

Review of Boise Front Geothermal Monitoring Data for Water Year 2011 (October 1, 2010 – September 30, 2011)

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EXECUTIVE SUMMARY

The total gross withdrawal from the four downtown Boise geothermal district heating systems in Water Year 2011 (WY11) was 741.2 million gallons (mgal), which was 43.2 mgal more than the total gross withdrawal in Water Year 2010 (WY10). The net withdrawal for WY11 was 265.3 mgal, which was 14.9 mgal more than the net withdrawal in WY10. Thus, both the gross and net withdrawals in WY11 were 6% more than in WY10. All four downtown heating systems had increases in gross withdrawals in WY11, ranging from 1% to 12%. Both the Boise Warm Springs Water District (BWSWD) and the City of Boise had increases in net water withdrawal. About 64% of the water withdrawn in WY11 was re-injected.

The BLM and Kanta wells are very useful for analyzing water level¹ trends in the downtown Boise area because they are unused, are in key locations, and have water level responses that reflect the regional changes in the aquifer as opposed to reflecting localized pumping impacts from individual wells. The changes in maximum and minimum water levels from WY10 to WY11 in these wells were very small. In WY11, the maximum value for the BLM well increased 0.3 feet, but this amount may have been less because of missing data from September 22 to October 10, 2010, which is the time period when the maximum water level usually occurs. The minimum value increased 0.3 feet from WY10 to WY11. Kanta's maximum water level increased 0.6 feet in WY11, while the minimum value decreased 0.7 feet. Water level trends in two other unused wells, BGL #1 and BWSWD #3, were similar to the BLM and Kanta wells in WY11. The Harris Ranch wells, located several miles east of the downtown area, also showed slight increases in water levels, although the annual water level cycles appear to be offset by about six months from the cycles in the downtown wells.

Maximum water supply temperatures from the Capitol Mall Production well were more consistent in WY11 than in WY10, and were slightly higher than in previous years. The maximum and minimum water supply temperatures at the BWSWD and City of Boise systems were slightly higher in WY11 than in WY10.

The total withdrawal of low temperature geothermal water in Stewart Gulch Ground Water District 63-S (GWD63-S) in WY11 was 170.8 mgal, which was 1.5 mgal more than in WY10. This equates to an increase of 1%. Overall, water levels in GWD63-S wells showed stable to slightly increasing trends in WY11.

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/HARRIS RANCH

Withdrawals and Re-Injection

In WY11, gross and net withdrawals from the four downtown Boise district heating systems were 741.2 mgal and 265.3 mgal, respectively (Table 1 and Figure 1). The gross withdrawal was 43.2 mgal more in WY11 than in the previous water year. The net withdrawal was 14.9 mgal more in WY11 than in WY10. Both the gross and net increases were 6% more than their respective amounts in WY10. About 64% of the fluids were re-injected.

Table 1. Withdrawals¹ from the four district geothermal heating systems in the downtown Boise area for Water Year 2011 (October 1, 2010 through September 30, 2011).

System	Gross Withdrawals ¹ for WY11 (million gallons) and percent change from WY10 to WY11	Net Withdrawals ² for WY11 (million gallons) and percent change from WY10 to WY11
Boise Warm Springs Water District	244.8 (+1%)	244.8 (+1%)
Capitol Mall	96.8 (+12%)	0 (NC ³)
City of Boise	218.3 (+8%)	20.5 (+150%)
Veterans Administration	181.2 (+8%)	0 (NC ³)
Total	741.2 (+6%)	265.3 (+6%)

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.

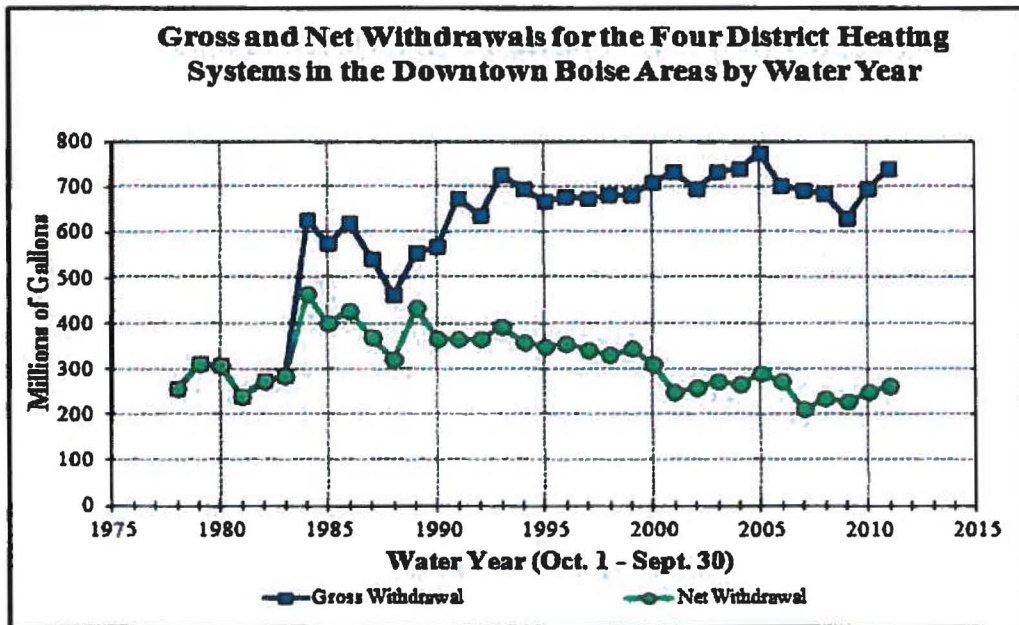


Figure 1. Gross and net withdrawals for the four district heating systems in the downtown Boise area for water years 1978 through 2011.

All four heating systems had increases in gross withdrawals in WY11. The City of Boise had the largest numerical increase in gross withdrawals (16.6 mgal), while the State of Idaho's Capitol Mall system had the largest percentage increase (12%). The percentage of net withdrawal to gross withdrawal for the City of Boise's system increased from 4% in WY10 to 9% in WY11. Some of this increase can be attributed to discharge into the Boise River, and some is attributed to "unaccounted-for water" (system leaks, unmonitored discharge, and variability in flow meter accuracies).

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 geothermal system. The BLM well is located in the western end of the downtown area near the City of Boise, Capitol Mall and VA wellfields. In WY11, the maximum and minimum values for the BLM well both increased 0.3 feet (Figure 2); however, the maximum value may not have been recorded in 2010 because of missing data from September 22 to October 10. Thus, the increase in the maximum value from WY10 to WY11 may have been a little less than 0.3 ft. Since 1999, when the City's injection well went online, the maximum water levels in the BLM well have risen about 23 feet. The minimum water levels have increased over 30 feet, with the largest increase occurring in the time period immediately following the completion of the injection well.

The Kanta well, located on the east side of the downtown geothermal 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). Kanta's maximum water level increased 0.6 feet from early October 2010 to mid October 2011 (these dates actually occur in WY11 and WY12, respectively, but they are used for this report because they reflect the maximum water level trends for WY10 and WY11). The minimum value for Kanta decreased 0.7 feet from WY10 to WY11 (January 2010 to February 2011, respectively).

All of the maximum and minimum values for the three BWSWD wells increased in WY11 compared to WY10 (Table 2, and Figures 4 and 5). The increase in the minimum value for BWSWD #3 is unusually large due to a lower-than-normal reading in WY10. The minimum water level for BWSWD #3 in WY11 was actually very similar to the minimums in WY08 and WY09.

Table 2. Water level changes in the maximum and minimum values for the Boise Warm Springs Water District wells between WY10 and WY11.

