Review of Boise Front Low Temperature Geothermal Monitoring Data for Water Year 2018 (October 1, 2017 – September 30, 2018)

Mike McVay, Technical Hydrogeologist
Idaho Department of Water Resources (IDWR)

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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 2018 (WY18) was 845.5 million gallons (mgal), which is 17.8 mgal less than in Water Year 2017 (WY17). The City of Boise system increased gross withdrawals in WY18 by 22 mgal. However, the City of Boise also injected more water in WY18, and the net withdrawal in WY18 was 3.8 mgal less than in WY17. The combined net withdrawal for all systems in WY18 was 256 mgal, which is 9.7 mgal less than WY17. The other three systems all decreased net withdrawals. Approximately 70% of the water withdrawn in WY18 was re-injected, which is an increase of about 2% from WY17.

In general, both the shallowest water levels (maximums) and deepest water levels (minimums) rose in WY18. The maximum water level for the BLM well rose 1.35 feet, and the minimum value rose 0.5 feet. The monitoring equipment in the Kanta well failed in October 2017, and was reset in September 2018; therefore, only the change in maximum water level is presented. The Kanta well maximum water level rose 0.4 feet. The changes in maximum water levels for the three Boise Warm Springs Water District (BWSWD) wells were as follows: a rise of 3 feet in the East well, no change in the West well, and a rise of 3 feet in BWSWD #3. The minimum water levels for the East and West wells were 64 and 45 feet higher, respectively, and the minimum water level for BWSWD#3 did not change.

The maximum water temperature for the State of Idaho Capitol Mall Production well, as determined on a monthly basis, was 0.4 degrees Fahrenheit (°F) lower in WY18. The average of the monthly temperatures was also 0.4°F lower in WY18. The maximum temperature for BWSWD system was 1°F lower in WY18; however, the WY17 value is based on a single reading in 2017. The maximum water temperature for the City of Boise system was about 0.2°F lower in WY18.

Withdrawals and Re-Injection

Combined gross and net withdrawals from the four Downtown Boise-East Boise district heating systems were 845.5 mgal and 256 mgal, respectively, in WY18 (Table 1 and Figure 1). Gross withdrawals were reduced 17.8 mgal (-2%), and net withdrawals were reduced 9.7 mgal (-4%). Approximately 70% of the fluids were re-injected, which is a 2% increase over WY17.

Table 1. Withdrawals[1] from the four district geothermal heating systems in the Downtown Boise-East Boise areas for Water Year 2018 (October 1, 2017 through September 30, 2018).

System	Gross Withdrawals (million gallons) and percent change from WY17 to WY18	Net Withdrawals[1] (million gallons) and percent change from WY17 to WY18
Boise Warm Springs Water District	240.6 (-2%)	240.6 (-2%)
State of Idaho Capitol Mall[3]	81.9 (-10%)	0 (NC[2])
City of Boise	312.5 (+8%)	15.41 (-20%)
Veterans Administration	210.4 (-11%)[3]	0 (NC[2])
Total	**845.5 (-2%)**	**256 (-4%)**

[1]Net Withdrawals equal Gross Withdrawals minus Injection amounts. [2]NC = No change. [3]Veterans Administration WY17 gross withdrawal was miscalculated; the WY17 to WY18 change has been calculated using the corrected value.

