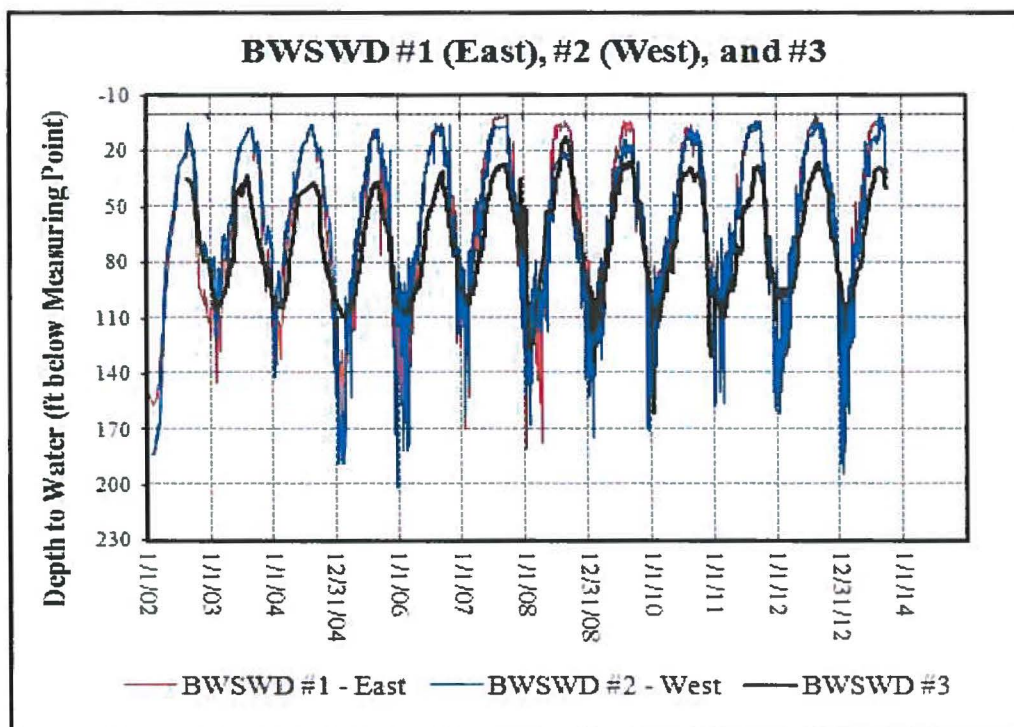


Figure 5. Water level hydrographs for the Boise Warm Springs Water District (BWSWD) wells, January 2002 to September 2012.

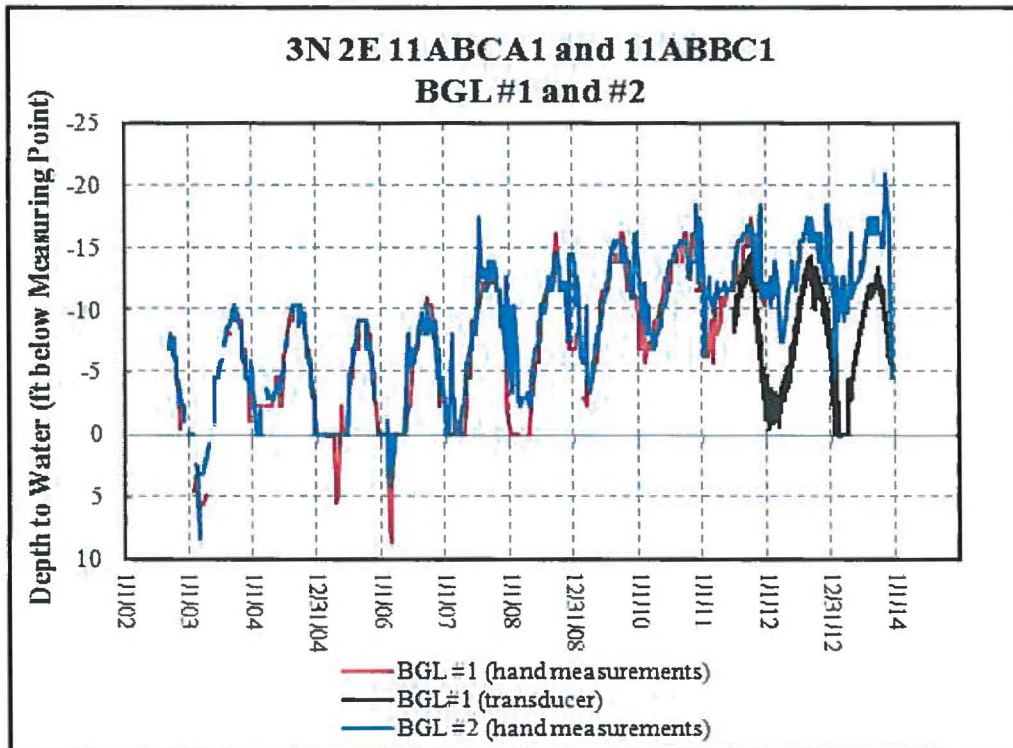


Figure 6. Water level hydrographs for the City of Boise's BGL #1 and #2 wells.