	WY10_max (ft below MP)	WY11_max (ft below MP)	Change in Max	WY10_min (ft below MP)	WY11_min (ft below MP)	Change in Min
BWSWD#1 East	6 ft	4 ft	+ 2 ft	164 ft	155 ft	+9 ft
BWSWD#2 West	9 ft	4 ft	+ 5 ft	171 ft	158 ft	+ 13 ft
BWSWD#3	29.4 ft	28 ft	+1.4 ft	161.5 ft	131 ft	+30.5

The maximum water level for the City of Boise's BGL#1 well was 1.2 feet higher in WY11 than in WY10; the minimum water level value was the same for both years (Figure 6). In July 2011, the City of Boise installed a pressure transducer in BGL#1 which records a measurement every hour. The data collected in 2011 indicates that the maximum value for

BGL#1 occurred on October 5, 2011 (which, like the Kanta well's maximum, is at the beginning of WY12). The maximum water level in the BGL #2 was the same in WY11 as it was in WY10. However, these readings occurred in late November of each year, and they are considerably higher than other readings during these time periods. The reason for these high readings is unknown. The maximum water level in BGL #4 decreased 4.0 feet from WY10 to WY11; the change in the minimum water level could not be determined because of insufficient data. Overall, water levels in the BGL wells have continued to improve over the last five years. For example, the minimum values for BGL #1 and BGL #2 have increased six to seven feet since 2007.

The Harris Ranch wells are located several miles east of the downtown geothermal heating systems. Water levels in the Harris Ranch West and East wells showed overall increasing trends in WY11 (Figure 7). This is continuation of an increasing trend that has shown about 12 feet of water level rise from 2002 to 2011. However, the Harris wells continued to have distinctly different water level signatures than the wells in the downtown area. For example, the minimum water levels for the West well occur in the fall of each year which is when the maximum water levels occur in the downtown Boise wells. Thus, it appears that there is an offset of about six months between the annual cycles in the downtown wells and the Harris Ranch wells.

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

During the time that the State of Idaho Capitol building was being renovated, the Capitol Mall system was in reduced operation. Consequently, there were no supply water temperature readings that met the criteria¹ for trend analysis for about a year and a half (Figure 8). By 2009, the system had returned to full operation, and the criteria for the supply water temperatures were being met again. The maximum supply water temperatures, determined on a monthly basis, for the Capitol Mall Production well were unusually low in WY10, but returned to normal patterns in WY11. Individual monthly maximum supply water temperatures were slightly higher in WY11 than in previous years. The average of the November-March maximum values in WY11 was the highest average for this time period since Water Year 2003 (Figure 9).

Water temperatures for the BWSWD were slightly higher in WY11 than in WY10 (Figure 10). The City of Boise's maximum and minimum supply water temperatures were also slightly higher in WY11 (Figure 11).

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.

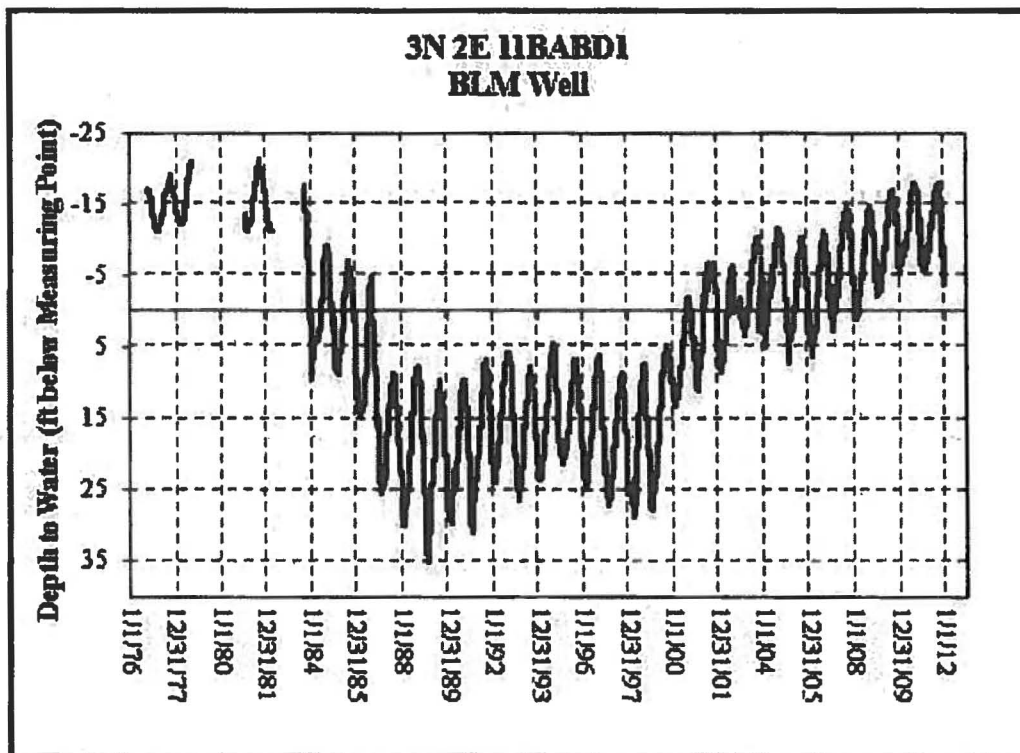


Figure 2. Water level hydrograph for the BLM well.

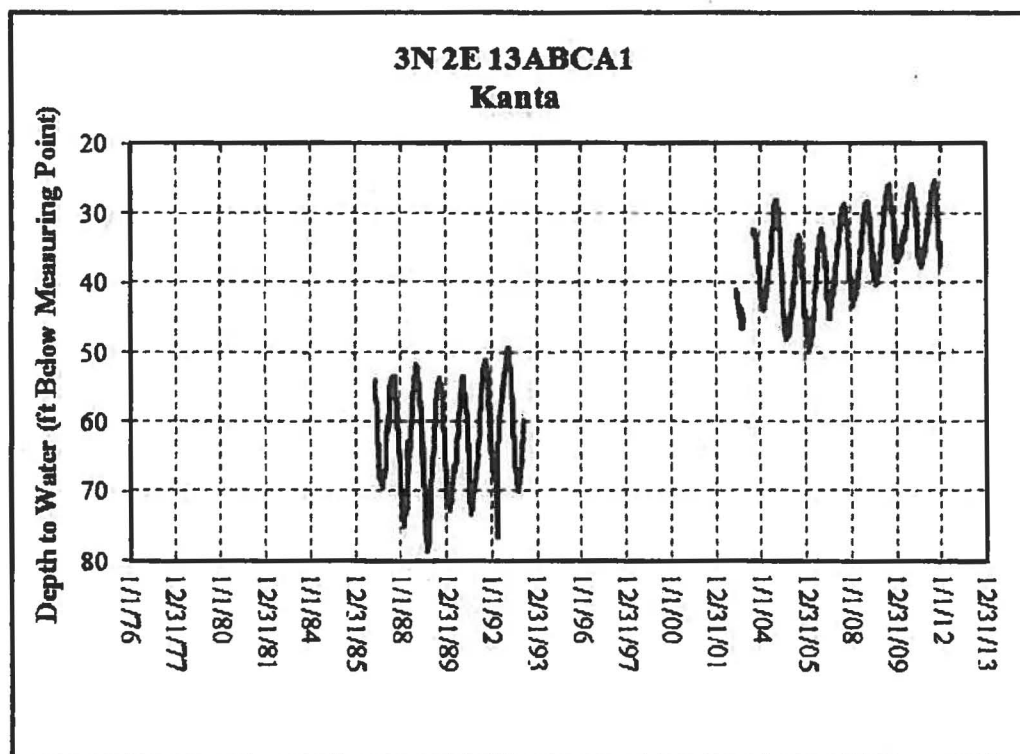


Figure 3. Water level hydrograph for the Kanta well.