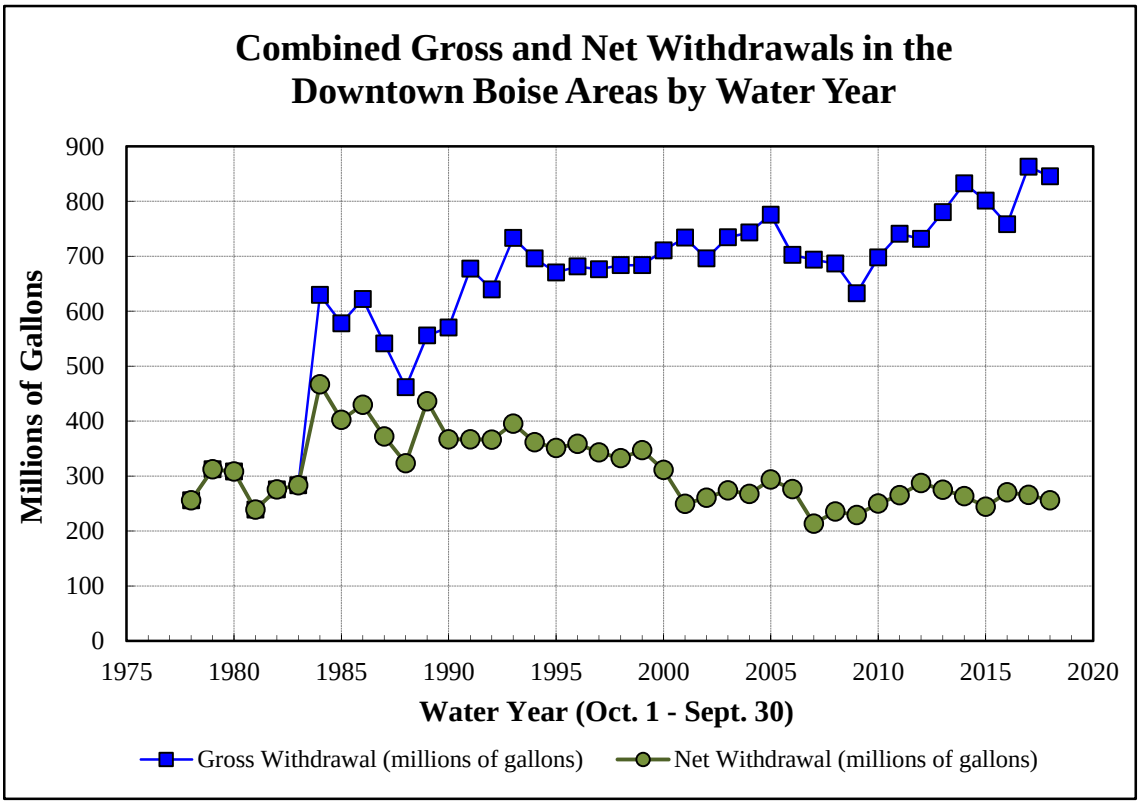

Figure 1. Gross and net withdrawals for the four district heating systems in the Downtown Boise area for water years 1978 through 2018.

The changes from WY17 to WY18 reflect the long-term trends in gross and net withdrawals. The trends in combined gross and net withdrawals are +5.4 and -4.6 mgal/year, respectively, and both trends are statistically significant (Table 2).

Table 2. Gross and net withdrawal trends and significance for the four district geothermal heating systems in Downtown Boise-East Boise areas for WY90 – WY18.

Withdrawals	Withdrawal Trends (mgal per year)[1]	Withdrawal Trend p-value[2]
Gross Withdrawals	**5.4**	**0.00**
Net Withdrawals	**-4.6**	**0.00**

[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.

The City of Boise is the only system that increased gross withdrawals in WY18. Although the City's withdrawals grew by 22 mgal (+8%), net withdrawals were 3.75 mgal less (-20%) than WY17 due to increased injection. The other three systems decreased gross withdrawals, and either decreased or held net withdrawals constant in WY18.

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

The BLM well is located near the City of Boise, Capitol Mall, and VA wellfields, which makes it a good indicator of system water levels. The maximum water level rose 1.3 feet from WY17 to WY18, and the minimum water level rose 0.5 feet (Figure 2).

The monitoring equipment in the Kanta well began to malfunction in October 2017, and was reset in September 2018 (Figure 3). The City has addressed the equipment issue and has resumed data collection. The maximum water level in September 2018 is assumed to represent the water-year maximum water level because the maximum water level often occurs near the end of September, but this assumption results in more uncertainty than if data had been collected over the entire water year. Using the September 2018 data, the maximum water level rose 0.4 feet from WY17 to WY18. The data gap prevents an analysis of changes in minimum water level.

The BGL #1 well continued to have unusually high values for the manual measurements, which were noted in previous reports (Figure 4). The transducer measurements indicate that the maximum water level in BGL1 fell 1.3 feet from WY17 to WY18, and the minimum water level rose 0.5 feet. The Harris Ranch wells have decreased 0.7 feet and 0.8 feet over the last two years (Figure 5).

The BWSWD East and West wells both had single readings of zero feet below their measuring points in WY17 and WY18 (Figures 6 and 7). During WY16 and WY 17, zeros were recorded when the wells flowed over the top of the well casings. Because the wells cannot be shut-in, the true water levels are unknown when a zero is recorded. If the zero readings are ignored,

then maximum water levels in the East and West wells experienced a rise of 3 feet and no change, respectively. Beginning in WY18, a "zero" is recorded when the water level is exactly at the top of the casing and "+1" when the water is flowing over the casing top; subsequent water-level analyses will include the zero values. The BWSWD #3 well maximum water level rose 3 feet in WY18. The minimum values for the East and West wells were 64 and 45 feet higher, respectively. The minimum value for the BWSWD #3 well did not change.

Water levels have generally risen over the last 14 years, with statistically significant rising trends in 4 of 5 wells analyzed. The water-level trends in BWSWD#3 are statistically insignificant, indicating that the water levels have remained statistically constant since WY05.

Table 3. Water-year water-level trends for select wells in the Downtown Boise-East Boise areas for WY05 – WY18.

Wells	Max Water Levels Trend (ft. per year)[1]	Max WL Trend p-value[2]	Min Water Levels Trend (ft. per year)	Min WL Trend p-value
BLM Well	**0.5**	**0.00**	**0.8**	**0.02**
Kanta Well	**0.4**	**0.00**	NA	NA
City of Boise[3]	NA	NA	NA	NA
Boise Warm Springs Water District[4]	0.33	0.15	0.74	0.3
Harris Ranch[5]	**0.6**	**0.00**	**0.6**	**0.00**

[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] Water-level trend has been not been calculated for BGL#1 nor BGL#2 due to lack of reliable data during the WY05 – WY18 period.

