01ACC2 is completed in the Eastern Snake Plain Aquifer. In Figure 5, wells with a declining trend have a brown halo, wells with an increasing trend have an orange halo. If the record for the well begins prior to 1991, when the Big Wood GWMA was formed, there is a second hydrograph beginning in 1991 with a trend line and a post-1991 slope and p-value.

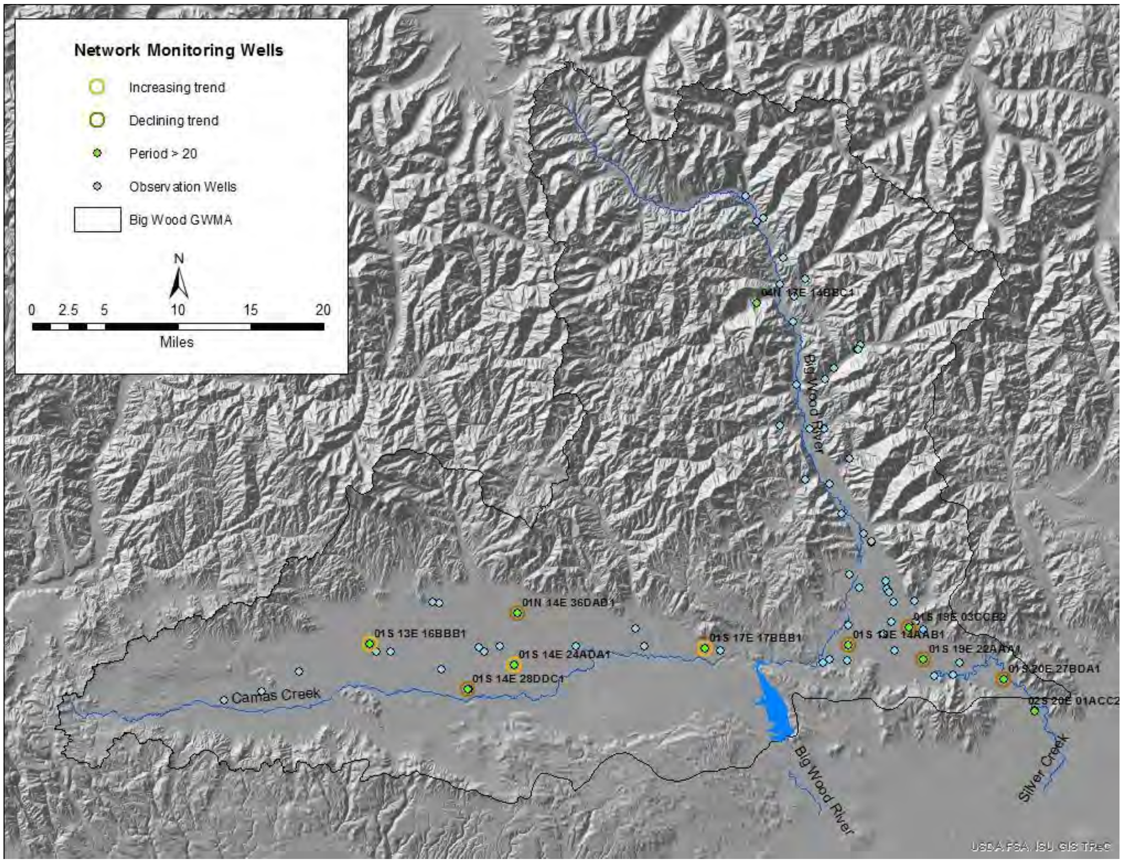


Figure 5. Wells with a record of over 20 years and at least 100 observations.

Potentiometric Analysis

Figures 6a-c are potentiometric maps for the unconfined Wood River Valley aquifer for October 2006, October 2012, and October 2018. These maps indicate that groundwater flows from the north to the south and out the basin to the east and west. The water table contours also show that the water table tends to be stable within the Wood River Valley portion of the Big Wood GWMA. This may be because the Big Wood River is in direct hydraulic communication with the unconfined aquifer and the river is depleted to sustain the unconfined aquifer.

