MEMO

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Department of Water Resources

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Date: September 25, 2015

To: Tim Luke, Water Compliance Bureau Chief

cc: Sean Vincent, Hydrology Section Manager

From: Mike McVay, Technical Engineer

Subject: 2015 Update water-level data for wells in the Malad Basin, Oneida County, Idaho

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Introduction

The following hydrographs illustrate the entire set of water-level data collected from the seven wells that IDWR currently monitors in the Malad Basin (Figure 1). The groundwater-data records begin on various dates and are current up to March of 2018. All seven of the wells exhibit declining water levels over recent years.

Trends in water-level changes have been calculated for the most recent 10-year and 20-year periods-of-record (2009 – 2018 and 1999 – 2018, respectively). Each trend has been calculated using the Mann-Kendall (MK) test; a test that was developed by the USGS and is now the one of the most frequently used tests for evaluating trend.

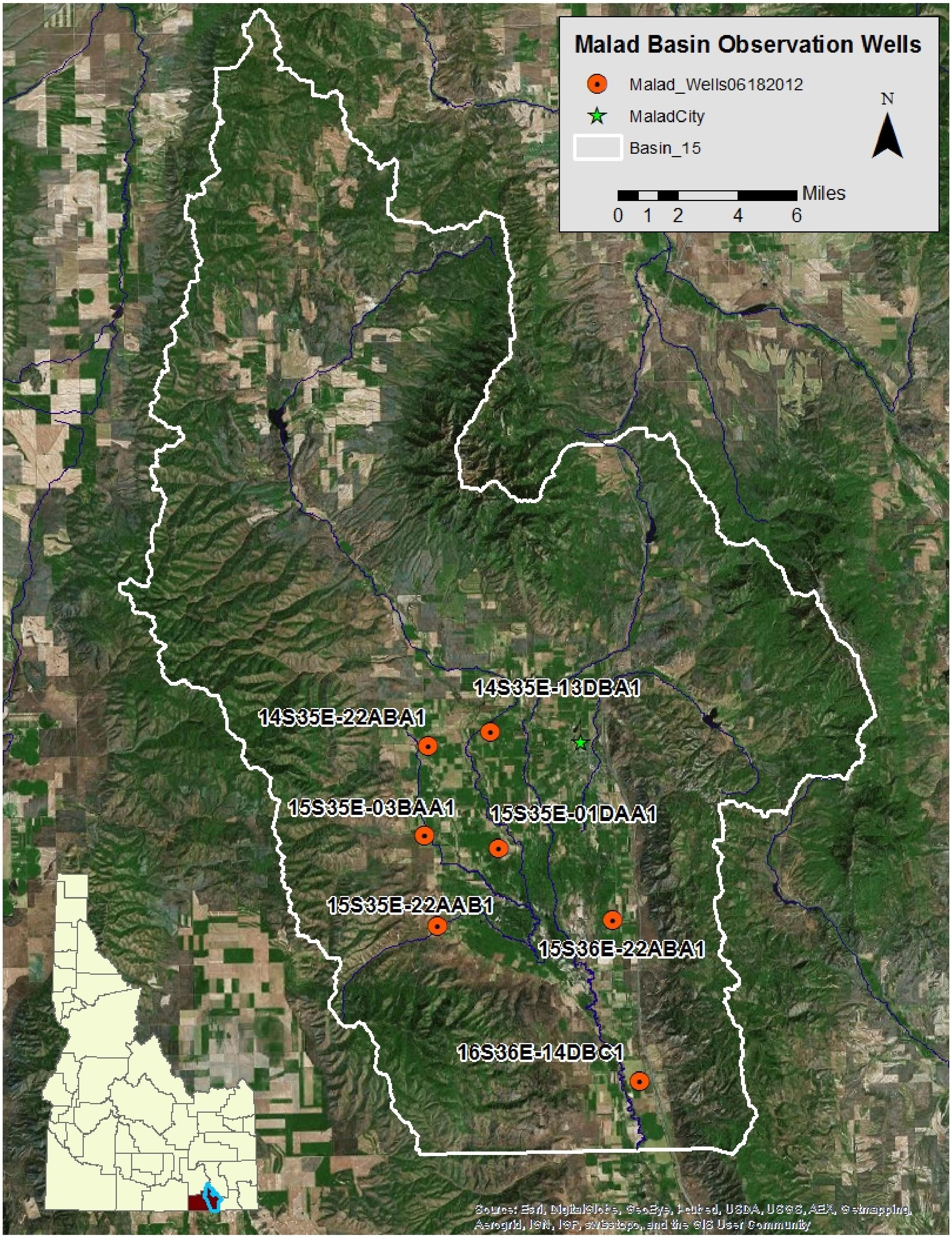

Figure 1. Location map for wells in the Malad Basin that are measured by IDWR. X

Generalized Local Hydrogeology

The Malad Basin is surrounded by mountains composed of crystalline, metamorphic, and consolidated sedimentary rocks. The valley floor consists of thick sequences (hundreds to thousands of feet) of lake-bed and fluvial sediment that formed beneath the ancient Lake Bonneville and Lake Provo. This sediment overlies a deeply depressed structural block (Pluhowski, 1970). The depression was formed primarily by normal faulting which is evident in the faults that are mapped in Figure 2.

The valley fill sediments constitute the main aquifer in the valley. Based on geophysical data, the depth of the sediments in the basin ranges from approximately 2,500 feet near Malad City to 600 feet near the southwest margin of the main aquifer, and the sediments thin to approximately 400 feet in the basin-outlet gap (Burnham, et al., 1969). The aquifer consists of several connected water bearing units composed primarily of sand and gravel that are interbedded with relatively impermeable beds of silt and clay. These distinct yet hydraulically connected layers form a single aquifer from the northern alluvium down through the outlet gap into Utah (Burnham, et al., 1969; Pluhowski, 1970). Although the basin is thousands of feet deep in places, the upper few hundred feet host the only known aquifer capable of producing viable volumes of water (Burnham, et al., 1969).

It is important to note the locations of the alluvium and lake sediments in Figure 2. The alluvium is highly permeable and serves as the primary recharge area for the entire basin. It has been hypothesized that the vast majority of the water in the basin is a result of infiltration of precipitation runoff into the alluvium. The lake sediments cap the majority of the valley floor, and serve as the principal confining unit, producing artesian conditions across the valley in an area that begins a couple miles south Malad City and extends southward to the Woodruff Fault (Burnham, et al., 1969; Figure 2).

The impermeable cap of lake sediments also confines the aquifer in the outlet gap, which is the area south of the Woodruff Fault, although pressures are not great enough to cause artesian conditions. The sediments appear to greatly limit recharge directly from the surface in this area. Water issuing from Woodruff Spring is reported to be warm (89° F) and of poor quality, and the Malad River in this area is also of poor quality (Burnham, et al., 1969; Mower and Nace, 1957; Pluhowski, 1970, http://nwis.waterdata.usgs.gov). Driller's reports in the gap indicate the wells are accessing cold (50° F), good quality water. This implies that the majority of the groundwater exiting the Malad Basin is underflow from the regional aquifer to the north.