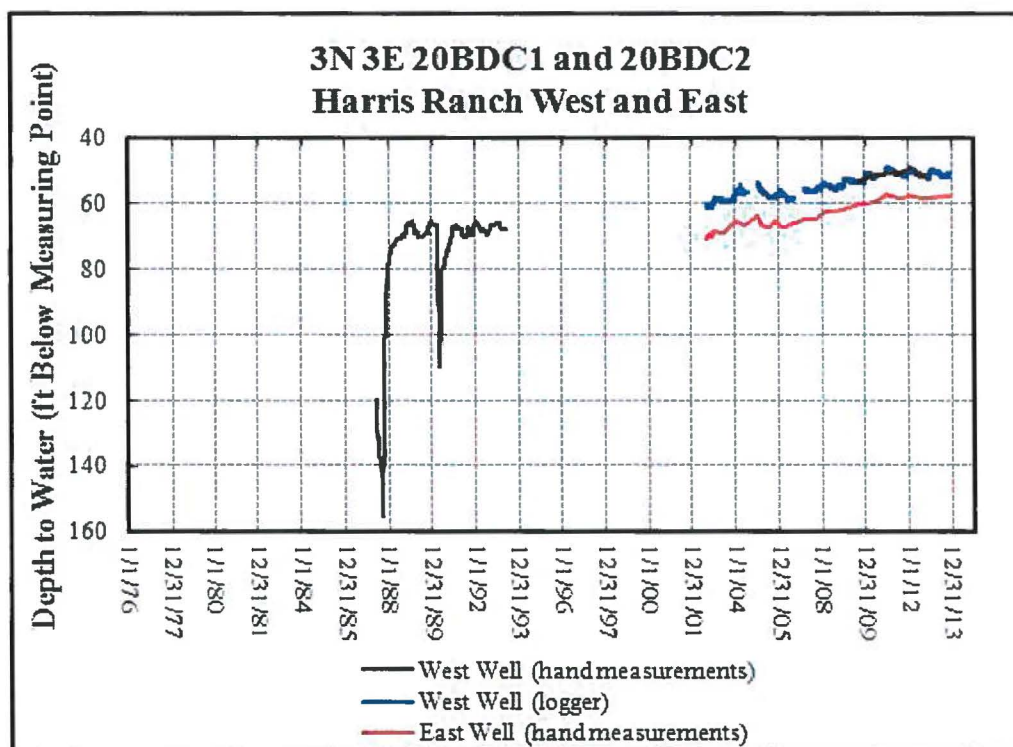


Figure 7. Water level hydrographs for the Harris Ranch wells.

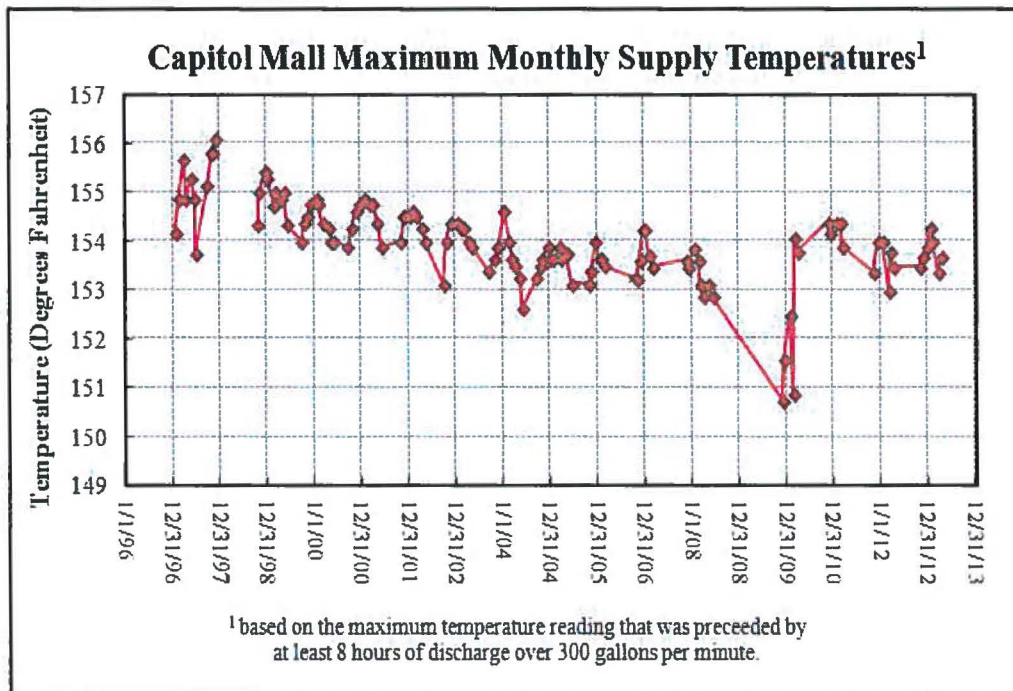


Figure 8. Monthly maximum supply water temperatures for the Capitol Mall geothermal system.