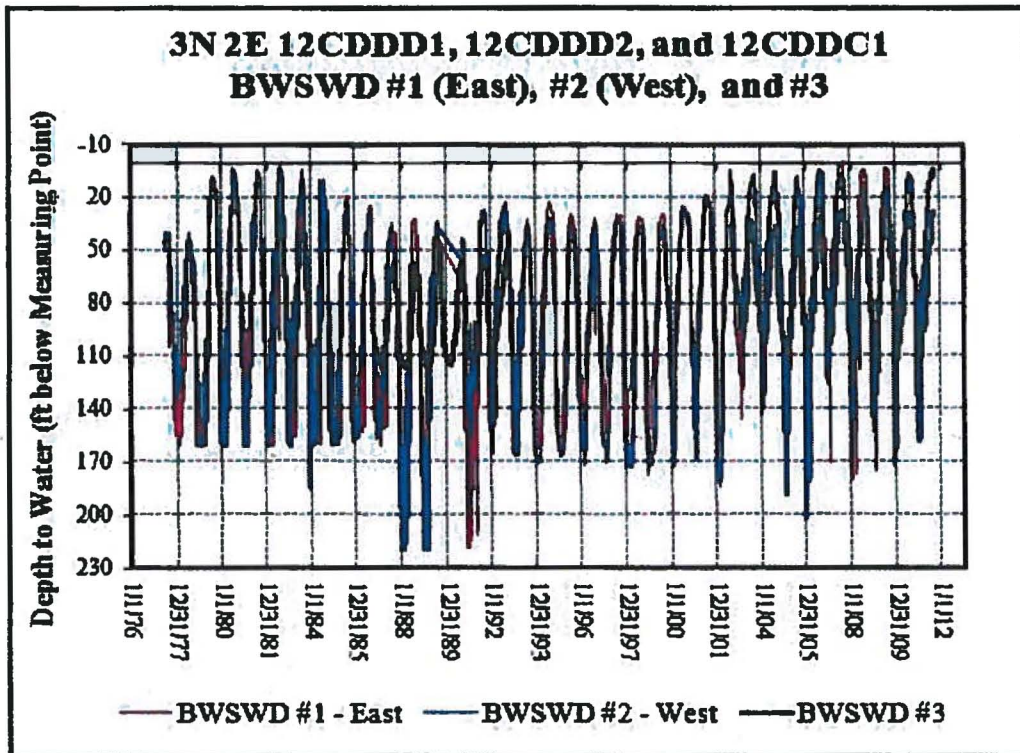


Figure 4. Water level hydrographs for the Boise Warm Springs Water District (BWSWD) wells.

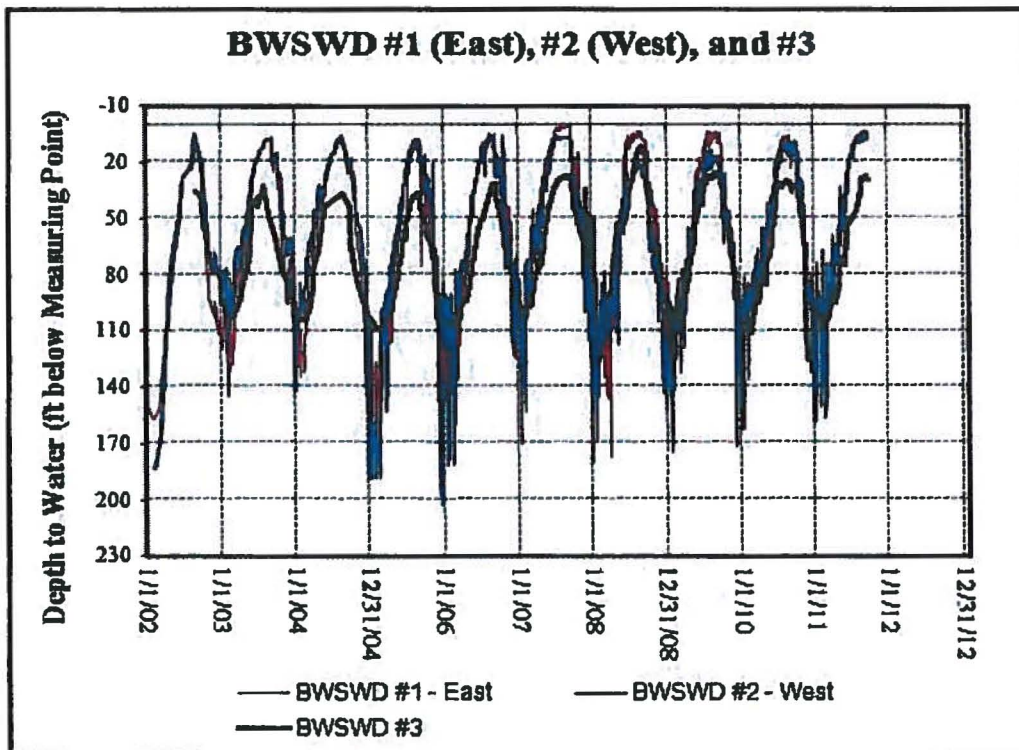


Figure 5. Water level hydrographs for the Boise Warm Springs Water District (BWSWD) wells, January 2002 to September 2011.

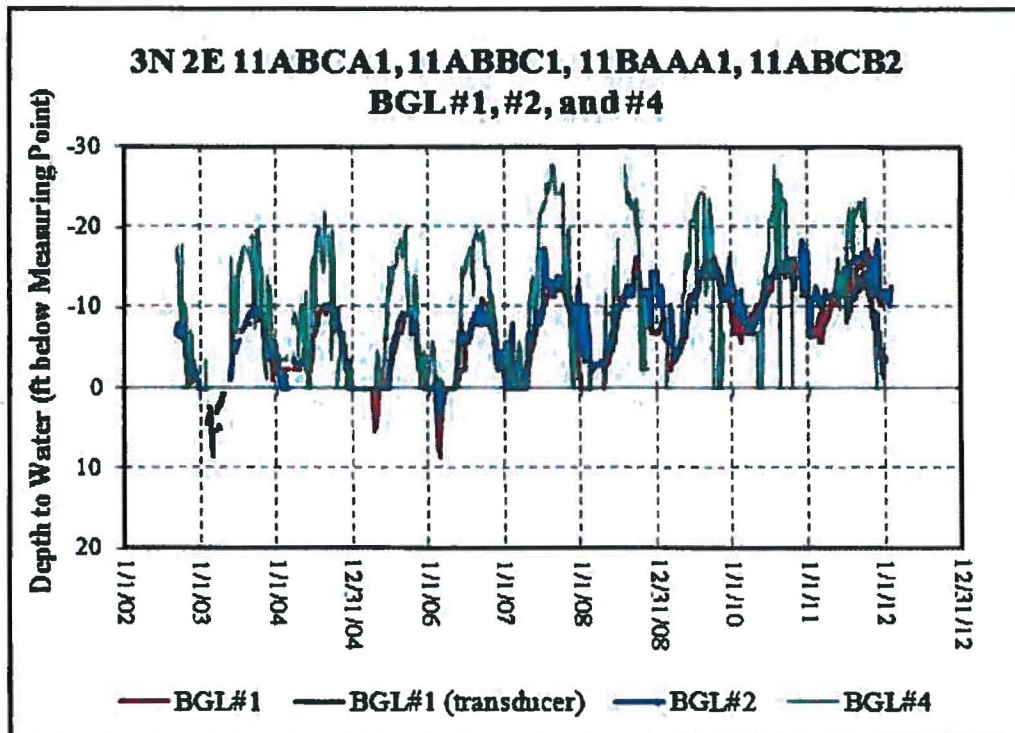


Figure 6. Water level hydrographs for the City of Boise's BGL #1, #2, and #4 wells.