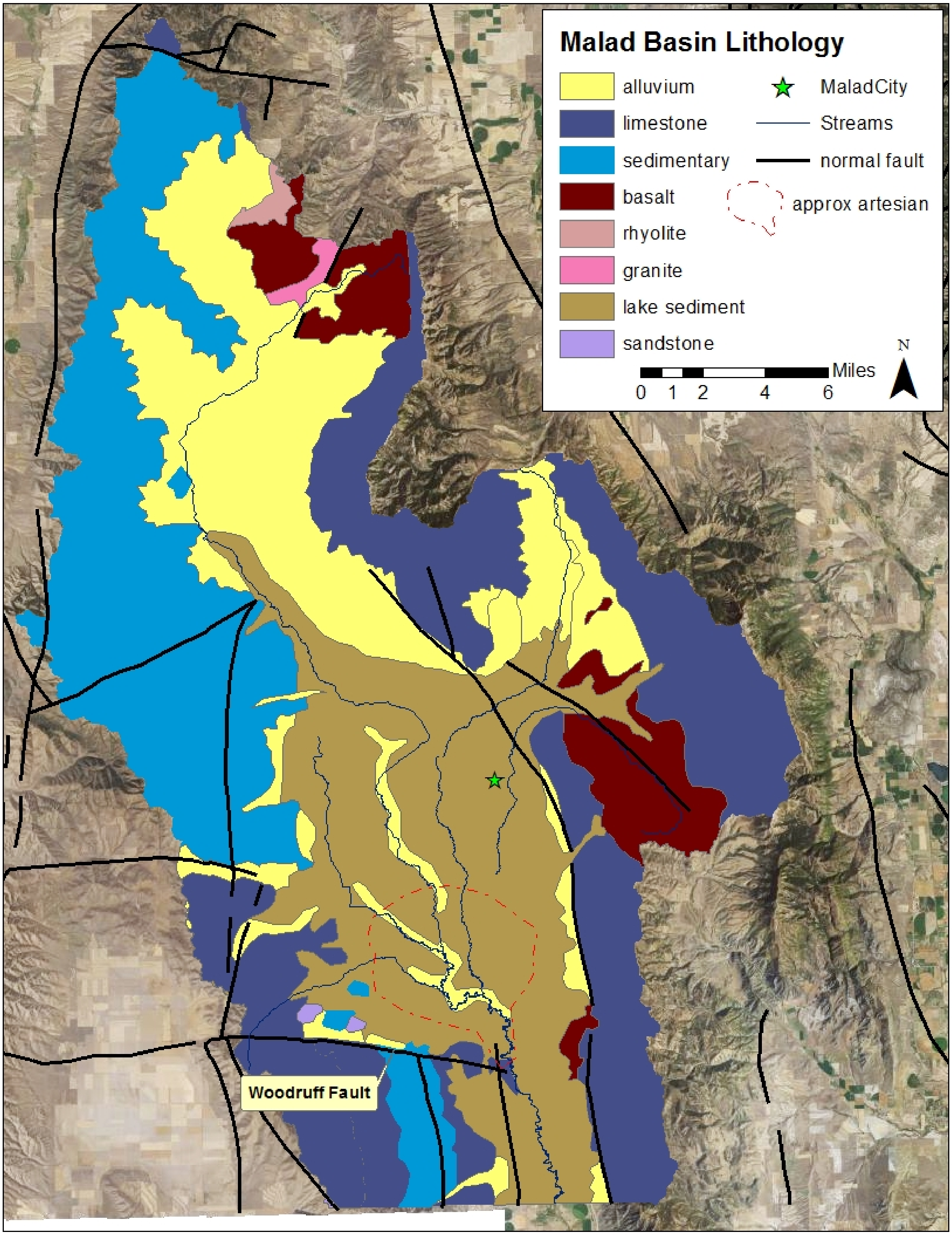

Figure 2. Generalized Lithology in the Malad Basin.

Water-Level Trends

IDWR currently monitors water levels in seven Malad Basin wells (Figure 1). The elevations and depth-of-completion of the wells are listed in Table 1.

Table 1. Well-completion information.

Well	Total Depth (ft)	Open Interval (ft)	Elevation (ft)	Production Elevation (ft)[1]
14S 35E-13DBA1	289	114-289	4,646	4,445
14S 35E-22ABA1	315	305-315	4,670	4,360
15S 35E-03BAA1	120	90-120	4,565	4,460
15S 35E-01DAA1	329	187-275	4,453	4,222
15S 35E-22AAB1	229	NA	4,575	4,346
15S 36E-22ABA1	100	NA	4,419	4,319
16S 36E-14DBC1	81	61-81	4,455	4,384

[1] Production elevation has been estimated as either the mean open interval or total depth.

The groundwater-data records in the Malad Basin begin on various dates and continue until March of 2014, and the following hydrographs illustrate all of the water-level data collected from the wells that IDWR currently monitors. The colored data markers on the hydrographs illustrate the season in which the water-level measurements were taken, and the seasons have been defined in the following manner: spring-season measurements occur in January, February, March or April, irrigation season measurements occur in May, June, July, August or September, and fall-season measurements occur in October, November or December. It is important to note that very few measurements occur in November, December, January, or February.

Trends in water-level changes have been calculated for the most recent 10-year and 20-year periods-of-record (2005 – 2014 and 1995 – 2014, respectively). Each trend has been calculated using the Mann-Kendall (MK) test. The MK test was developed by the USGS and is the most frequently used test for trend in environmental sciences (Helsel and others, 2006). In an effort to segregate water-level changes due to annual water-budget changes from local, short-term irrigation impacts, all trends have been calculated using only spring-season measurements. The significance in water-level trends has been set to 0.10 (90% probability); therefore, any trend with a p-value less than 0.10 is considered to be significant.

Well 14S 35E 13DBA1

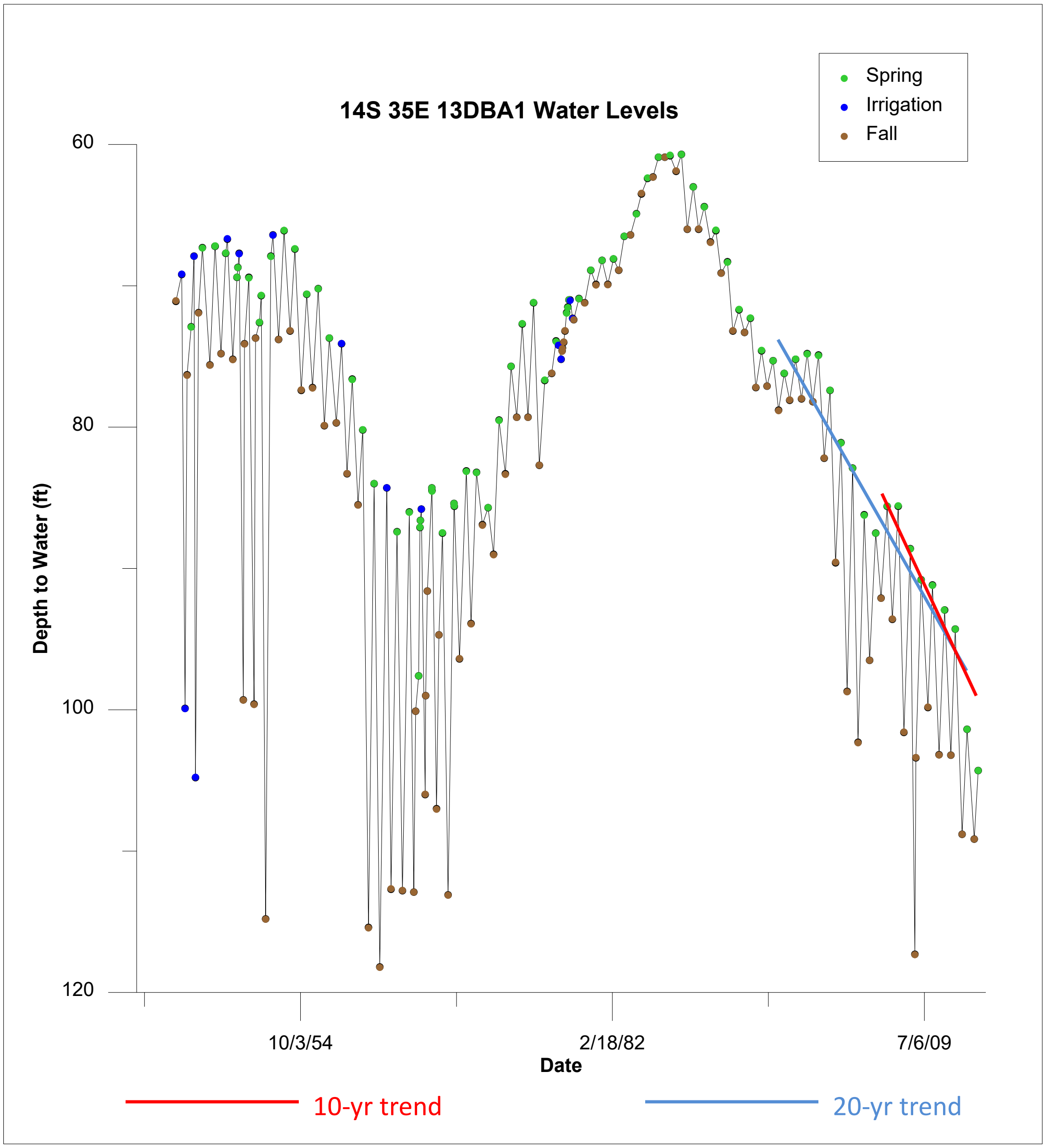

Figure 3. Water levels in well 14S 35E-13DBA1.