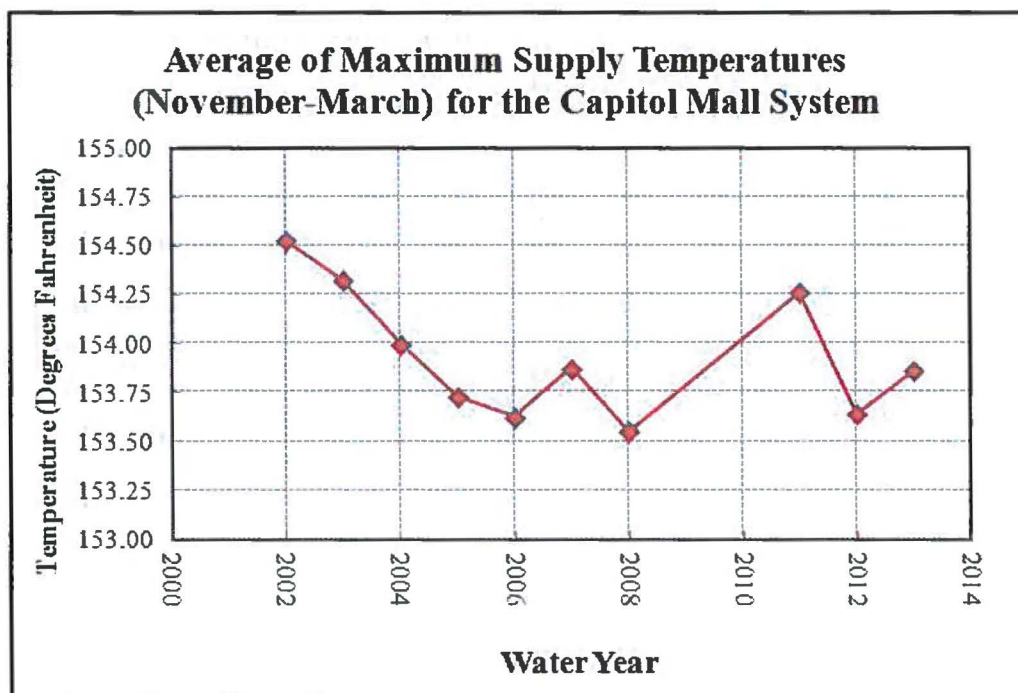


Figure 9. Average of the Capitol Mall maximum supply water temperatures for the November-March time periods for Water Years 2002 through 2013.

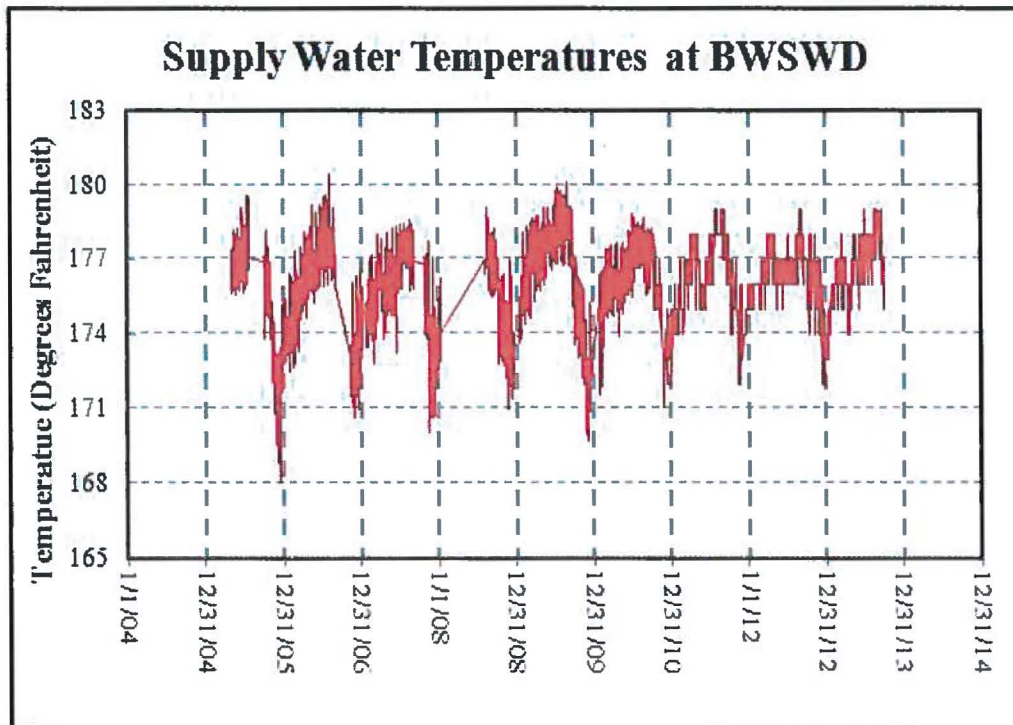


Figure 10. Supply water temperatures for the Boise Warm Springs Water District.