[4] Water-level trend has been calculated for only BWSWD#3.

[5] Water-level trend has been calculated for only Harris Ranch West.

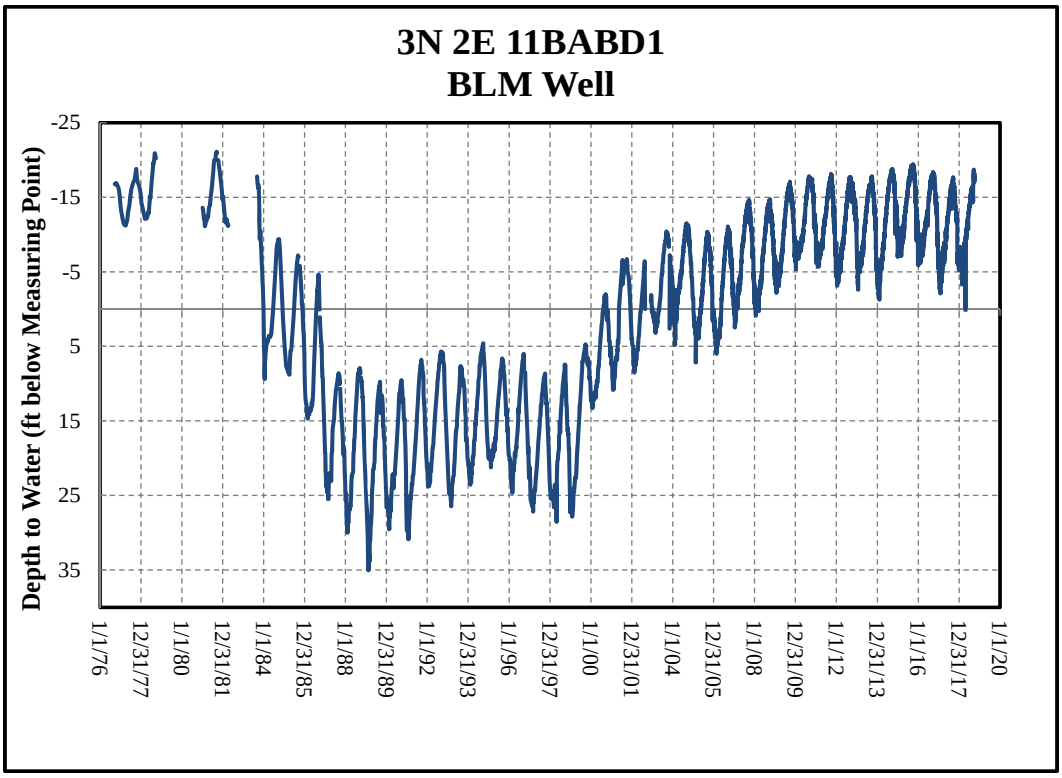

Figure 2. Water levels in the BLM well.