The period of record begins in the fall of 1945 and ends in the spring of 2014. Depth-to-water has been below ground surface for the entire period of record, and it appears that this well has never flowed from artesian pressure. Both the 10 and 20-year trends indicate declining water levels (Table 2). Due to the long period-of-record and relatively small degree of inter-annual variability, both the 10 and 20-year trends exhibit a high degree of significance.

Table 2. Calculated trends in water-level changes.

Trend Period	Trend (ft/yr)	p-value	Significance
Recent 20 Years	-1.41	0.0000	Significant
Recent 10 Years	-1.74	0.0005	Significant

Well 14S 35E 22ABA1

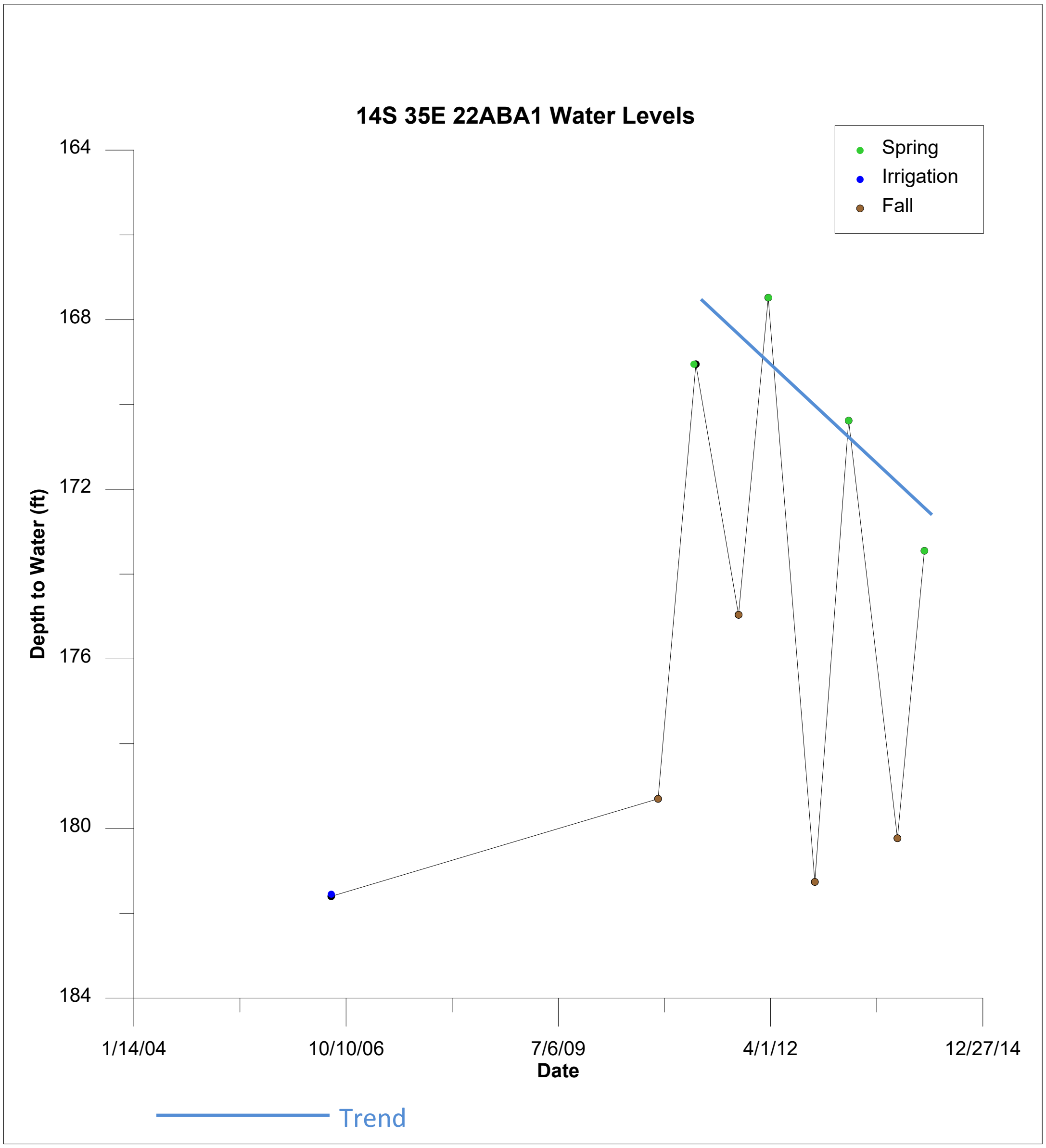

Figure 4. Water levels in well 14S 35E-22ABA1.

The period of record begins in the fall of 2006 and ends in the spring of 2014. Depth-to-water in this well has been below ground surface for the entire period of record, and it appears that this well has never flowed from artesian pressure. Because of the limited record, all spring-season measurements have been included in the trend calculation. The trend indicates declining water levels (Table 3). Due to the limited data set (four data points), the calculated trend is not significant and only limited conclusions can be drawn.

Table 3. Calculated trends in water-level changes (ft/year).

Trend Period	Trend (ft/yr)	p-value	Significance
Period of record	-2.18	0.3082	Not Significant