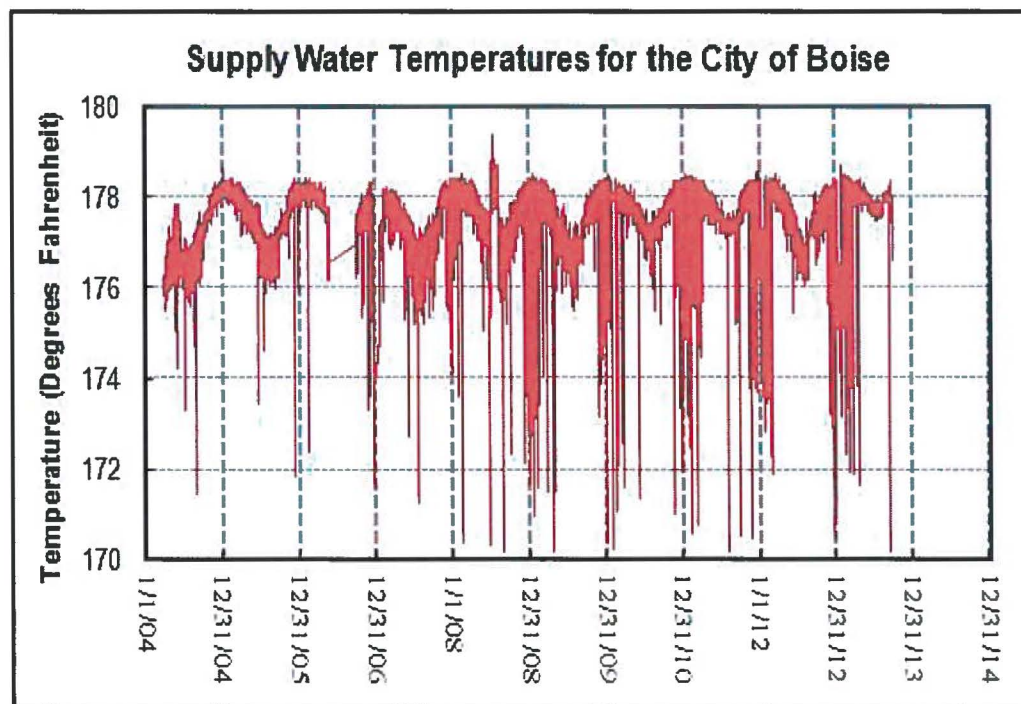


Figure 11. Supply water temperatures for the City of Boise's geothermal system. Readings less than 170 degrees Fahrenheit were removed from the dataset.

STEWART GULCH GROUND WATER DISTRICT 63-S

Withdrawals

The total withdrawal of low temperature geothermal water in GWD63-S in WY13 was 195.0 mgal (Figure 12). This amount is 18.6 mgal more than the withdrawal in WY12, which is an 11% increase (Table 3). This increase is attributable to higher than usual withdrawals at the Quail Hollow Golf Course in WY13.

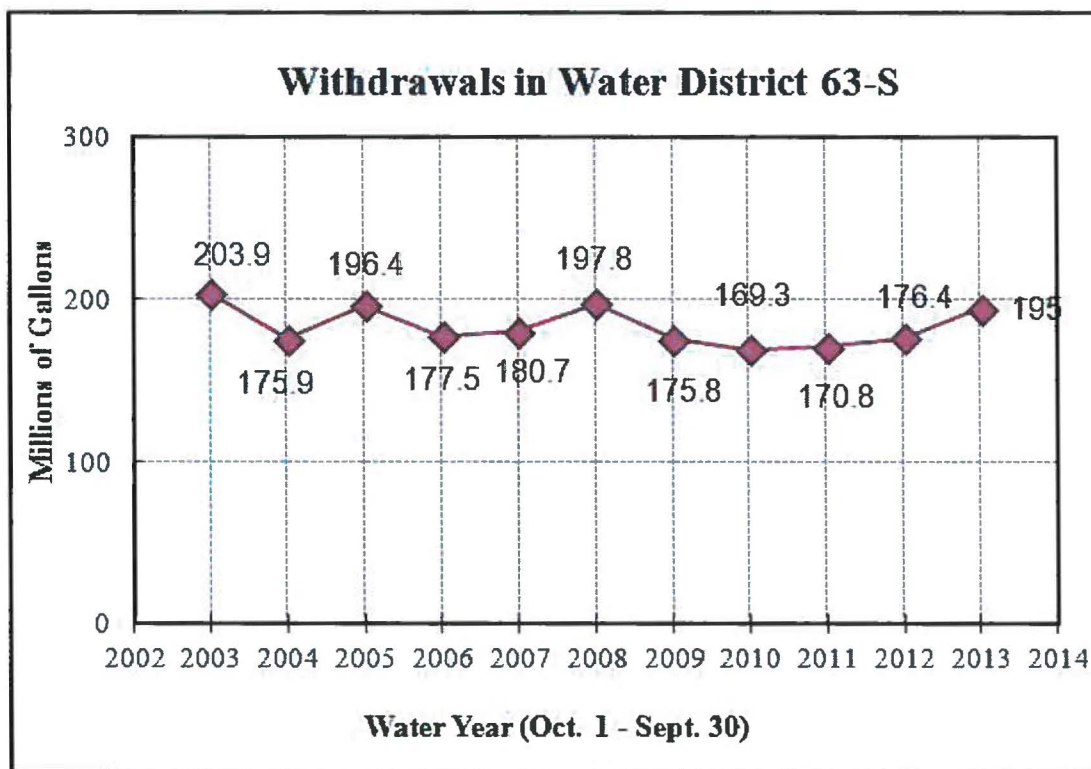


Figure 12. Geothermal withdrawals in Stewart Gulch Water District 63-S for Water Years 2003-2013.