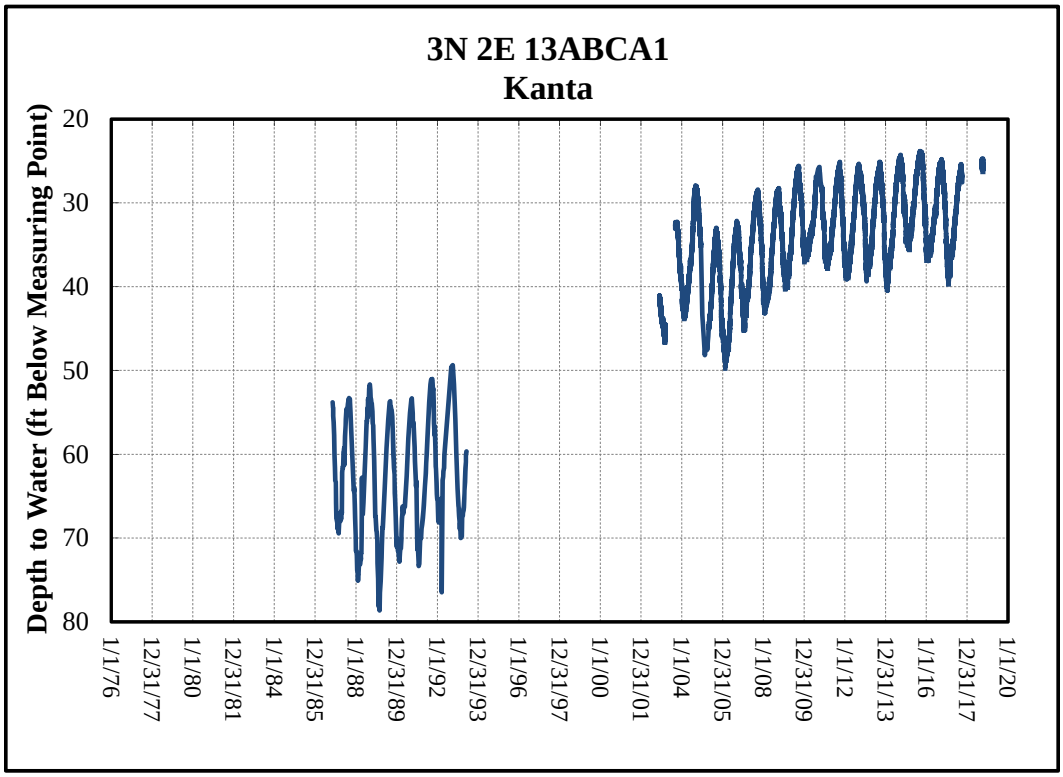

Figure 3. Water levels in the Kanta well.

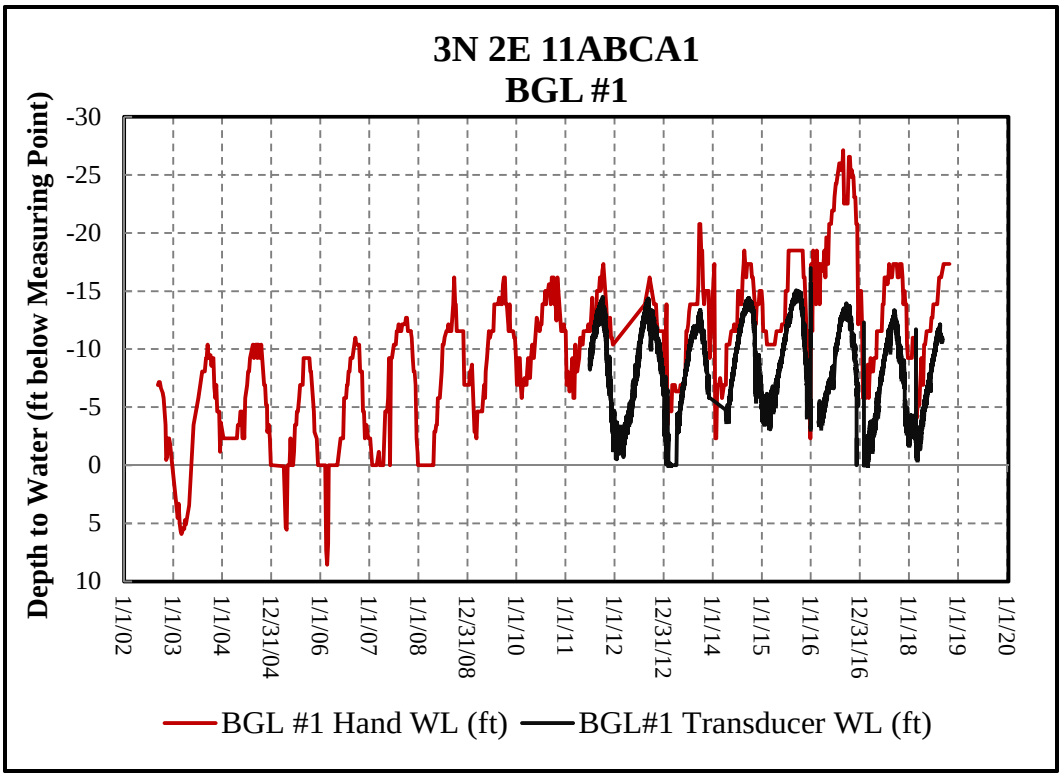

Figure 4. Water levels in the City of Boise's BGL #1 well.