Well 15S 35E 03BAA1

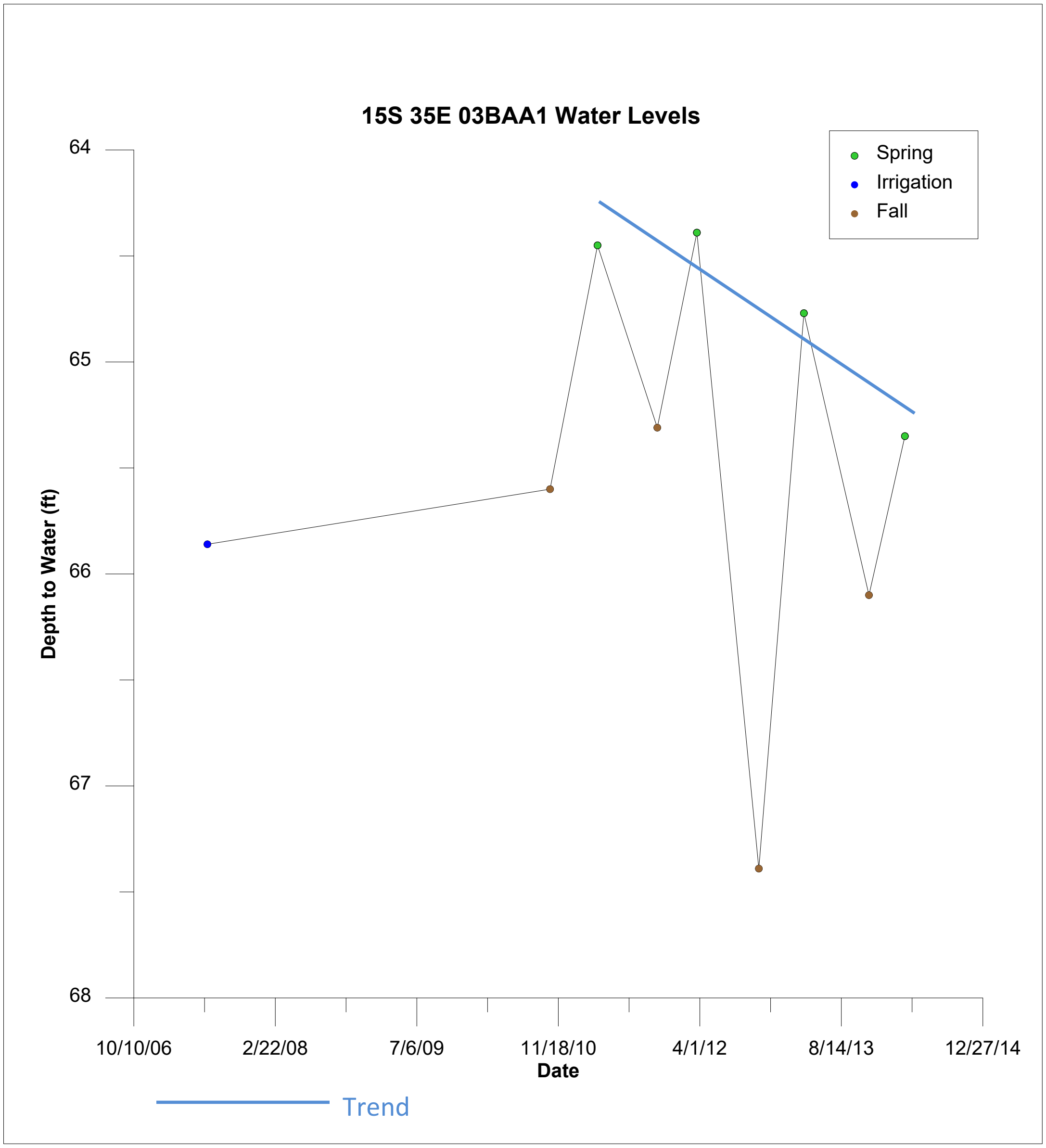

Figure 5. Water levels in well 15S 35E-03BAA1.

The period of record begins in the fall of 2006 and ends in the spring of 2014. Depth-to-water in this well has been below ground surface for the entire period of record, and it appears that this well has never flowed from artesian pressure. Because of the limited record, all spring-season measurements over the period-of-record have been included in the trend calculation. The trend indicates declining water levels (Table 4). Due to the limited data set (four data points), the calculated trend is not significant and only limited conclusions can be drawn.

Table 4. Calculated trends in water-level changes (ft/year).

Trend Period	Trend (ft/yr)	p-value	Significance
Period of record	-0.34	0.3082	Not Significant

Well 15S 35E 01DAA1

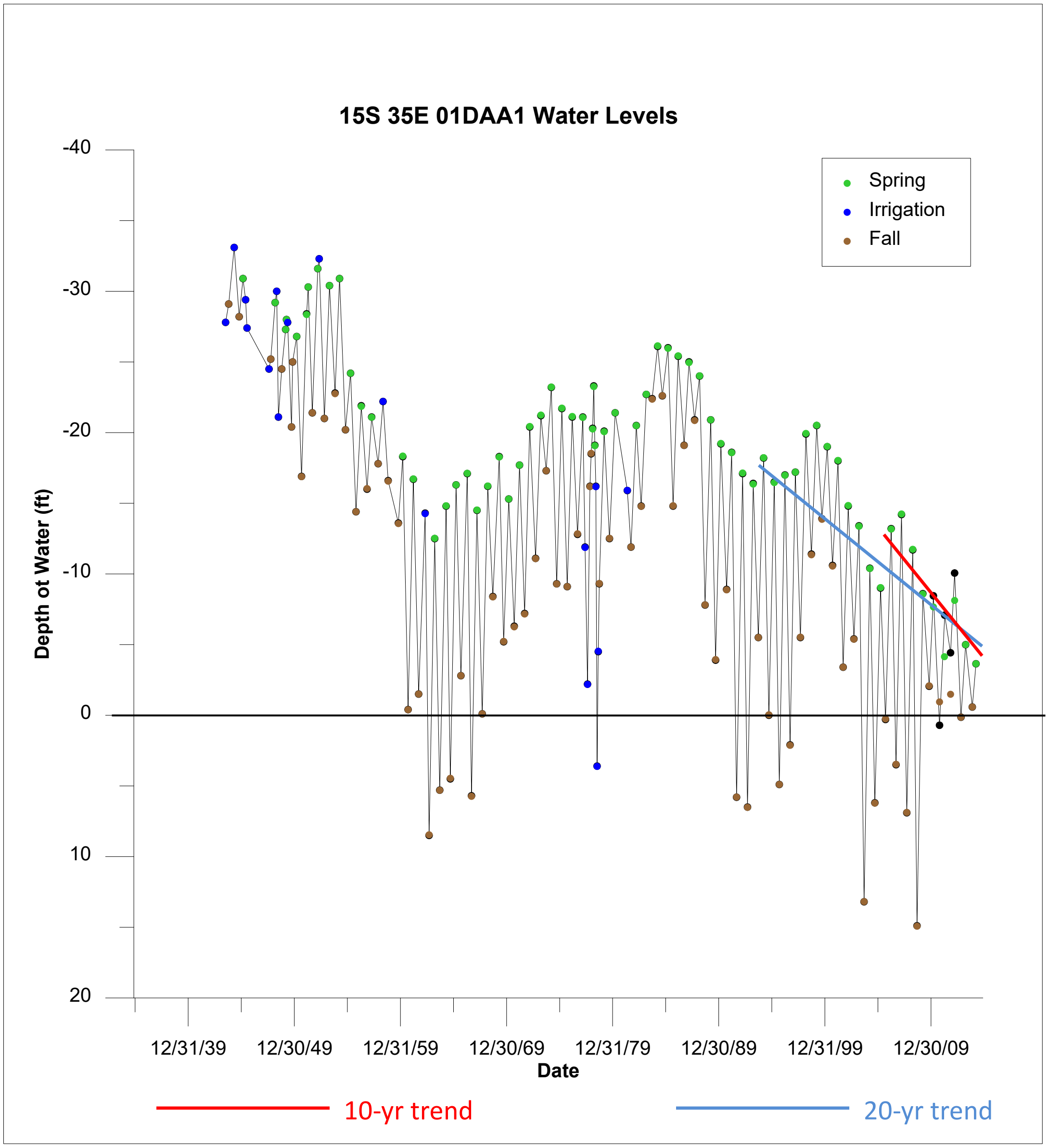

Figure 6. Water levels in well 15S 35E-01DAA1. Negative depths indicate that the water level is above land surface.

The period of record begins in the fall of 1943 and ends in the spring of 2014. Depth-to-water in this well was historically above ground surface; however, water-level declines have resulted in periods when this well ceases to flow. Both the 10 and 20-year trends indicate declining water levels (Table 5). Due to the long period-of-record and relatively small degree of inter-annual variability, both the 10 and 20-year trends exhibit a high degree of significance.

Table 5. Calculated trends in water-level changes (ft/year).