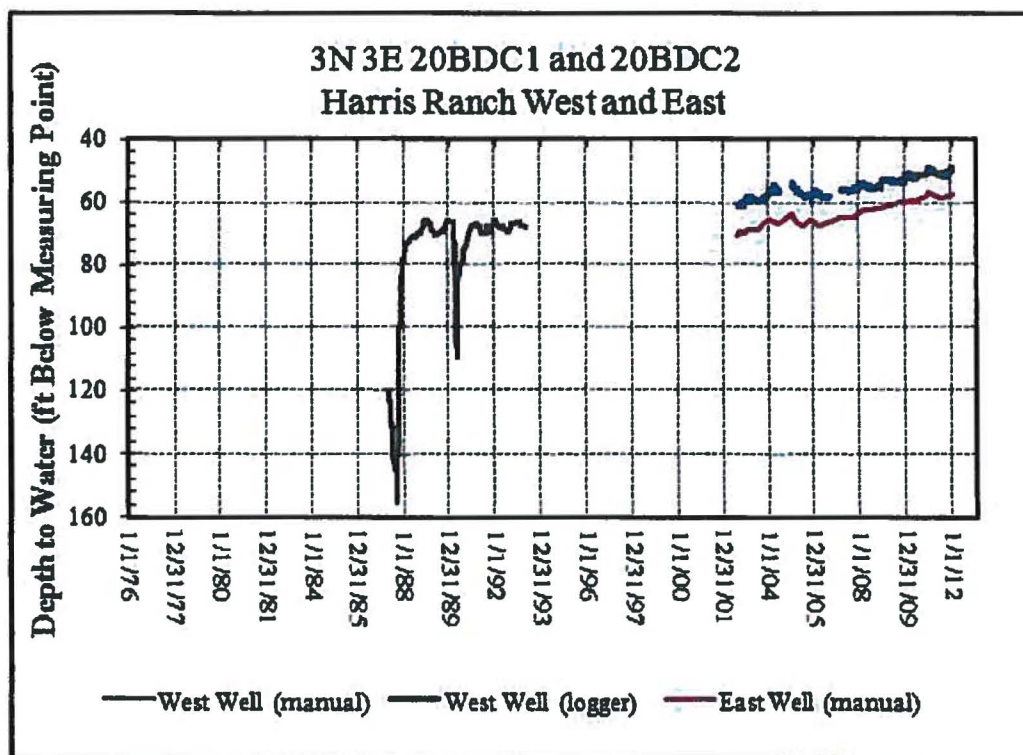


Figure 7. Water level hydrographs for the Harris Ranch wells.

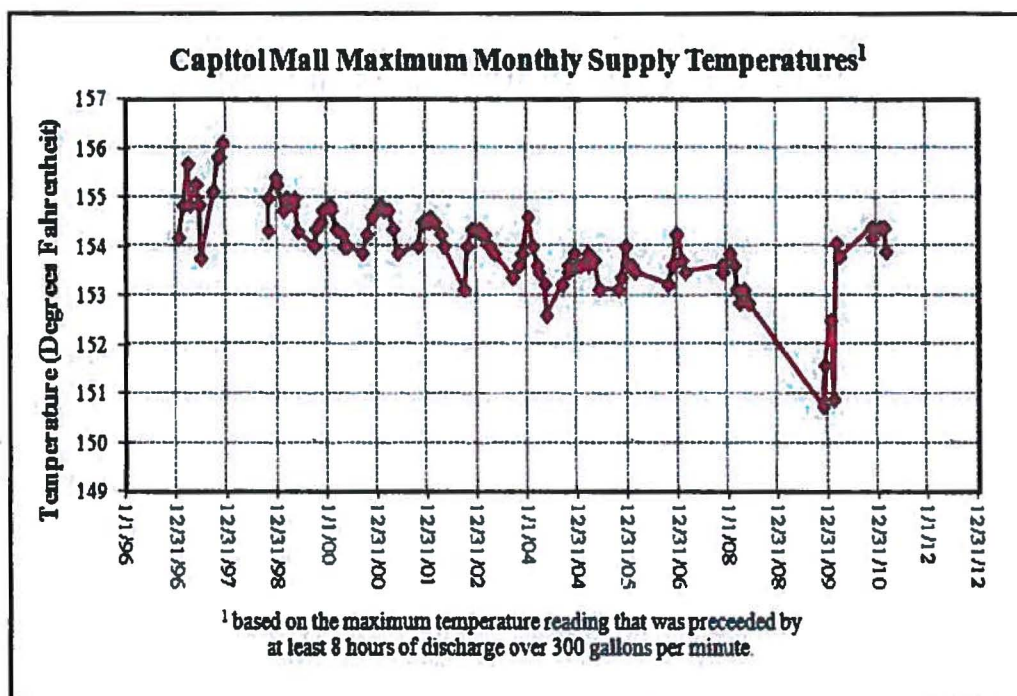


Figure 8. Monthly maximum supply water temperatures for the Capitol Mall geothermal system.

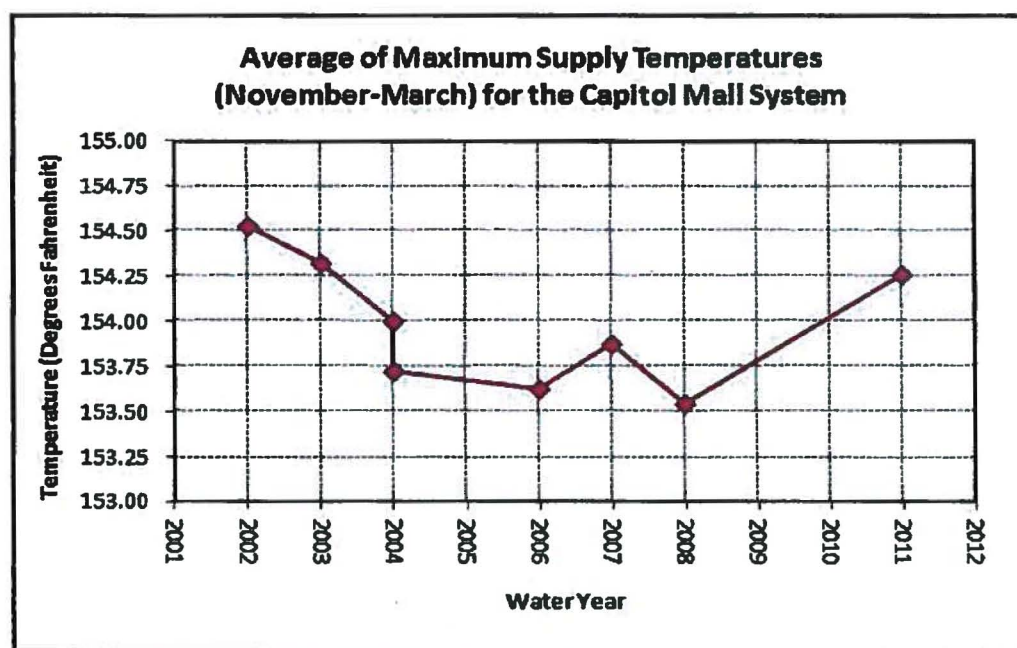


Figure 9. Average of the Capitol Mall maximum supply water temperatures for the November-March time periods for Water Years 2002 through 2011. WY09 did not have data because of reduced usage during the Capitol Mall renovations, and WY10 had abnormally low values, probably related to the system's recovery after the reduced usage in WY09.