Table 3. Withdrawals¹ from Stewart Gulch Ground Water District 63-S geothermal wells for Water Year 2013 (October 1, 2012 through September 30, 2013).

Well	Withdrawals in WY13 (millions of gallons)	Change from WY12 (millions of gallons)	Percent Change from WY12
TTCI Tiegs (Triangle)	0	0	0
TTCI Silkey (Shed)	8.7	+0.8	+10%
TTCI House (Office)	0.5	+0.2	+60%
Edwards Greenhouse	58.1	-7.4	-11%
Terteling Ranch Windsock	62.1	-4.8	-7%
Terteling Ranch Pool	18.6	-0.6	-3%
Quail Hollow (Tee Ltd) Upper	8.8	+8.8	See Comments ²
Quail Hollow (Nibbler) Lower	32.3	+20.6	+276%
Whitehead	5.9	+0.9	+20%
Total	195.0	+18.6	+11%

¹These numbers contain some degree of uncertainty which is typically associated with measurement equipment and methods. Therefore, the amounts are being reported in millions with one decimal place.

²The withdrawal in WY12 was 71,700 gallons. Calculation of a Percent Change would be so high that it would be misleading to report.

The ownerships and locations of the wells allow them to be grouped into withdrawal centers, which is a useful approach for summarizing the withdrawals in these localized areas within the District. Table 4 shows the three centers and the changes in withdrawals from WY12 to WY13.

Table 4. Three withdrawal centers in GWD63-S and changes from WY12 to WY13.

Withdrawal Center	Number of Wells	Numerical change from WY12 to WY13	Percentage change from WY12 to WY13
Edwards Greenhouse and Terteling Garden Center	4 (3 in use; 1 unused)	-6.4 mgal	-8%
Quail Hollow	2	+29.4 mgal	+352%
Terteling Ranch	2	-5.4 mgal	-6%

Water Levels

The reporting of water level monitoring data for the Terteling Company wells changed in WY13 as per an agreement between the water district members at the annual water district meeting in March 2013. The new approach requires the Terteling Company to submit water level monitoring data only for the Tiegs (Triangle) well. The justification for this change is based on years of observations that show the wells throughout GWD63-S have very similar hydrograph patterns related to natural cycles and withdrawal changes within the District. Thus, the four wells that are currently monitored by their owners for water levels are the Tiegs, Edwards, Quail Hollow Lower, and Quail Hollow Upper. The Silkey well is used as a backup for the Tiegs well in the event that the transducer in the Tiegs wells should fail. Additionally, the Water Master conducts water level measurements at all nine wells listed in Table 3 in March and September.

Overall, ground water levels in GWD63-S wells showed a decreasing trend in WY13.

The Edwards well had a decrease in the maximum water level of 4.6 feet from late June 2012 to late June 2013 (Figure 13). Water levels continued to decline in July and August 2013 primarily because of higher than usual withdrawals at Quail Hollow Golf Course. The lowest water level of the season was recorded on August 21, 2013; the level had fallen 16.2 feet since late June. Water levels recovered about 12 feet by the end of September, remained unchanged until early November, and then began declining in response to the winter demand for heating. The minimum water level for the Edwards wells, which occurs annually in the December – February period, declined 4.6 feet from WY12 to WY13. The minimum water level in WY13 was very similar to the minimum values in Water Years 2007 to 2011, but it appears that it is going to be lower in Water Year 2014 than in previous years based on the readings as of late December 2013.

The Tiegs well had a decrease in the maximum water level of 5.6 feet, based on the late June readings in 2012 and 2013. The water levels dropped 17.5 feet from late June 2013 to mid August 2013 primarily due to Quail Hollow withdrawals. The Tiegs well had a decrease in the minimum water level of 4.9 feet based on the January readings in 2012 and 2013 (Figure 14).

The maximum water levels in the Quail Hollow (QH) wells were both lower in WY13 than in WY12. The QH Lower well declined 2.6 feet and the QH Upper well declined 4.6 feet. These measurements are based on the readings in June or July in 2012 and 2013 (Figures 15 and 16). The minimum levels for the Lower and Upper wells declined 4.1 feet and 4.2 feet, respectively, from January 2012 to January 2013.

The Windsock and Pool wells showed decreases of 0.7 feet and 3.3 feet, respectively, in the maximum water levels in WY13 (Figures 17 and 18). However, these observations are based on a single measurement at each well recorded in April by the Water Master.