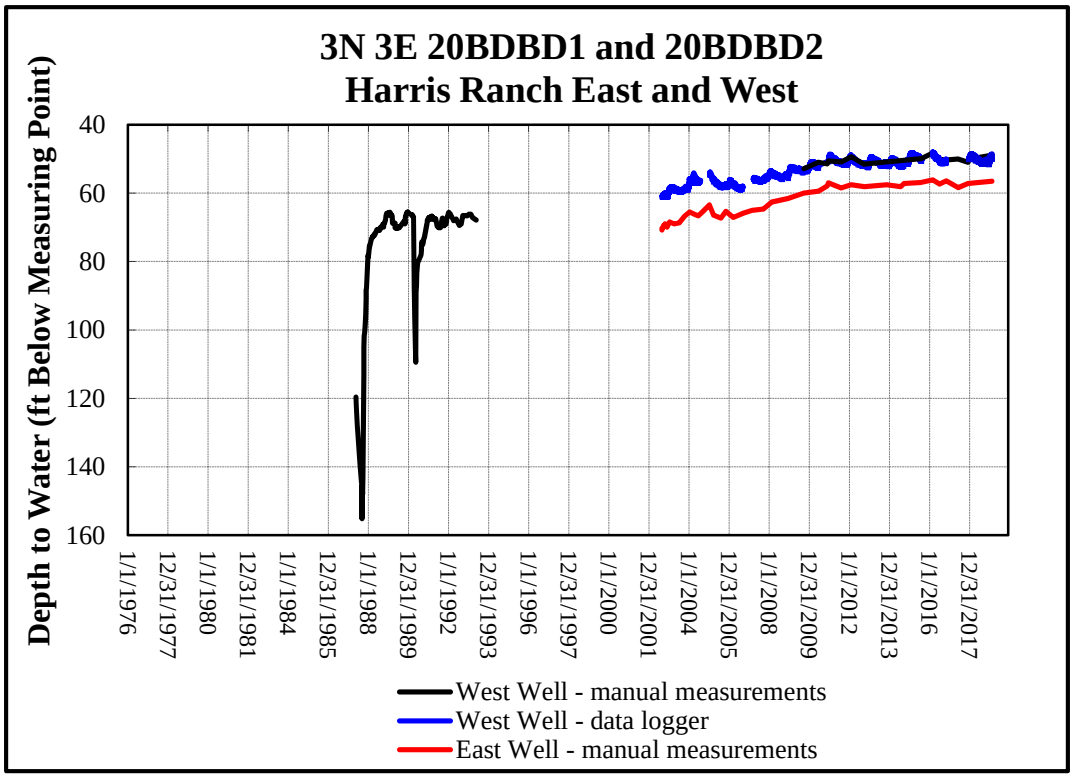

Figure 5. Water levels in the Harris Ranch wells.

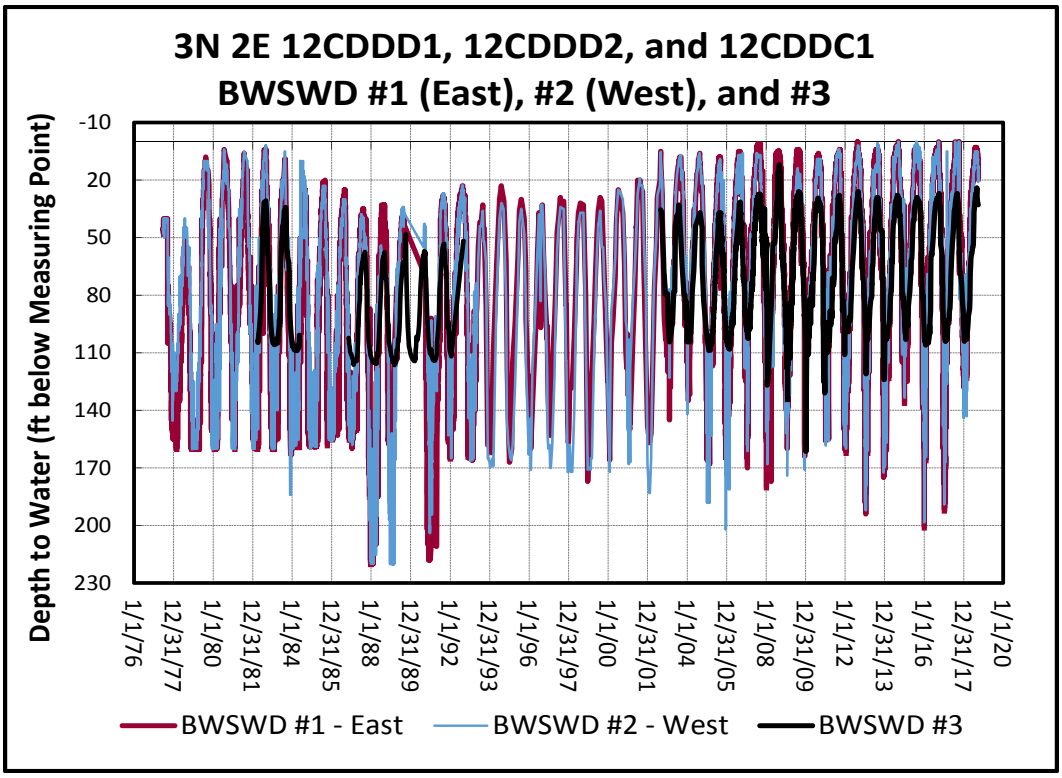

Figure 6. Water levels in the BWSWD wells.