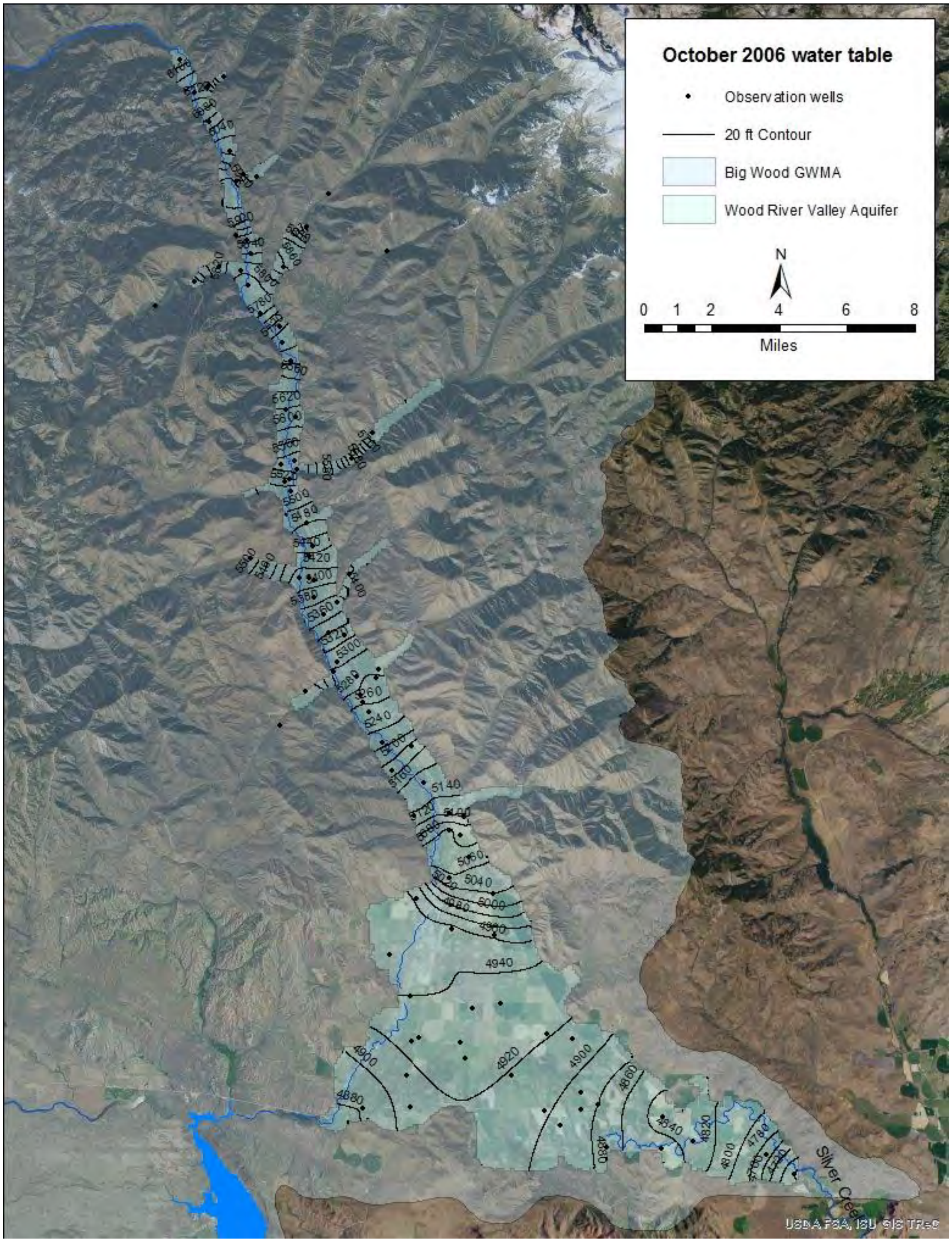


Figure 6a. Potentiometric surface for the unconfined aquifer in the Wood River Valley from October 2006.