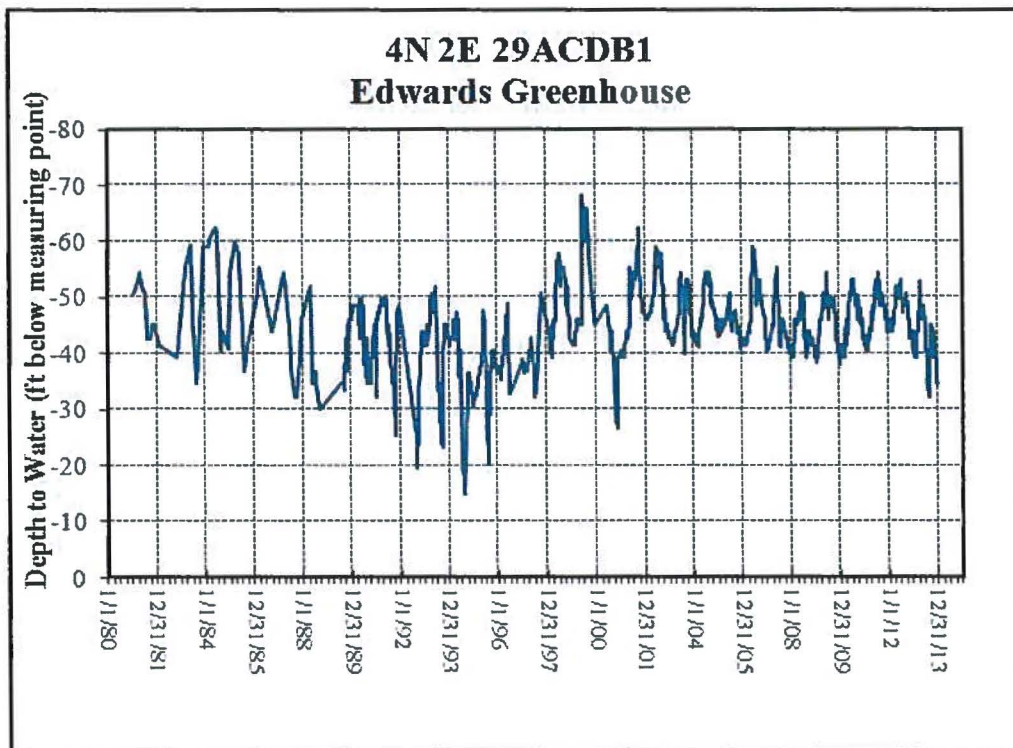


Figure 13. Water level hydrograph for the Edwards Greenhouse well.

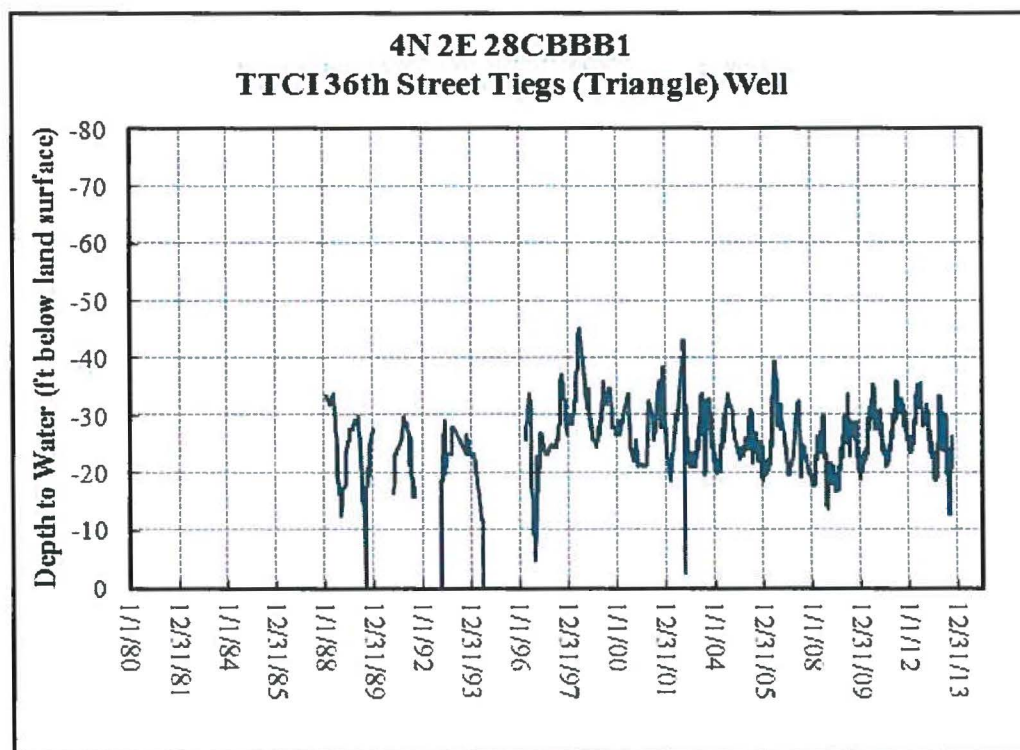


Figure 14. Water level hydrograph for the TTCI 36th Street Tieg's (Triangle) well.