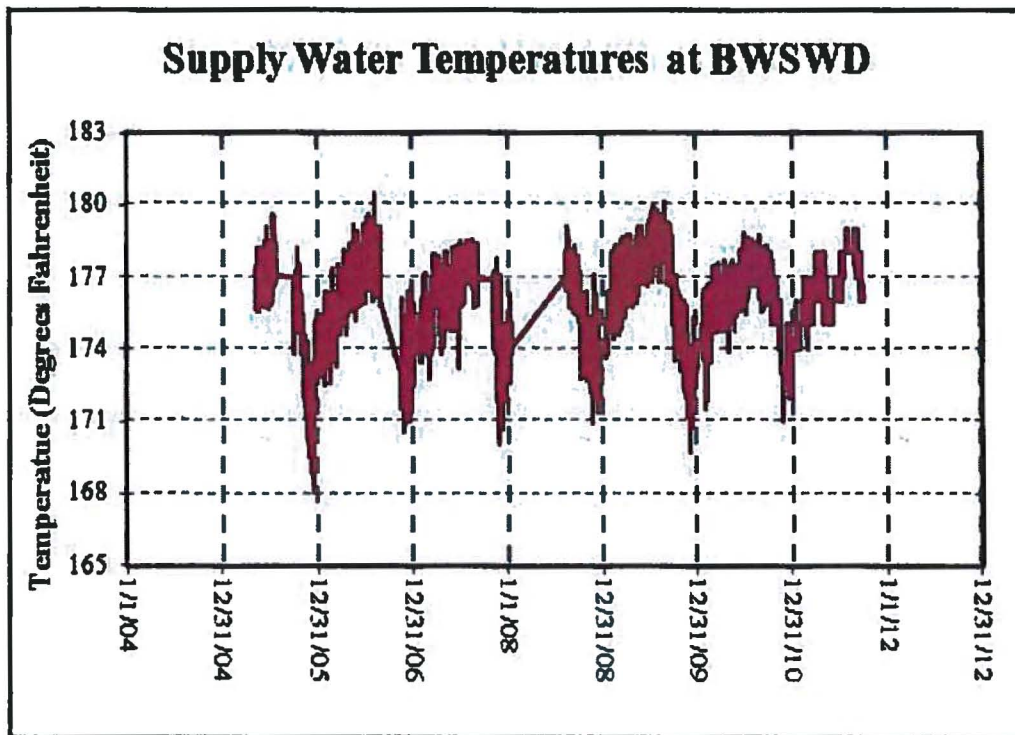


Figure 10. Supply water temperatures for the Boise Warm Springs Water District.

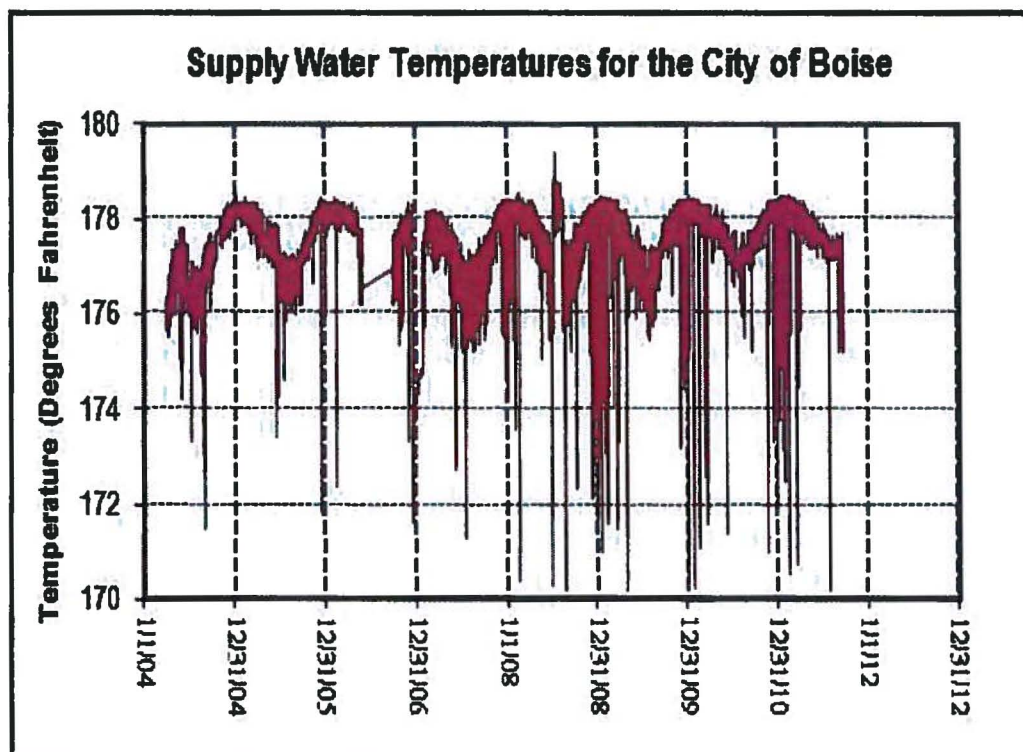


Figure 11. Supply water temperatures for the City of Boise's geothermal system. Readings less than 170 degrees Fahrenheit were removed from the dataset.

STEWART GULCH GROUND WATER DISTRICT 63-S

A couple atypical things occurred in the Stewart Gulch Ground Water District 63-S (GWD63-S) this past year that need to be discussed before the withdrawal and water level information are presented. First, the meter for the Quail Hollow Lower well ceased functioning in 2011. This was not detected till after the summer/fall pumping season. Thus, the withdrawal for Quail Hollow Lower was estimated for WY11. Second, a calculation mistake was made by the author in last year's analysis that resulted in an error for the Quail Hollow Upper well withdrawal. Instead of 16.7 mgal as reported in last year's report, the actual withdrawal was 1.2 mgal in WY10. The following figures and tables take into account the aforementioned items.

Withdrawals

The total withdrawal of low temperature geothermal water in GWD63-S in WY11 was 170.8 mgal (Figure 12). This amount was 1.5 mgal more than the withdrawal in WY10, which is a 1% increase (Table 3).

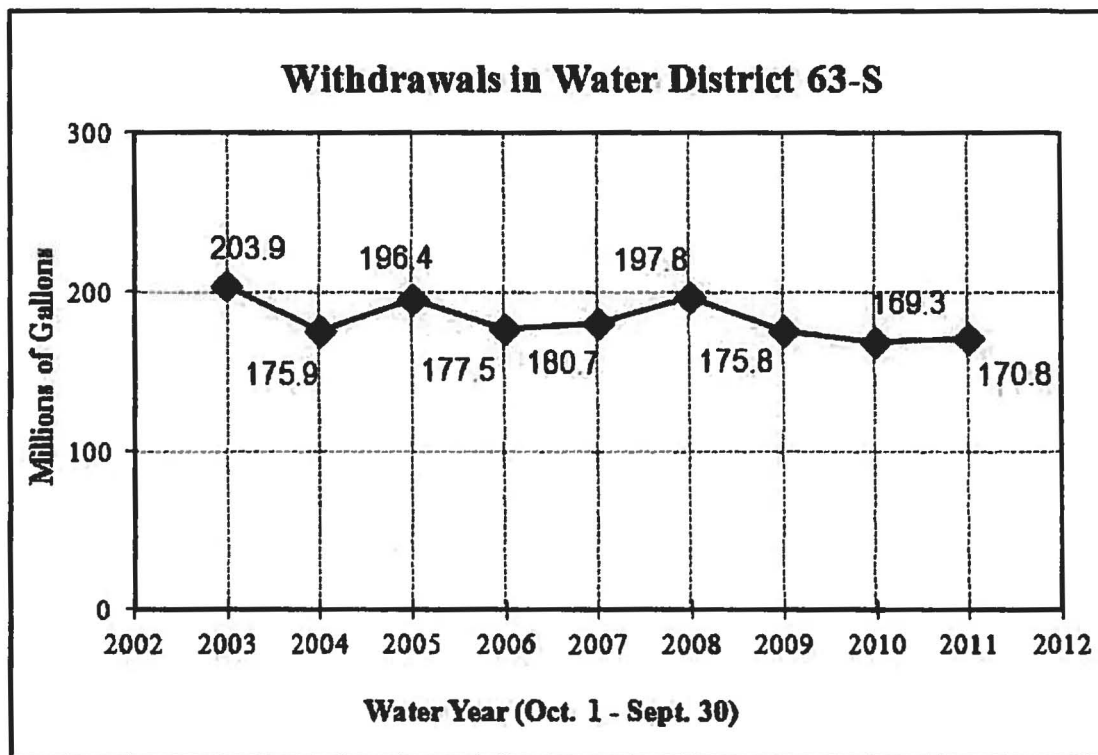


Figure 12. Geothermal withdrawals in Stewart Gulch Water District 63-S for Water Years 2003-2011.