Trend Period	Trend (ft/yr)	p-value	Significance
Recent 20 Years	-0.85	0.0000	Significant
Recent 10 Years	-1.01	0.0073	Significant

Well 15S 35E 22AAB1

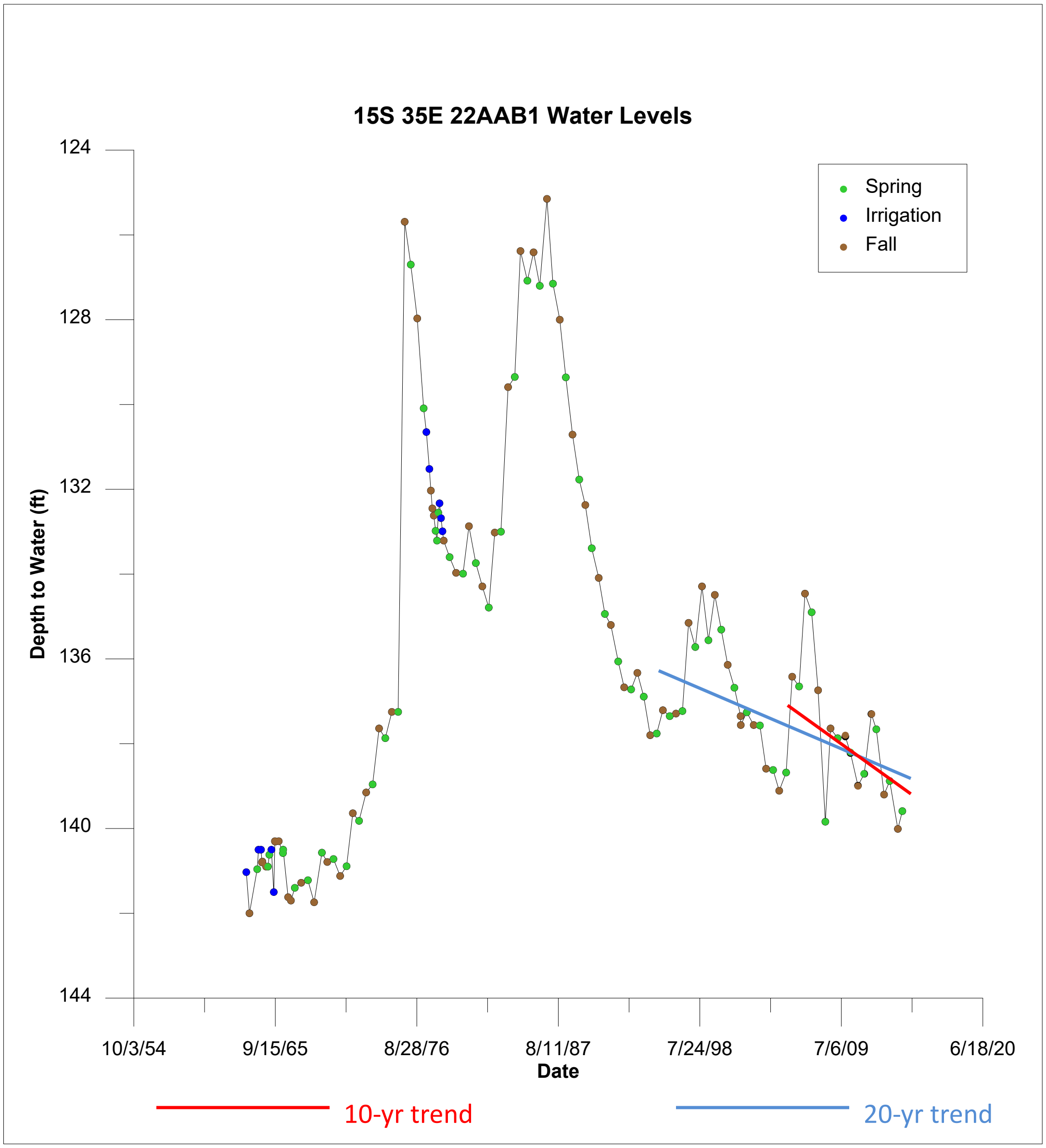

Figure 7. Water levels in well 15S 35E-22AAB1.

The period of record begins in the summer of 1963 and ends in the spring of 2014. Depth-to-water has been below ground surface for the entire period of record, and it appears that this well has never flowed from artesian pressure. Both the 10 and 20-year trends indicate declining water levels (Table 6). The 20-year trend is significant. However, the high degree of inter-annual variability results in a calculated 10-year trend that is not significant.

Table 6. Calculated trends in water-level changes (ft/year).

Trend Period	Trend (ft/yr)	p-value	Significance
Recent 20 Years	-0.13	0.0162	Significant
Recent 10 Years	-0.29	0.2430	Not Significant

Well 15S 36E 22ABA1

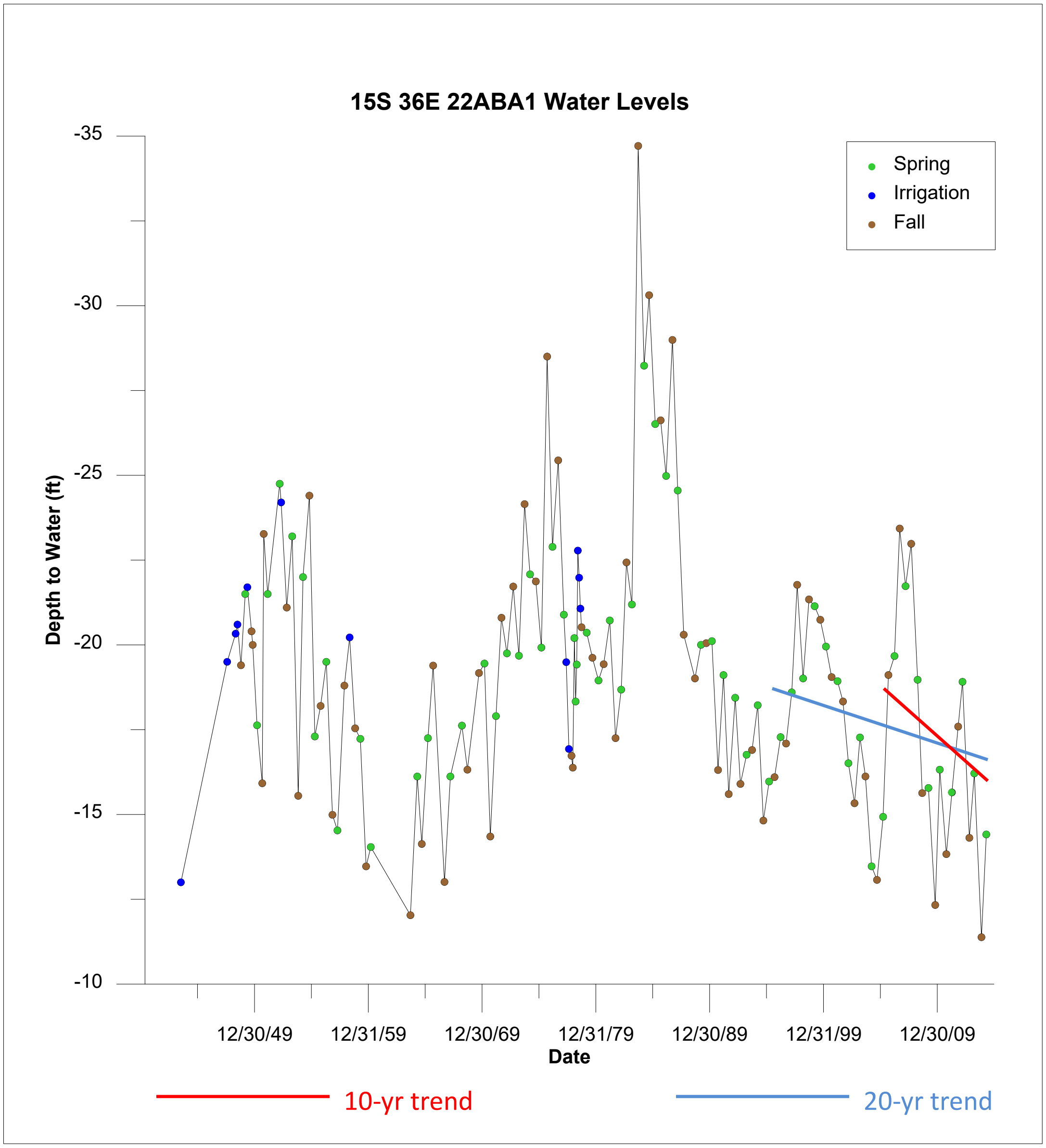

Figure 8. Water levels in well 15S 36E-22ABA1. Negative depths indicate that the water level is above land surface.