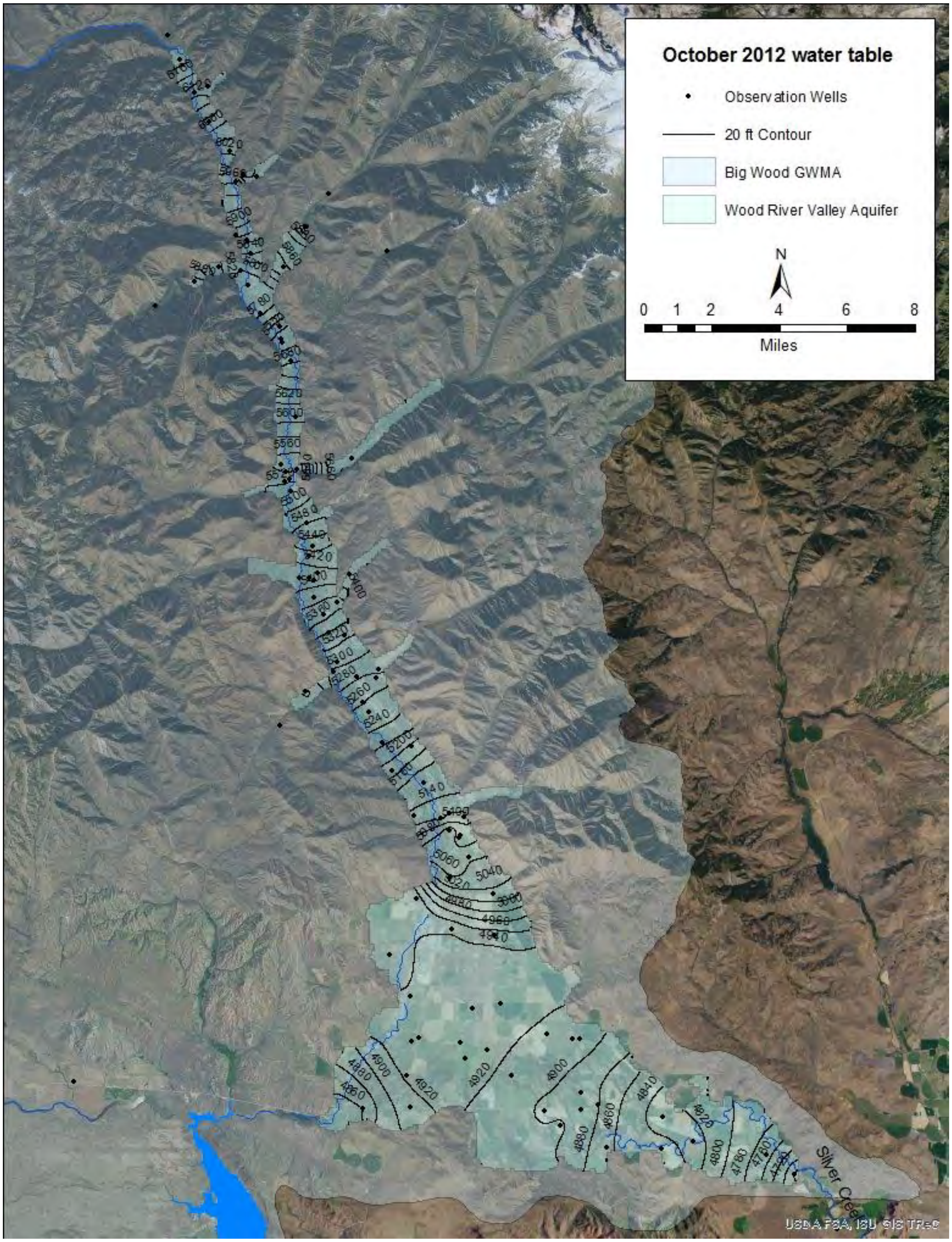


Figure 6b. Potentiometric surface for the unconfined aquifer in the Wood River Valley from October 2012.