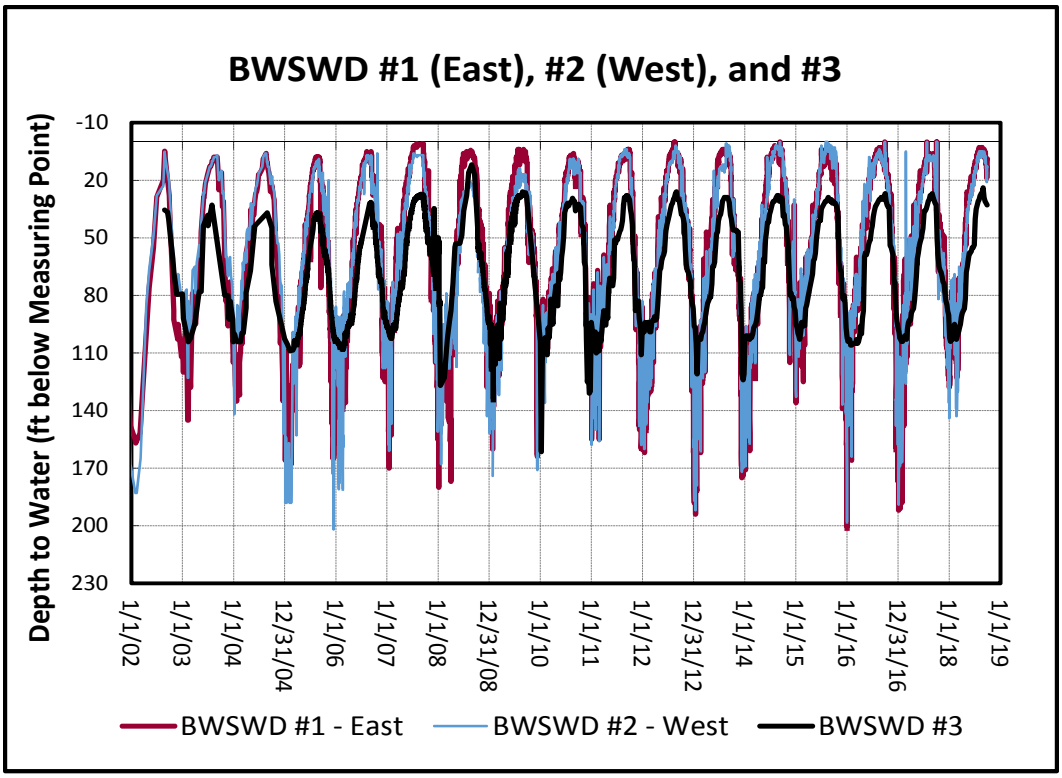

Figure 7. Water levels in the BWSWD wells, January 2002 to September 2018.

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

The maximum temperature for the BWSWD system was 1°F lower in WY18 (Figure 8); however, the WY17 value is based on a single reading in 2017. The very small calculated trend in water temperature is not statistically significant, which means maximum water temperatures have remained statistically constant since 2005 (Table 5).

The maximum monthly water temperature for the State of Idaho Capitol Mall Production well[1] was 0.4°F lower in WY18 (Figure 9). The water-year average of the maximum monthly temperatures was also 0.4°F lower in WY18 (Figure 10). It is important to note that in some water years, data that met the requirements for analyses were available for six months; in other years, fewer than six months had temperature data that met the requirements. Despite the decline in temperature over time that is visible in Figures 9 and 10, the trend is insignificant (Table 5). Therefore, the water-year average of the maximum monthly water temperatures have been statistically constant over the span of WY05 – WY18.

The maximum daily-average water temperature for the City of Boise was about 0.2°F lower in WY18 (Figure 11). Despite the temperature decline from WY17 to WY18, the calculated trend is not statistically significant, and the maximum daily-average temperatures have remained statistically constant since 2004 (Table 5).

Table 5. Water-year temperature trends in the four district geothermal heating systems in the Downtown Boise-East Boise areas for WY05 – WY18.

System	Calculated Trend (^{0}F per year) [2]	Trend p-value[3]
Boise Warm Springs Water District	0.003	0.46
State of Idaho Capitol Mall	-0.02	0.22
City of Boise	0.002	0.96
Veterans Administration	NA	NA

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

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

[1]Readings that are preceded by 8 hours of discharge rates over 300 gallons per minute are valid for use in this analysis.