The period of record begins in the fall of 1943 and ends in the spring of 2014. Depth-to-water in this well is above ground surface. Despite water-level declines, this well continues to flow due to artesian pressure. Both the 10 and 20-year trends indicate declining water levels (Table 7). Despite the long period-of record, the high degree of inter-annual variability results in calculated trends that are not significant.

Table 7. Calculated trends in water-level changes (ft/year).

Trend Period	Trend (ft/yr)	p-value	Significance
Recent 20 Years	-0.11	0.2044	Not Significant
Recent 10 Years	-0.41	0.2105	Not Significant

Well 16S 36E 14DBC1

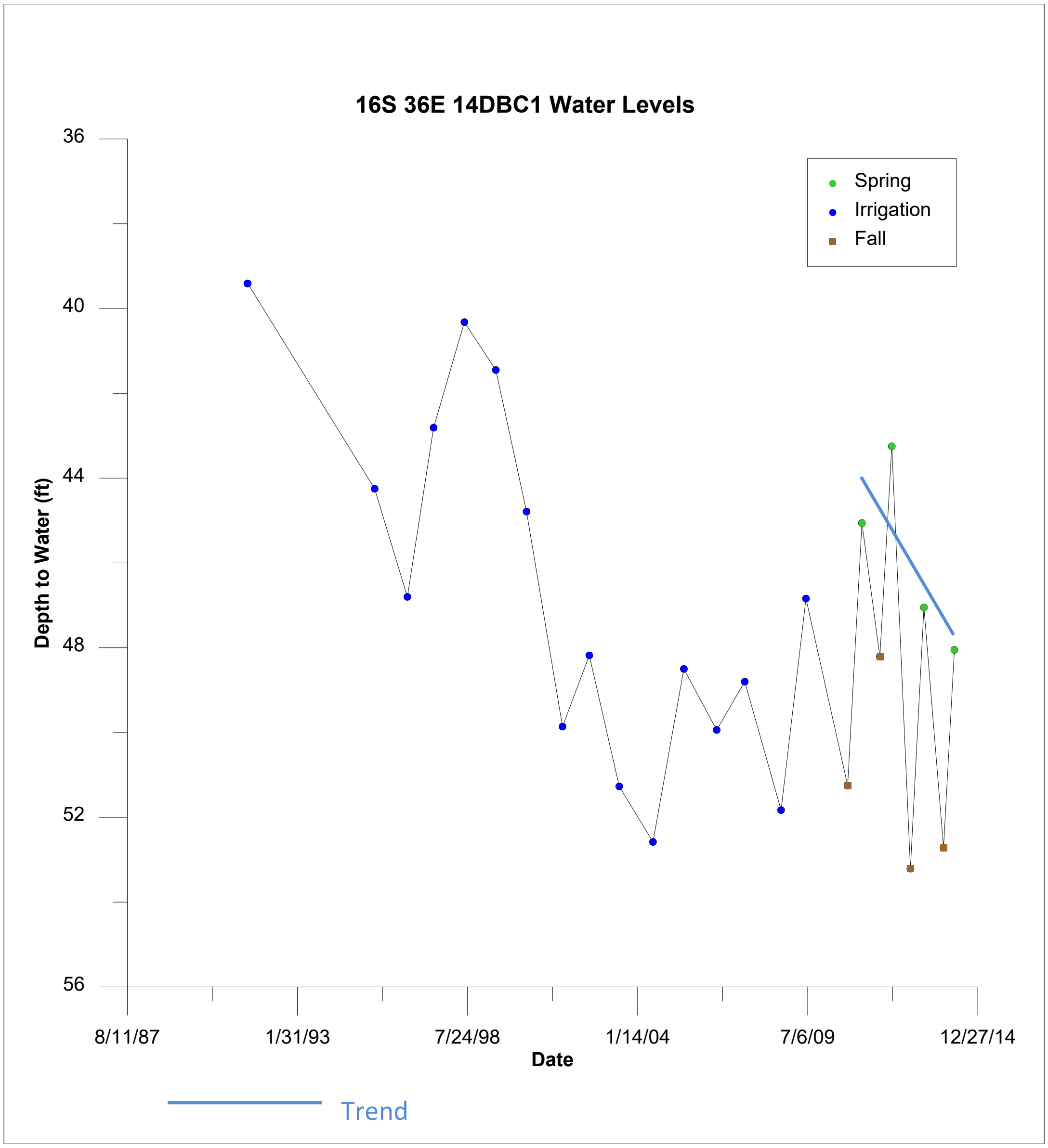

Figure 9. Water levels in well 16S 36E-14DBC1.

The period of record begins in the fall of 2006 and ends in the spring of 2014. Depth-to-water in this well has been below ground surface for the entire period of record, and it appears that this well has never flowed from artesian pressure. Although this well has been monitored since 1991, all of the measurements prior to 2010 were taken during the irrigation season. Therefore, all spring-season measurements (four years) have been included in the trend calculation. The trends indicate declining water levels (Table 8). Due to the limited data set (four data points), the calculated trend is not significant and only limited conclusions can be drawn.

Table 8. Calculated trends in water-level changes (ft/year).

Trend Period	Trend (ft/yr)	p-value	Significance
Period of record	-1.0	0.3082	Not Significant

Water levels Compared with Precipitation

In an effort to understand the water-level fluctuations that have been observed in the Malad area wells, water levels from the seven IDWR-measured wells have been graphed with precipitation.

Precipitation data from PRISM have been used to estimate precipitation in the Malad Basin. Because the natural variation in annual precipitation tends to obscure the long-term precipitation signature, precipitation has been smoothed using a 5-year averaging window. Although there is a lag of approximately four years, it appears via visual inspection that water levels in the Malad Basin tend to follow changes in precipitation. More specifically, it appears that water-level declines correspond to extended periods of below average precipitation (1943-2103 average). Water-level increases that occurred from the 1970's to 1980's corresponds to a period of above average precipitation. Shorter periods of of above average precipitation, or periods with precipitation that is marginally above average, result in generally stable water-level trends (Figure 10).

Trends in precipitation were calculated for the most recent 10 and 20-year periods-of-record using the Mann-Kendall test for trend. Both the periods exhibit declining trends in precipitation (Table 9). Despite the long period-of record, the high degree of inter-annual variability over the results in calculated trends that are not significant.

Table 9. Calculated trends in precipitation (acre-ft/year).

Trend Period	Trend (ft/yr)	p-value	Significance
Recent 20 Years	-18,268,440	0.5813	Not Significant
Recent 10 Years	-17,887,186	0.1074	Not Significant

The declines in precipitation appear to have slowed over the last 10 years as compared to the 20-year trend, which is opposite of what is observed in the water levels (Tables 1, 4, 5, and 6). However, it is important to note that neither trend in precipitation is significant (Table 8).