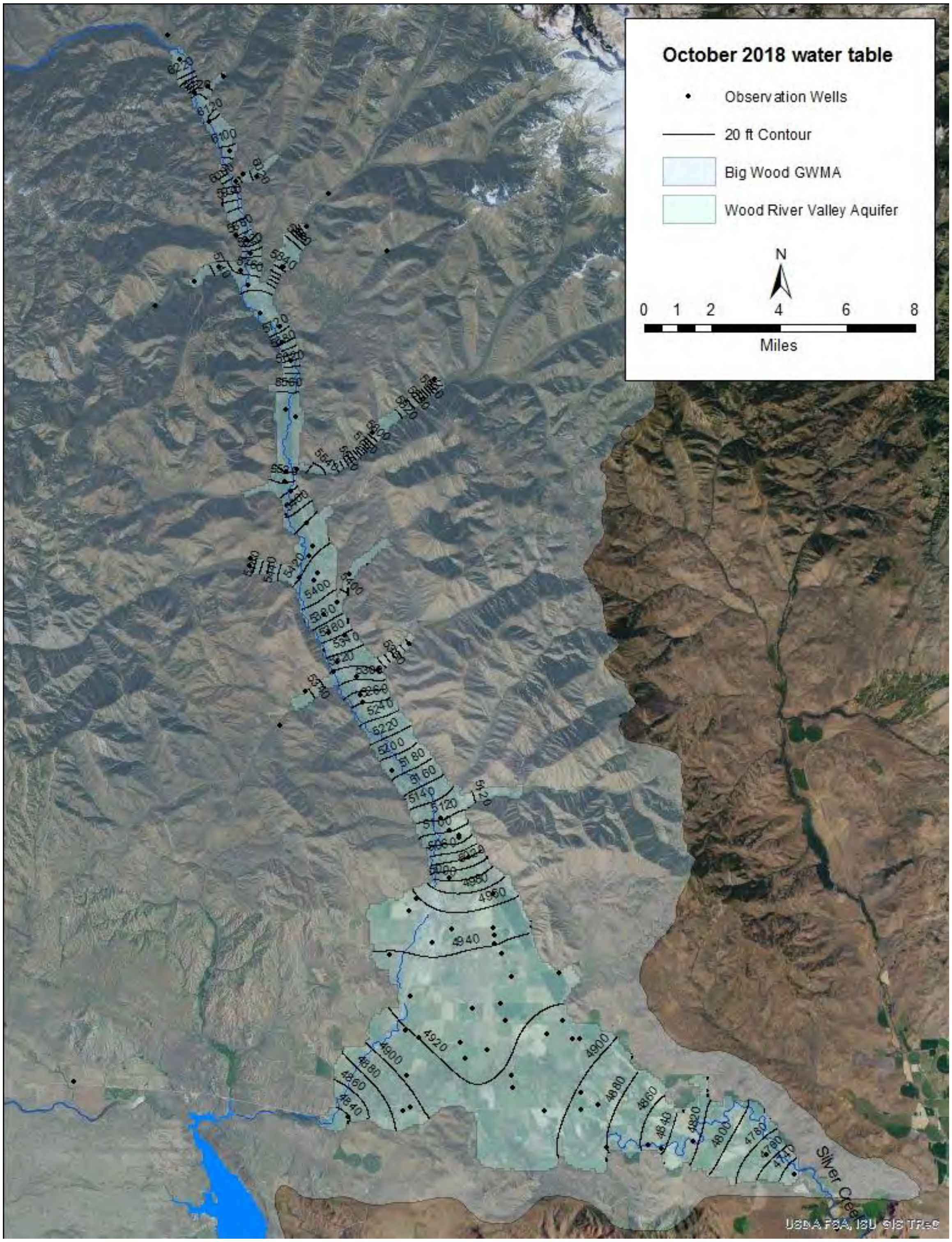


Figure 6c. Potentiometric surface for the unconfined aquifer in the Wood River Valley from October 2018.