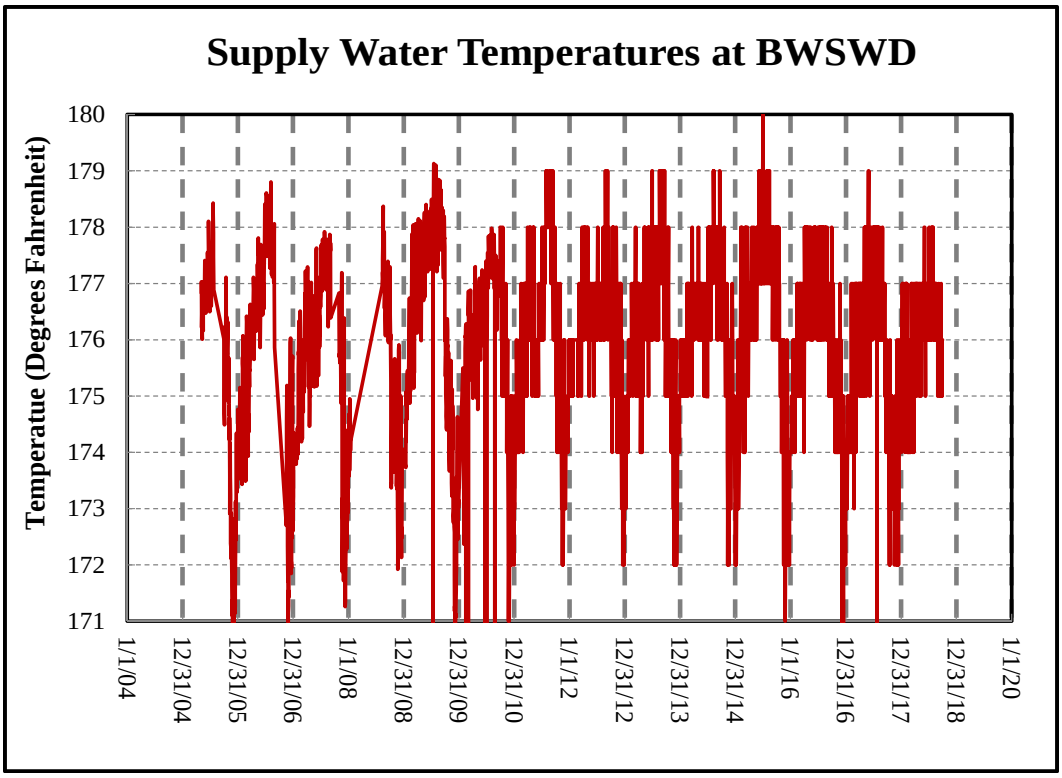

Figure 8. Supply water temperatures for the Boise Warm Springs Water District.

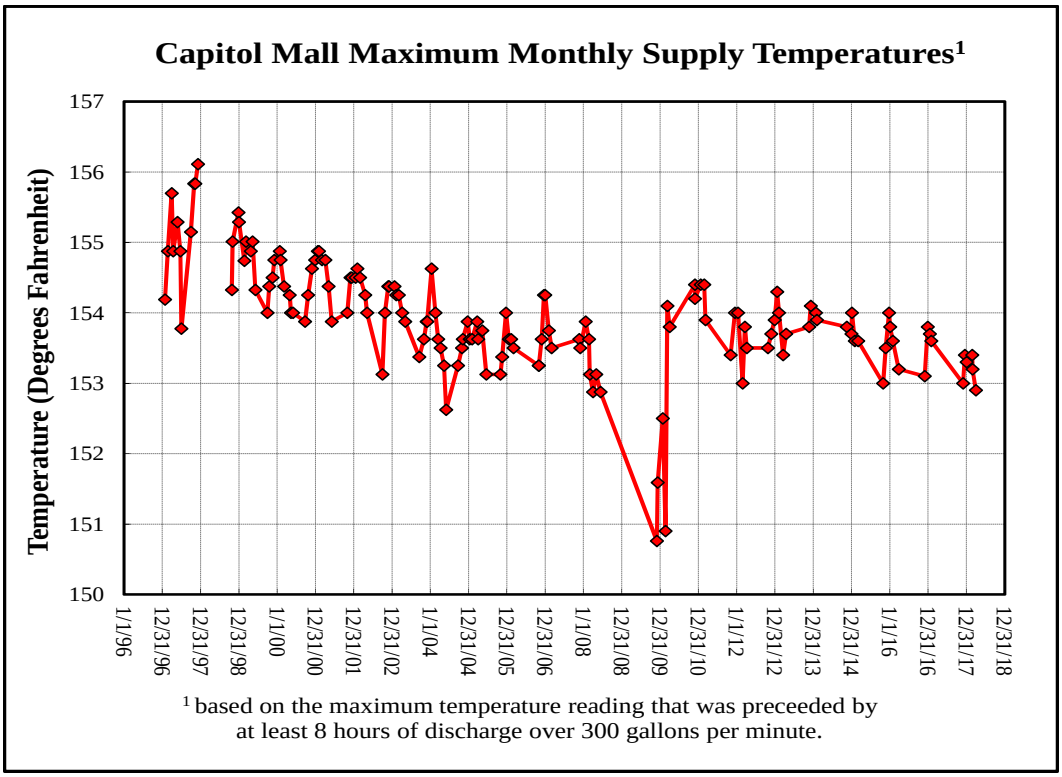

Figure 9. Monthly maximum supply water temperatures for the Capitol Mall geothermal system.