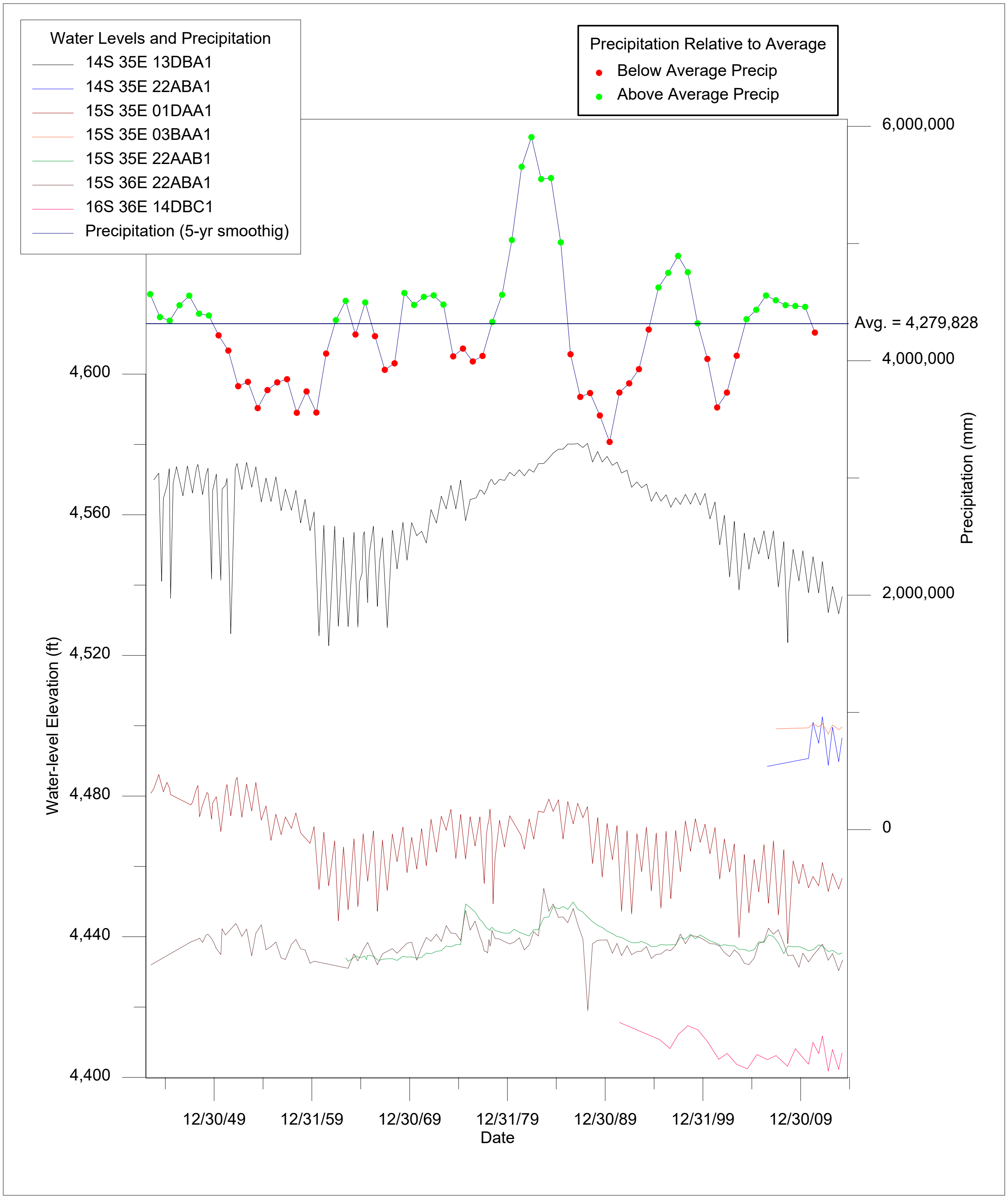

Figure 10. Water levels in comparison with precipitation. Precipitation has been smoothed using a 5-year averaging window; therefore, no single data point represents an actual precipitation value. Note that the precipitation axis (right axis) has been adjusted up for clear display with water levels.

Additional Data Needs

IDWR currently monitors water levels in seven Malad Basin wells. However, there are several data needs that should be addressed in order to provide the necessary information for water-resource decision making.

Additional Wells

There are three areas with little or no groundwater information in the Malad Basin. These areas are illustrated in Figure 10 and listed below:

- Daniels Reservoir Area (Zone 1) – There are no water-level data in this area. Additional data will allow for both the monitoring of water levels over time and determination of the groundwater flow direction.

- Malad City Area (Zone 2) – Most of the population of the Malad Basin lives in this area, and two of the four surface-water inflows enter the main aquifer here. No current water-level monitoring is occurring in this area.

- Haylands Area (Zone 3) – This is an area in which water levels are above land surface. IDWR currently monitors two flowing wells located on the fringes of the area; one of which now only flows intermittently. This area is critical to understanding the water resources of the area. Furthermore, several wells are free-flowing, and at least some of the wells are too old or poorly constructed to be shut-in. This area has the need for more monitoring, as well as an inventory of flowing wells and their construction status.

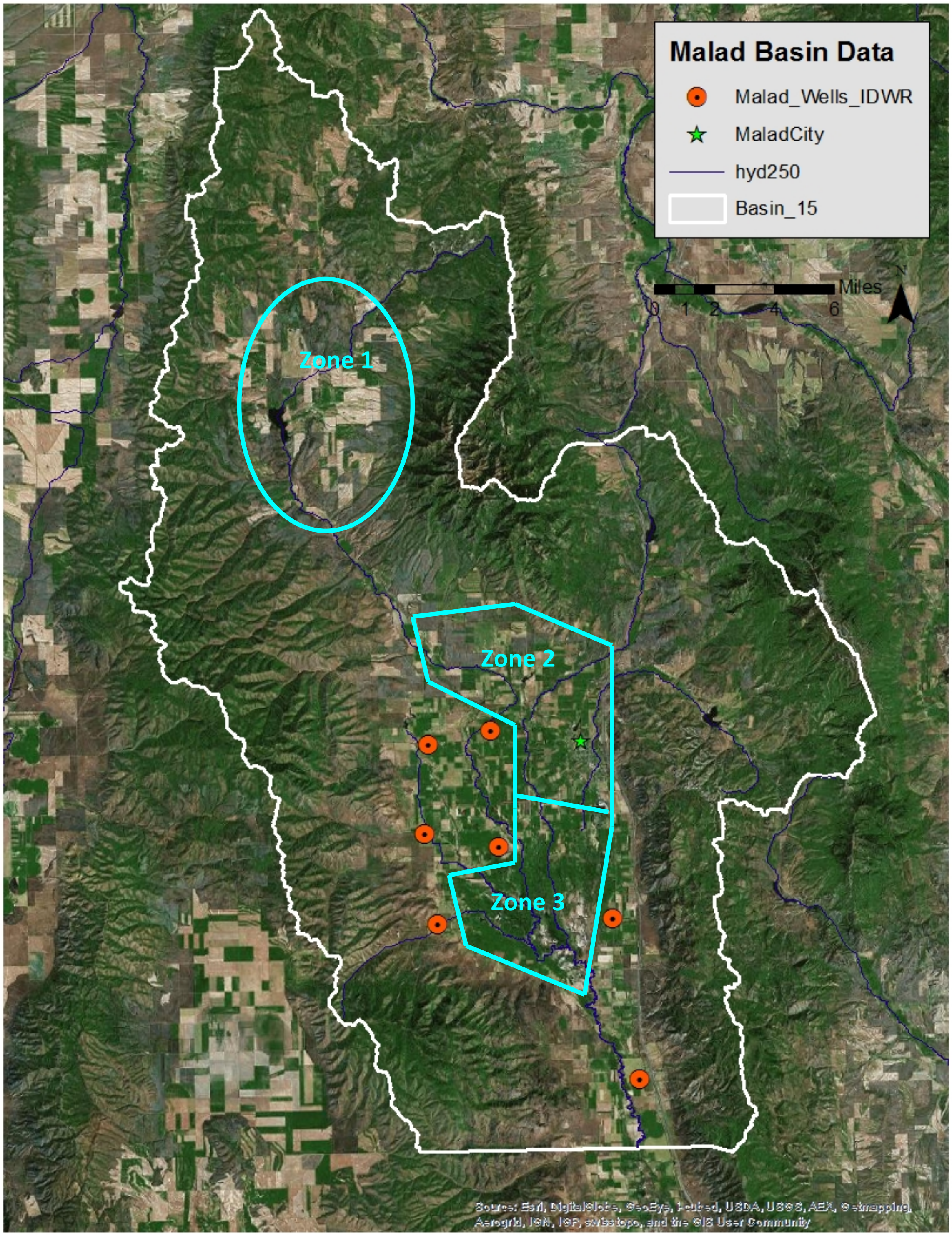

Figure 11. Locations of proposed areas for additional water-level data collection.