The Camas Prairie can also be divided into shallow unconfined and deep confined aquifer systems. Figure 7 shows wells with water-levels collected during October 2018 in the Camas Prairie shallow and deep aquifer systems. The maps indicate that groundwater flow direction in both the unconfined aquifer and the confined aquifer is from the west to the east.

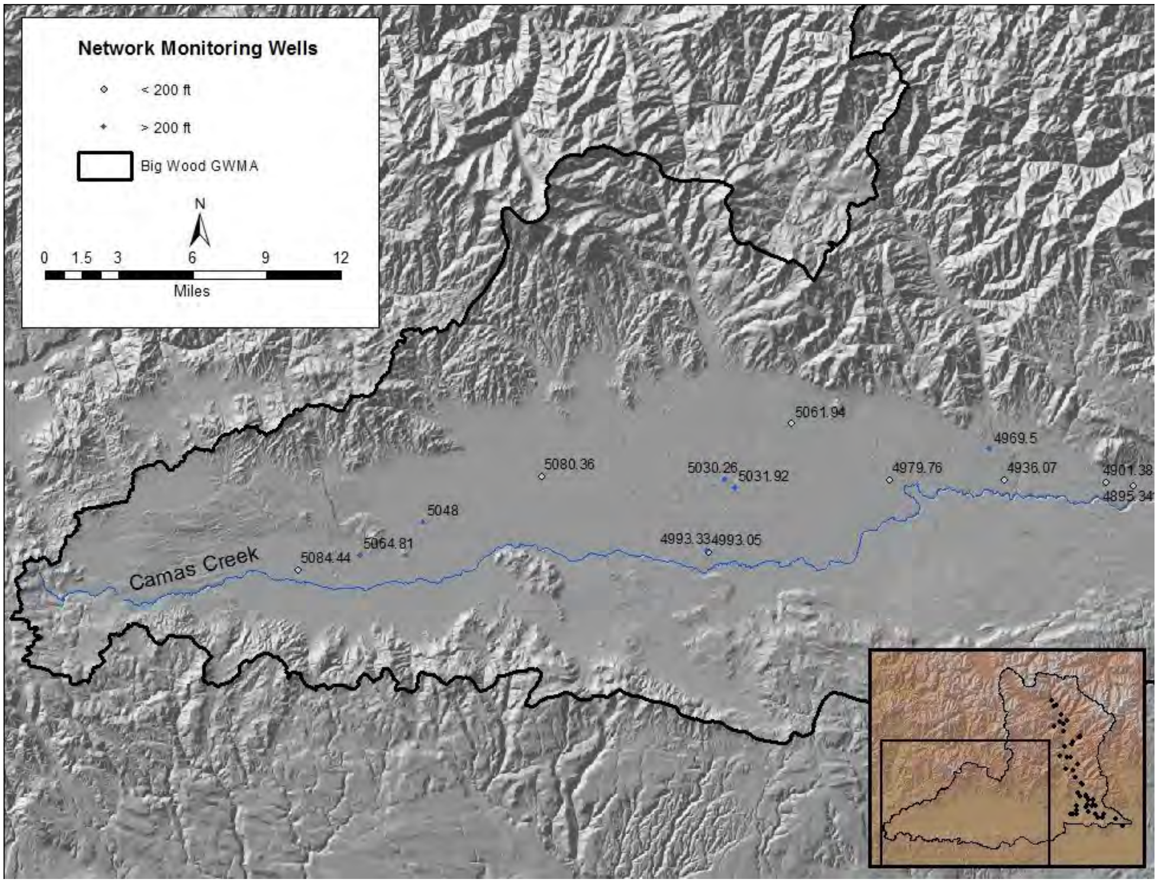


Figure 7. Water-levels in the shallow unconfined and deep confined aquifers in the Camas Prairie.