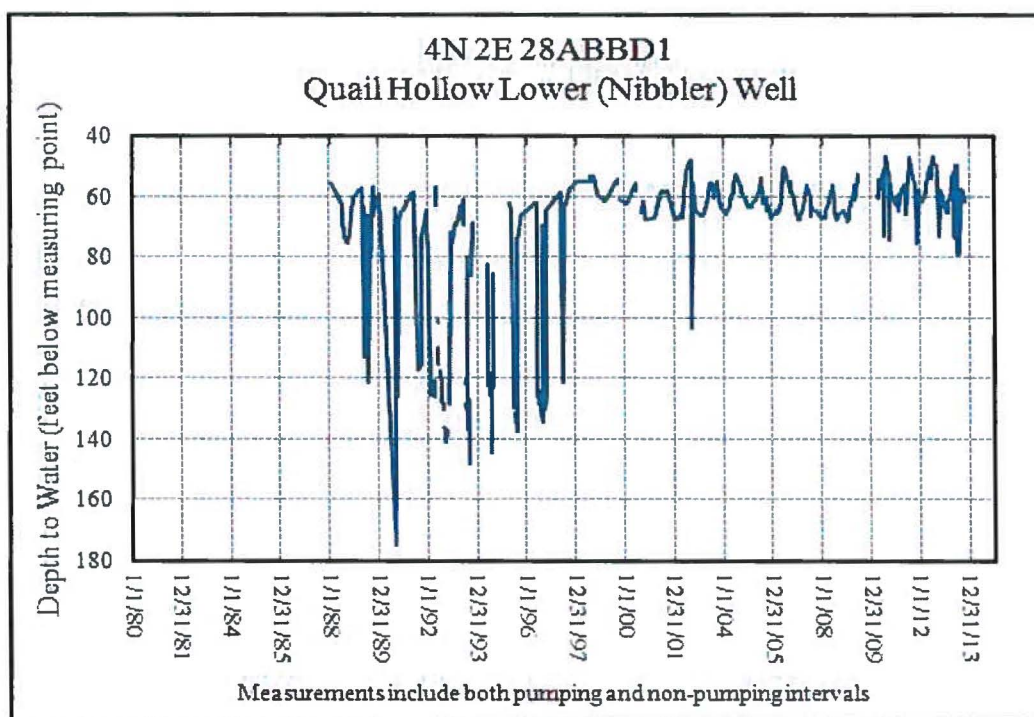


Figure 15. Water level hydrograph for the Quail Hollow Lower well.

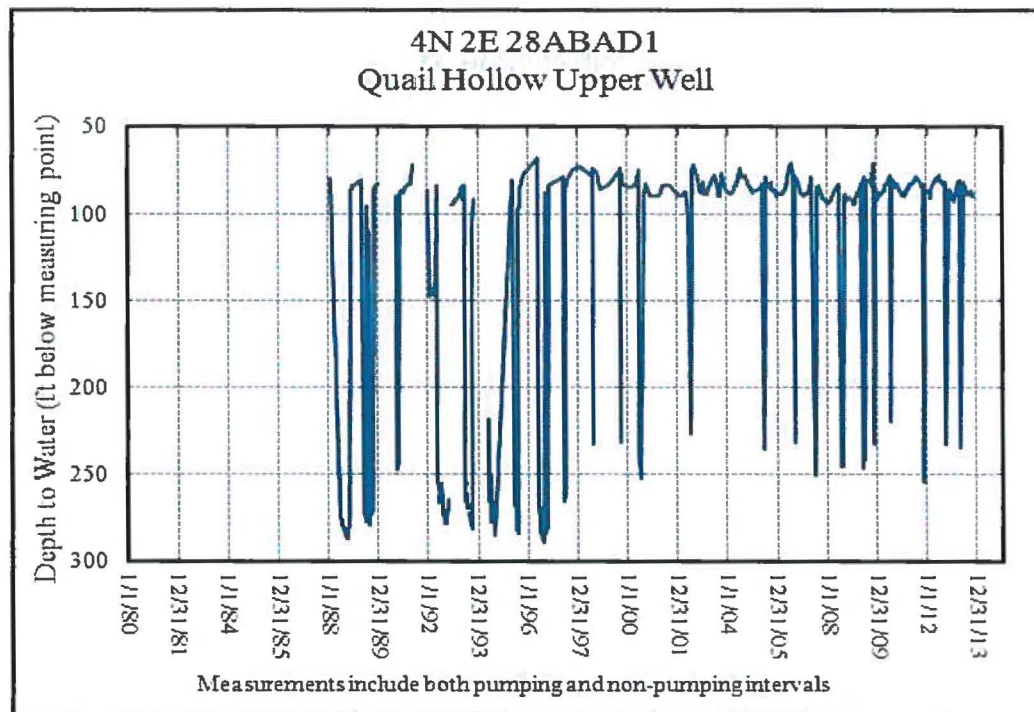


Figure 16. Water level hydrograph for the Quail Hollow Upper well.