Table 3. Withdrawals¹ from Stewart Gulch Ground Water District 63-S geothermal wells for Water Year 2011 (October 1, 2010 through September 30, 2011).

Well	Withdrawals in WY11 (millions of gallons)	Change from WY10 (millions of gallons)	Percent Change from WY10
TTCI Tiegs (Triangle)	0	0	0
TTCI Silkey (Shed)	7.6	+1.8	+31%
TTCI House (Office)	0.8	+0.3	+60%
Edwards Greenhouse	65.0	-2.4	-4%
Terteling Ranch Windsock	69.3	-4.4	-6%
Terteling Ranch Pool	18.6	+3.7	+25%
Quail Hollow (Tee Ltd) Upper	<0.1	-1.1	See Comments ²
Quail Hollow (Nibbler) Lower	4.2 ³	+2.6	+135%
Whitehead	5.1	+0.9	+20%
Total	170.8	+1.5	+1%

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 WY11 was only 59,500 gallons compared to 1.15 million gallons in WY10. Thus, a calculated percent change would be exceptionally large and not valid for comparison with the other wells.

³The meter for Quail Hollow Lower ceased working sometime in WY11, so the total for the water year was calculated by multiplying an estimated usage rate of 220 gallons per minute times an estimated duration of usage of 320 hours.

The ownerships and locations of the wells allow them to be grouped into four individual withdrawal centers, which is a useful approach for summarizing the withdrawals in these localized areas within the District. Table 4 shows the four centers and the changes in withdrawals from WY10 to WY11

Table 4. Four withdrawal centers in GWD63-S and changes from WY10 to WY11.

Withdrawal Center	Number of Wells	Numerical change from WY10 to WY11	Percentage change from WY10 to WY11
Edwards Greenhouse	1	-2.4 mgal	-4%
Terteling Garden Center	3 (2 in use; 1 unused)	+2.1 mgal	+33%
Quail Hollow	2	+1.5 mgal	+56%
Terteling Ranch	2	-0.7 mgal	-1%

Water Levels

Overall, ground water levels in GWD63-S wells showed stable to slightly increasing trends in WY11. The Edwards well had an increase in the maximum and minimum water levels of 1.2 feet and 2.3 feet, respectively in WY11 (Figure 13). The TTCI Tiegs (Triangle) well had increases in the maximum and minimum water levels of 0.7 feet and 3.6 feet, respectively (Figure 14). The TTCI House (Office), and Silkey (Shed) also had similar water level trends as the Tiegs well (Figures 15 and 16). The Quail Hollow Lower well has shown higher maximums in the last two years as compared to the previous seven years (4 – 7 feet higher)(Figure 17). The maximum value for the Quail Hollow Upper well was 1.5 feet lower in WY11 (Figure 18). The Terteling Ranch Windsock and Pool wells showed slight declines in maximum values (2.3 feet in both wells)(Figures 19 and 20). The trends for the minimum values for the Quail Hollow and Terteling Ranch wells are difficult to discern because of pumping effects.

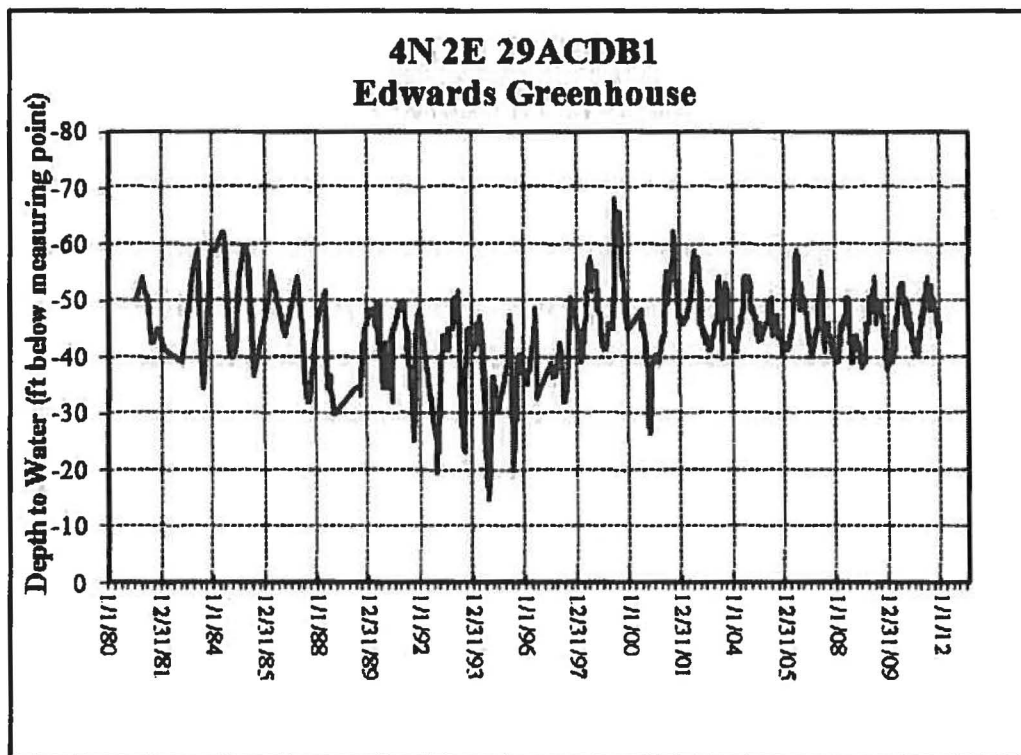


Figure 13. Water level hydrograph for the Edwards Greenhouse well.

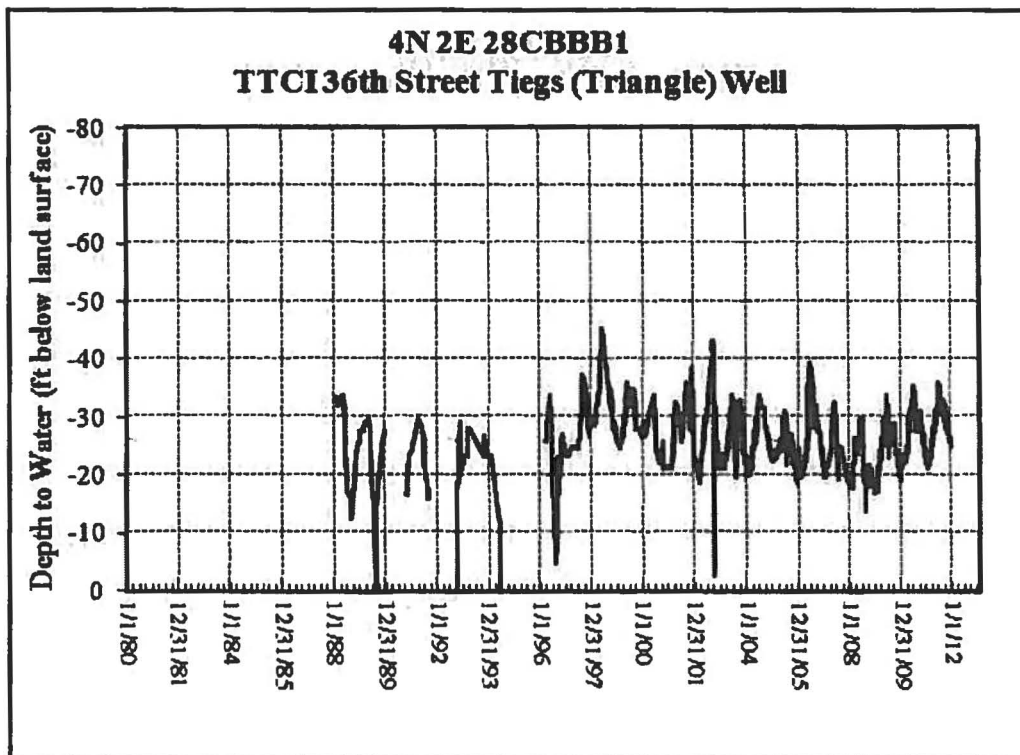


Figure 14. Water level hydrograph for the TTCI 36th Street Tiegs (Triangle) well.