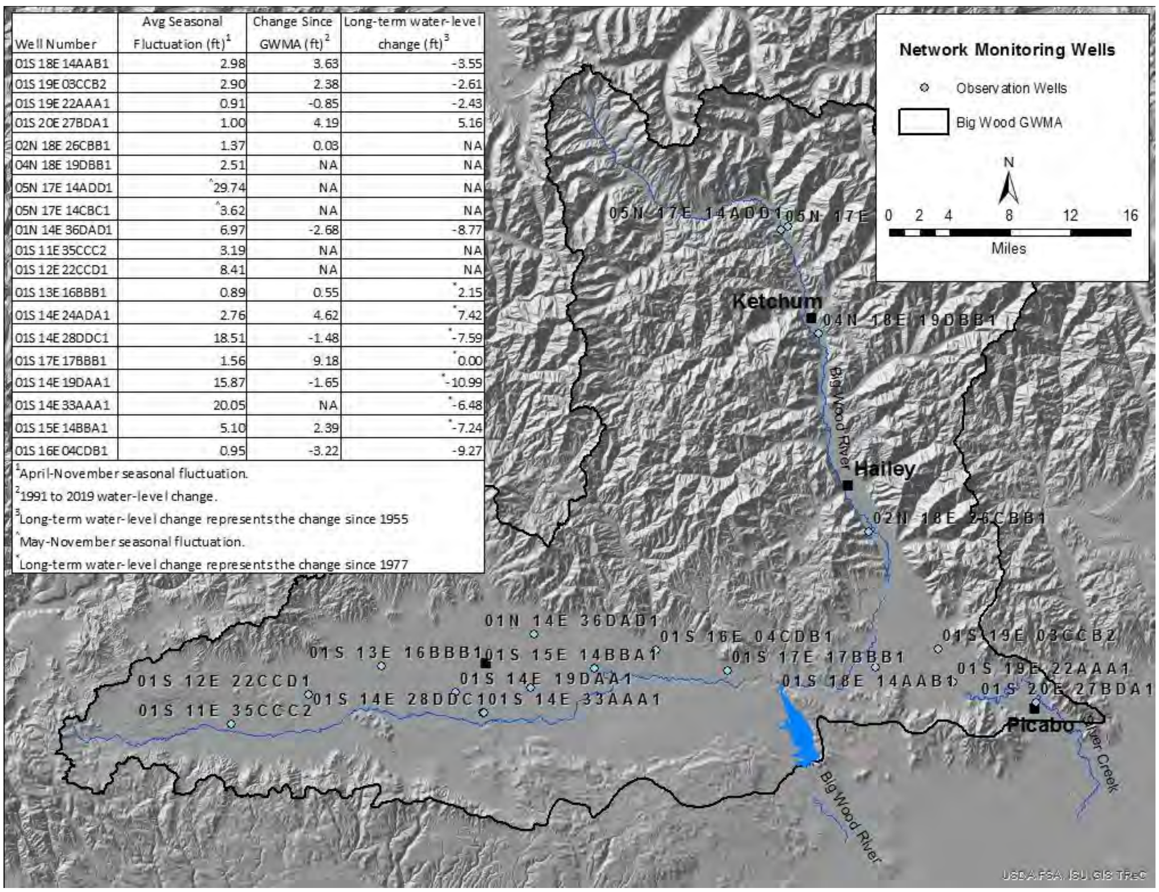
General Water-Level Elevation Analysis

To critically evaluate aquifer health in an aquifer system in which a river is in direct hydraulic communication with the aquifer, the wells not in immediate hydraulic communication with the river system need to be examined. There are four such wells in the Wood River Aquifer system with a significant measurement period: 01S 18E 14AAB1, 01S 19E 03CCB2, 01S 19E 22AAA1, and 01S 20E 27BDA1 (Figure 2). Wells 01S 18E 14 AAB1 and 01S 19E 22AAA1 are in a confined aquifer, well 01S 19E 03CCB2 is about four miles from either the Big Wood River or Silver Creek, and well 01S 20E 27BDA1 is in an area where Silver Creek is perched and not in direct communication with the aquifer. These wells are identified in Figure 2 and Figure 5 and their hydrographs are shown in Appendix D with trend lines and p-values for the slope of the trend line. All four are declining over the entire period of record, which begins in 1954 for all of these wells, and the p-values are less than 0.05, indicating that the decline is statistically significant at the 95% confidence interval. However, since 1991, when the area became a GWMA, the rate of decline is significantly less for 01S 18E 14AAB1 and 01S 19E 22AAA1, and positive for 01S 19E 03 CCB2 and 01S 20E 27BDA1.