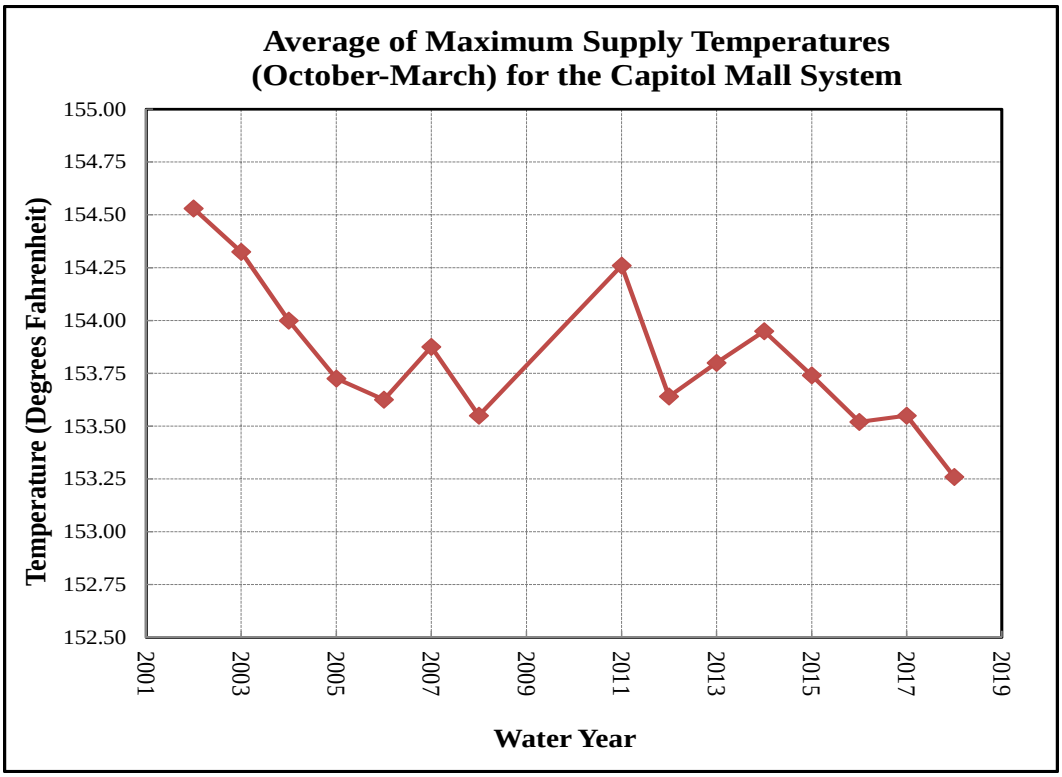

Figure 10. Average of the Capitol Mall maximum supply water temperatures for the October-March time periods for Water Years 2002 through 2018.

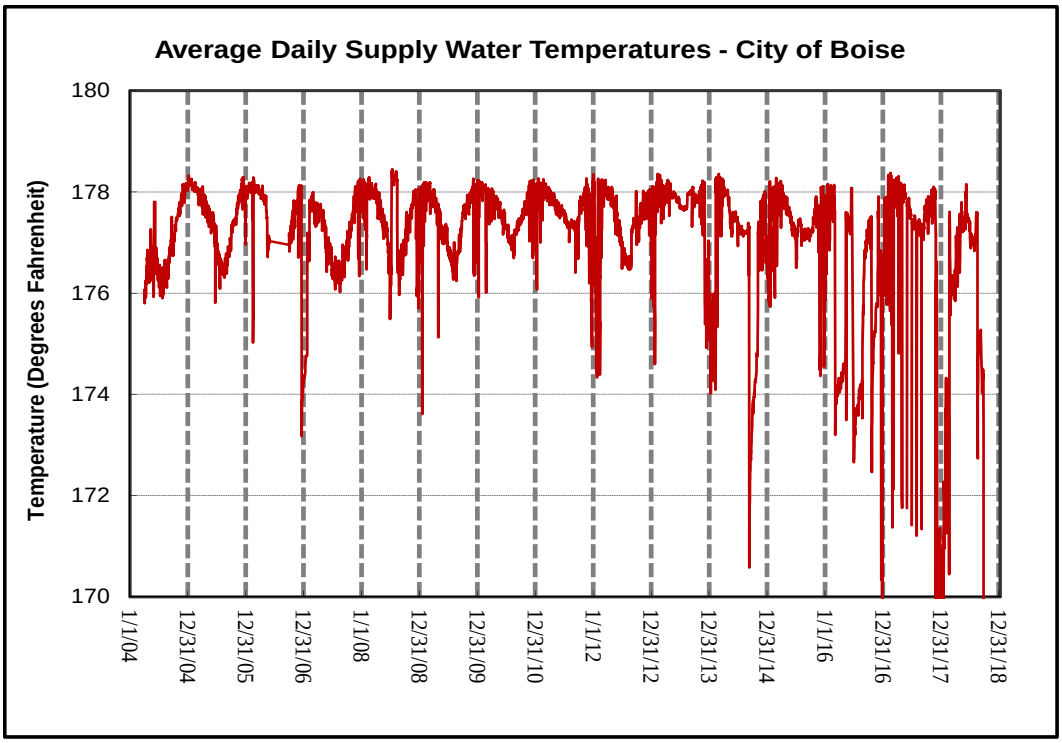

Figure 11. Supply water temperatures for the City of Boise geothermal system. Readings less than 170°F were omitted from the analysis.