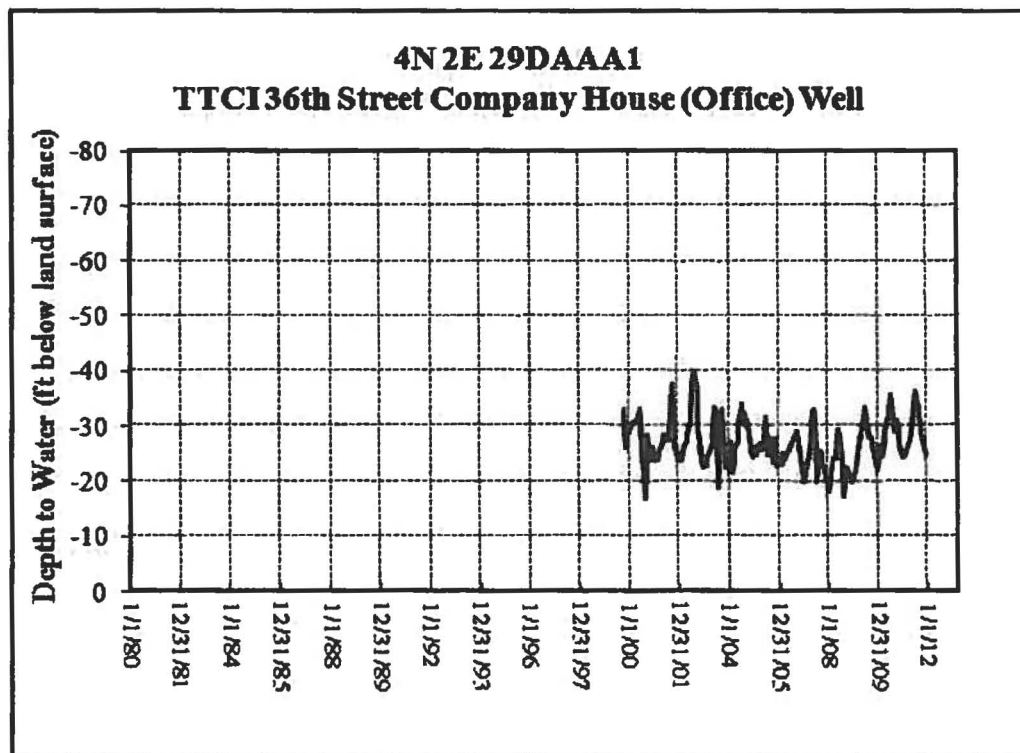


Figure 15. Water level hydrograph for the TTCI 36th Street House (Office) well.

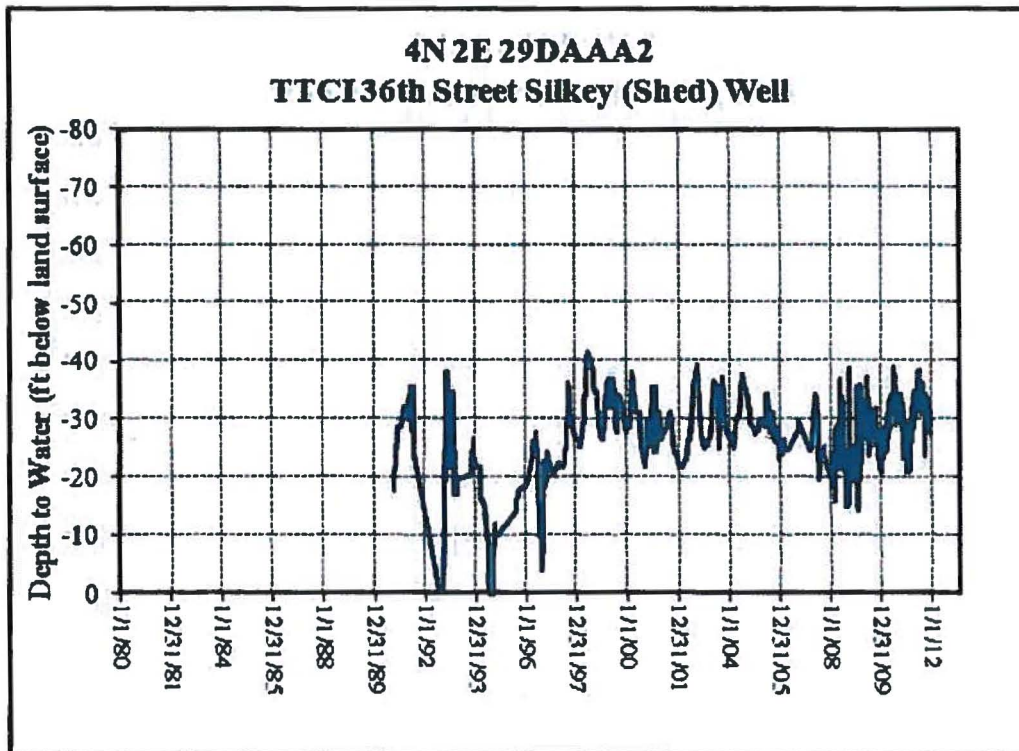


Figure 16. Water level hydrograph for the TTCI 36th Street Silkey (Shed) well.

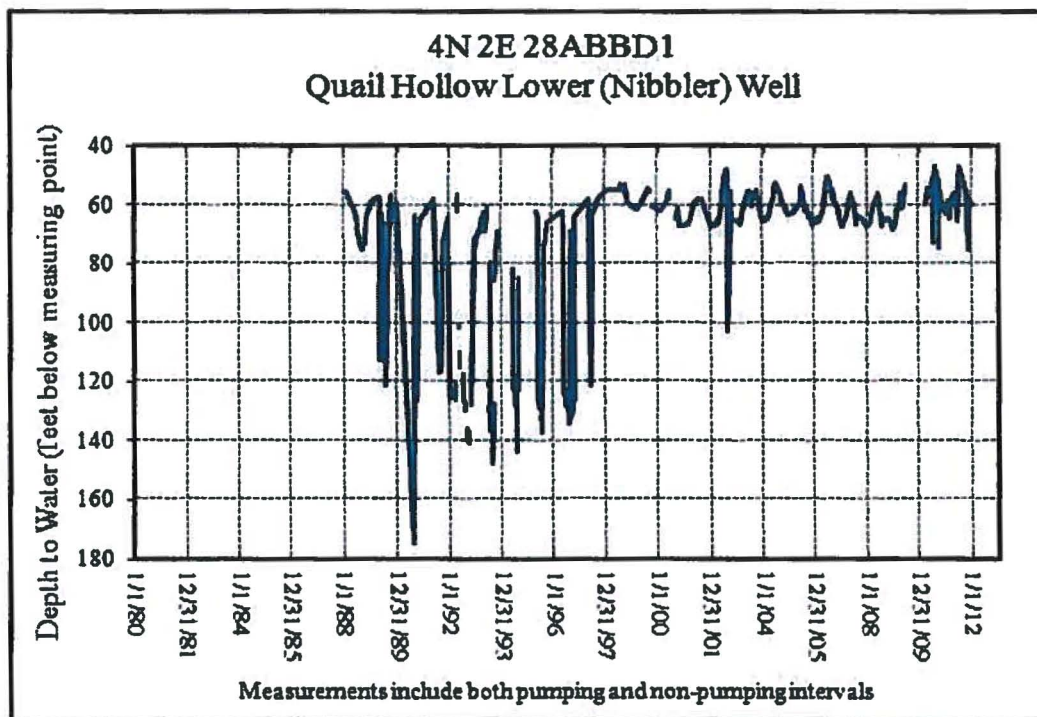


Figure 17. Water level hydrograph for the Quail Hollow Lower well.