In the Camas Prairie water-level trends in the unconfined system show increasing water-levels as shown by wells 01S 13E 16BBB1, 01S 14E 24DA1, and 01S 17E 17BBB1. Wells 01S 14E 28DDC1 and 01N 14E 36DAD1 completed in the confined system show declining trends. Appendix D contains hydrographs along with trend lines and p-values for the trend lines.

Seasonal Fluctuations

Responses to seasonal hydrologic changes are apparent in the hydrographs for each of the wells presented in Appendix D. In general, the hydrographs show similar responses over time. The average seasonal fluctuations for each well were determined by finding the difference between the summer and fall measurements (Figure 8). The average seasonal fluctuation for the selected wells is 6.8 ft. The average water-level change since the Wood River GWMA was established in 1991 is an increase of 1.31 ft and the average long-term change is a decline of 3.40 ft.



Well Number	Avg Seasonal Fluctuation (ft)[1]	Change Since GWMA (ft)[2]	Long-term water-level change (ft)[3]
01S 18E 14AAB1	2.98	3.63	-3.55
01S 19E 03CCB2	2.90	2.38	-2.61
01S 19E 22AAA1	0.91	-0.85	-2.43
01S 20E 27BDA1	1.00	4.19	5.16
02N 18E 26CBB1	1.37	0.03	NA
04N 18E 19DBB1	2.51	NA	NA
05N 17E 14ADD1	^29.74	NA	NA
05N 17E 14CBC1	^3.62	NA	NA
01N 14E 36DAD1	6.97	-2.68	-8.77
01S 11E 35CCC2	3.19	NA	NA
01S 12E 22CCD1	8.41	NA	NA
01S 13E 16BBB1	0.89	0.55	*2.15
01S 14E 24ADA1	2.76	4.62	*7.42
01S 14E 28DDC1	18.51	-1.48	*-7.59
01S 17E 17BBB1	1.56	9.18	*0.00
01S 14E 19DAA1	15.87	-1.65	*-10.99
01S 14E 33AAA1	20.05	NA	*-6.48
01S 15E 14BBA1	5.10	2.39	*-7.24
01S 16E 04CDB1	0.95	-3.22	-9.27

[1]April-November seasonal fluctuation.
[2]1991 to 2019 water-level change.
[3]Long-term water-level change represents the change since 1955
^May-November seasonal fluctuation.
*Long-term water-level change represents the change since 1977

Figure 8. Summary of water-level changes in the Big Wood GWMA.

Mann-Kendall Trend Analysis

The Mann-Kendall test is a nonparametric test for trend that allows missing values and is widely used in environmental sciences (Gilbert, 1987). The Regional Mann-Kendal incorporates numerous wells in one analysis to determine the presence or absence of a district wide long-term rising or falling trend. The USGS KENDALL program by Helsel and others (2005), performs a Regional Kendall test for trend in which numerous wells within an area are evaluated to test for a consistent trend. The IDWR typically collects water-levels at least twice a year, spring and fall so three datasets were prepared from wells within the Wood River Valley (Figures 2 and 3) consisting of water-levels collected in October, November, and April.

The data in Table 2 displays the results of the Mann-Kendall analysis beginning in 1968, where:

> locations – number of wells included in the analysis
> Ƭ – a measure of correlation were 1.0 is perfectly correlated
> S – if S is positive, the water-table is rising with time, if S is negative (-) the water-table is declining with time
> z – if z is positive, the water-table is rising with time, if z is negative (-) the water-table is declining with time. The z statistic can also be used to determine critical points for a two tailed statistical test.
> p – if less than 0.05, the data supports the trend at a 95% confidence interval
> Δ – the average change in water-level in feet per year

Since the S and z statistics are negative for all three datasets presented in Table 2 and p is less than 0.05 in all three datasets, the trend since 1968 for water-levels collected in October, November, and April indicate a declining water-table at a 95% confidence level. The decline is between 0.22 and 0.10 ft per year.