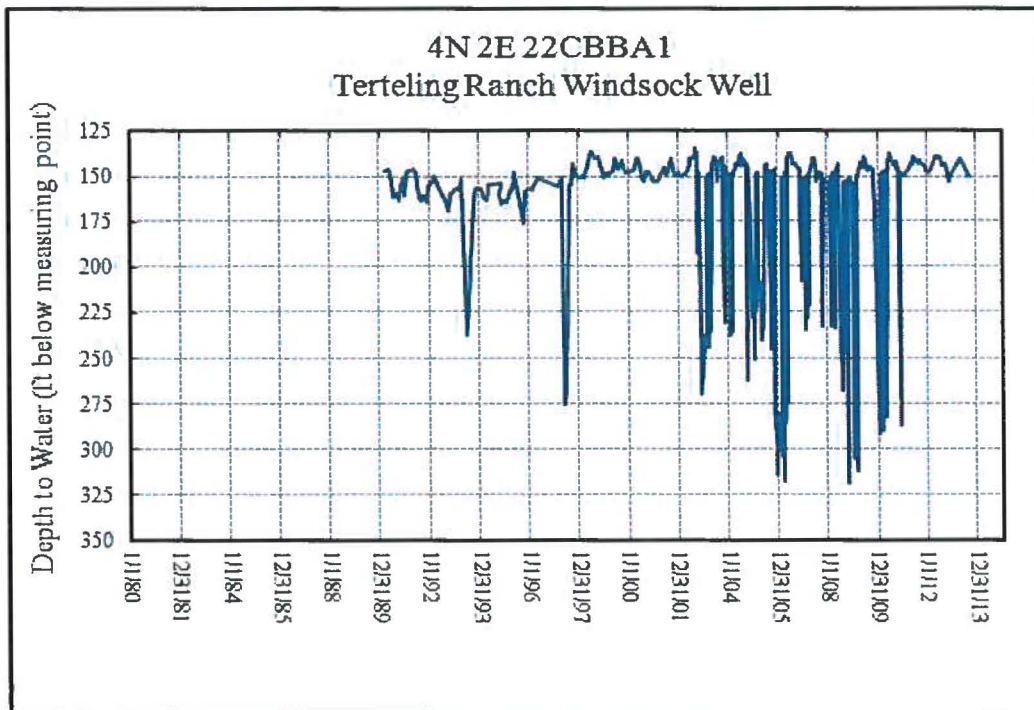


Figure 17. Water level hydrograph for the Terteling Ranch Windsock well.

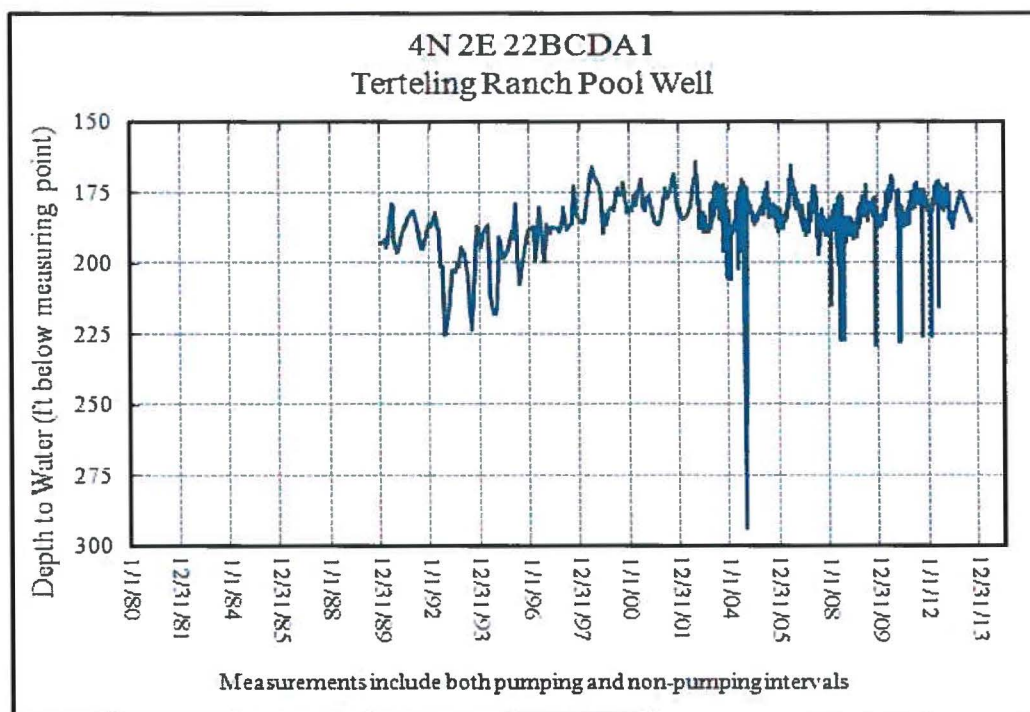


Figure 18. Water level hydrograph for the Terteling Ranch Pool well.