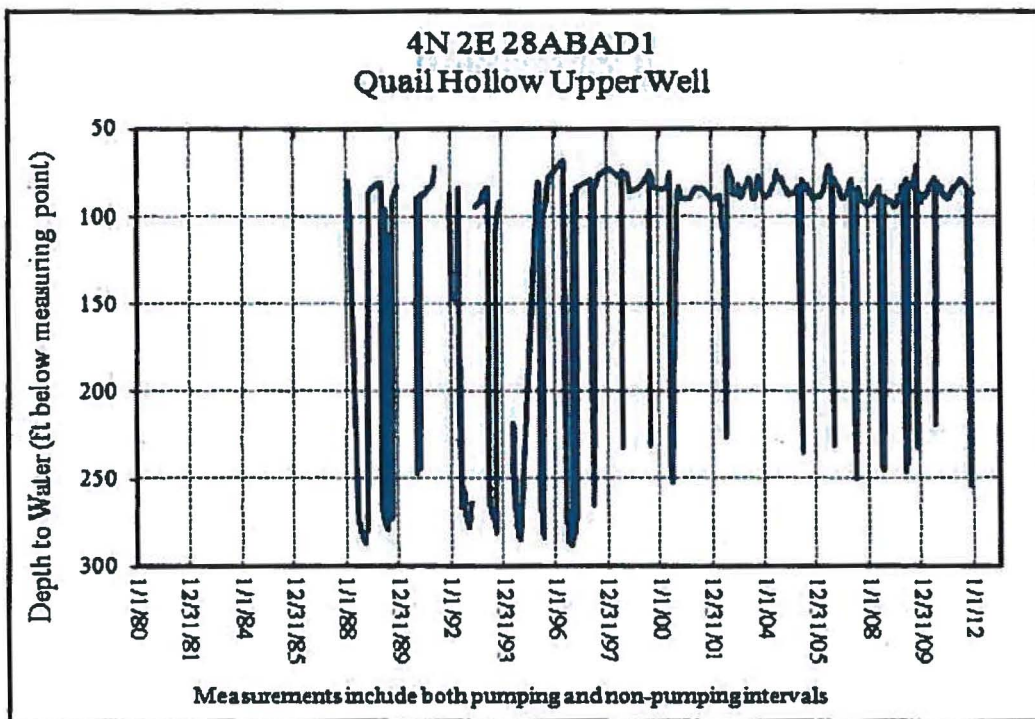


Figure 18. Water level hydrograph for the Quail Hollow Upper well.

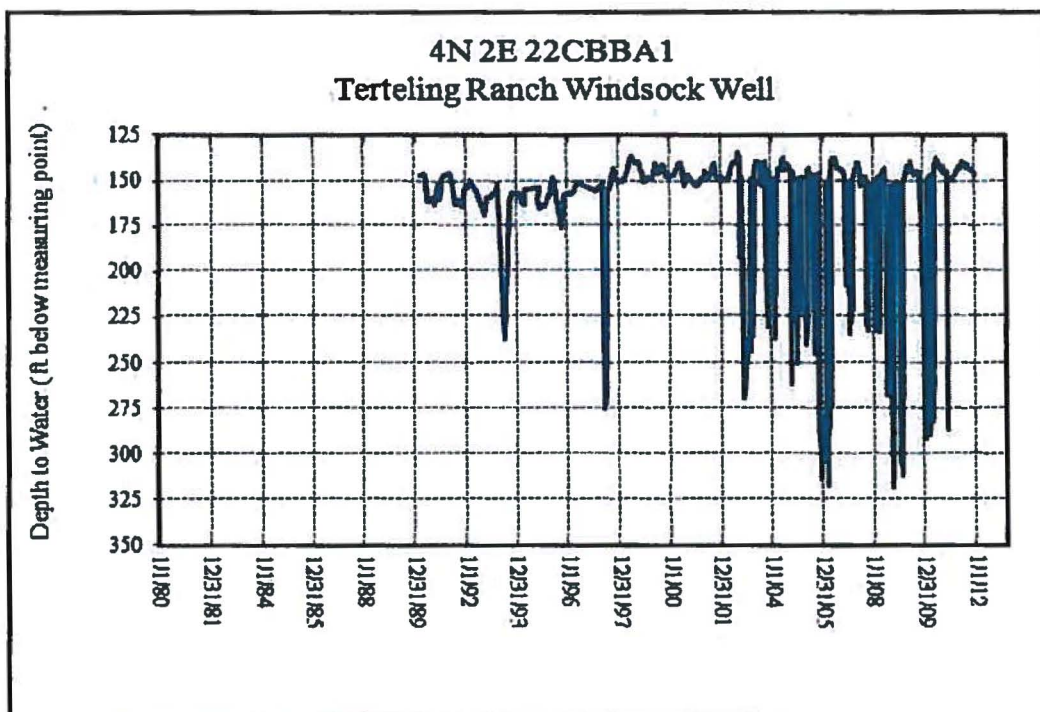


Figure 19. Water level hydrograph for the Terteling Ranch Windsock well.

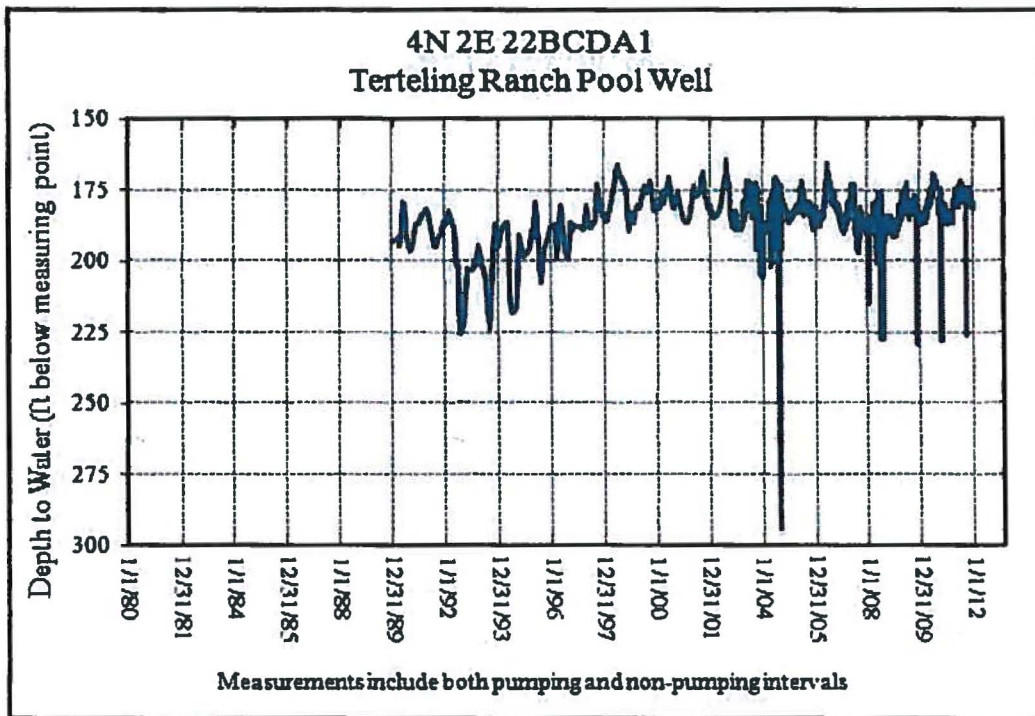


Figure 20. Water level hydrograph for the Terteling Ranch Pool well.