Table 2. Mann-Kendall analysis for Wood River Valley wells beginning in 1968.

Kendall Statistics	October	November	April
locations	45	43	42
Ƭ	-0.341	-0.405	-0.267
S	-406	-883	-273
z	-5.073	-6.507	-3.541
p	0	0	0.0004
Δ	-0.1702	-0.217	-0.102

The same analysis conducted for the wells in the Camas Creek drainage (Figure 4) is presented in Table 3. The number of wells is smaller, the correlations (Ƭ) are weaker, and the history is shorter (beginning in 1968 in the Wood and 1976 in the Camas). The p value is significant for the April data, but the October and November data do not show a consistent trend. The April data has a stronger Ƭ, a more significant S and z, and a p value statistically significant at the 95% confidence interval indicating declining water-table trend of about 0.06 ft/yr.

Table 3. Mann-Kendall analysis for Camas wells beginning in 1976.

Kendall Statistics	October	November	April
locations	19	17	18
τ	-0.026	-0.032	-0.195
S	-7	-38	-164
z	-0.215	-0.428	-2.598
p	0.8294	0.6688	0.0094
Δ	-0.02625	-0.01639	-0.06257

The Big Wood GWMA was formed in 1991, in part because the water-table was declining, so a declining water-table for a period beginning prior to 1991 is not unexpected. A more useful analysis would be to evaluate the trend since formation of the GWMA to determine if the administrative action is having its intended impact. Table 4 shows the Mann-Kendall statistics for wells in the Wood River Valley (Figures 2 and 3) including only data collected since 1991. τ, S, z, and Δ are all positive indicating rising groundwater-levels. However p is only statistically significant at the 95% confidence interval for the April data; the October and November data do not show a statistically significant trend. Perhaps the October and November data contain enough noise that the trend is masked, or perhaps there is no trend and the water-table is stable. The April groundwater increase is about 0.18 ft/yr.

Table 4. Mann-Kendall analysis for Wood River Valley wells beginning in 1991.

Kendall Statistics	October	November	April
locations	46	43	43
τ	0.111	0.041	0.182
S	55	29	67
z	1.644	0.538	2.356
p	0.1001	0.5908	0.0185
Δ	0.09833	0.062	0.18

The results for the Mann-Kendall analysis for the Camas Prairie wells beginning in 1991 is presented in Table 5. Neither October, November, nor April have a statistically significant p-value at the 95% confidence interval. τ is positive for October and November, but negative for April. S is positive for October and November, but negative for April; z is zero for October, positive for November, and negative for April. As indicated by the p-values, there is no trend at the 95% confidence interval for any of these datasets. These data might be inconclusive because, as noted previously, the water-table is rising in the unconfined aquifer and declining in the confined system and there is therefore no regional trend at a 95% confidence interval.

Table 5. Mann-Kendall analysis for Camas Prairie wells beginning in 1991.

Kendall Statistics	October	November	April
locations	18	15	18
T	0.008	0.247	-0.064
S	1	67	-31
z	0	1.943	-0.708
p	1	0.052	0.4786
Δ	0.01944	0.184	-0.02067

Conclusions and Recommendations

In the Wood River Valley portion of the GWMA, the water-table has declined at rate of about 0.17 ft/yr since 1968 (Table 2). However, since formation of the GWMA in 1991 the water-table appears to be either reasonably stable or recovering at a rate of about 0.18 ft/yr (Table 4).

Interpretation of the data from the Camas side of the GWMA is less clear. The data in Table 4 for April water-levels indicate a water-table declining at about 0.06 ft/yr since 1976. The data gathered since formation of the GWMA from the Camas show no discernable trend. Perhaps this is because water-levels in the unconfined aquifer are rising while water-levels in the confined system are declining.

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