Surface Water Monitoring

There are currently no surface-water monitoring sites in the Malad Basin. Surface-water data are imperative for understanding the relationship between water supplies and consumptive use. There are four main surface-water inflows into the Malad Basin water supply: the Little Malad River, the Malad River, Devil Creek, and Deep Creek. Potential locations are based on previously located USGS gages. Suggested locations for surface-water measurement are illustrated in Figure 11 and listed below:

- Little Malad River ab Elkhorn Res. Nr Malad City (USGS #10119000) – This gage is located on the Little Malad River downstream of the Danielson Reservoir and captures the Little Malad River flow below Danielson Reservoir, as well as some springs. This site would measure the surface-water inflow from the Little Malad River, which is the largest tributary stream in the basin.

- Malad River bel Malad Springs nr Malad (USGS #10118200) – This gage located on the Malad River just downstream of the source at Malad Springs. This site would measure the surface-water inflow from the Malad River.

- Devil Creek ab Evans Dividers nr Malad City (USGS #10123000) – This gage is located on Devil Creek below Devil Creek Reservoir. This gage would measure surface-water inflow from Devil Creek as well as the volume of water imported from the neighboring Birch Creek basin.

- Deep Creek bl First Creek nr Malad City (USGS #10125000) – This gage is located on Devil Creek just below the reservoir and is an important source of water for Malad City. This gage would measure surface-water inflow from Devil Creek.

- Malad River at Woodruff (USGS #10125500) – This gage is located on the Malad River, south of Woodruff, ID. This is the last gage location before the Malad River exits Idaho. This gage is necessary for measuring surface-water outflow from the basin. Discharge from Woodruff Spring may be necessary to calculate the actual discharge from the Malad Basin.

- Woodruff Springs (or Woodruff Hot Springs USGS #420322112144101) – This gage would measure the flow from Woodruff Spring. Woodruff Spring appears to discharge groundwater from the basin aquifer, as well as out-of-basin geothermal water moving up the Woodruff fault. This site is necessary for calculating the outflow from the Malad Basin.

All of the potential surface-water monitoring sites would provide valuable information regarding the water resources of the Malad Basin. However, monitoring resources can be maximized by monitoring the outflow from the basin as calculated from the flow at Woodruff Springs and the Malad River at Woodruff. To compute the basin water budget (Inflow – Outflow = Change-in-Storage), basin-wide precipitation can be used as inflow, flow from Woodruff Springs and the

Malad River at Woodruff (in combination with evapotranspiration) can be used as outflow, and water-level changes can be used to estimate changes in aquifer storage.

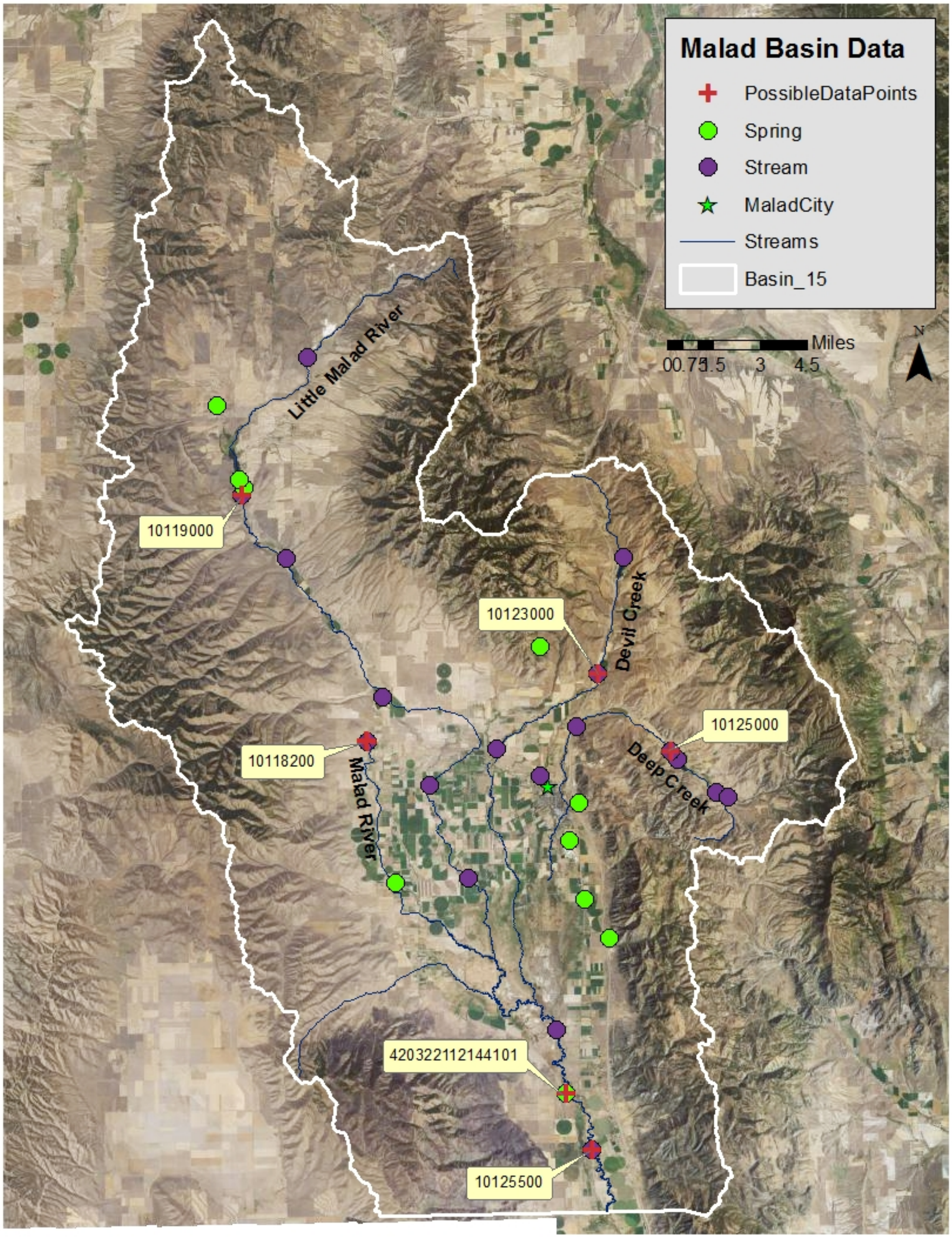

Figure 12. Locations of proposed surface-water gage locations.

Summary

IDWR currently monitors water levels in seven Malad Basin wells, and all seven of the wells indicate declining water levels over recent years (Table 10).

Table 10. Water-level trends (ft/yr) for all Malad Basin wells currently monitored by IDWR.

Well	20-Year Trend	20-Year Significance	10-Year Trend	10-Year Significance	4-Year Trend	4-Year Significance
14S 35E 13DBA1	-1.41	Significant	-1.74	Significant	--	--
14S 35E 22ABA1	--	--	--	--	-2.81	Not Significant
15S 35E 01DAA1	-0.85	Significant	-1.01	Significant	--	--
15S 35E 03BAA1	--	--	--	--	-0.34	Not Significant
15S 35E 22AAB1	-0.13	Significant	-0.29	Not Significant	--	--
15S 36E 22ABA1	-0.11	Not Significant	-0.41	Not Significant	--	--
16S 36E 14DBC1	--	--	--	--	-1.00	Not Significant

Table 11. Precipitation trends (acre-ft/yr) for the Malad Basin.

	20-Year Trend	20-Year Significance	10-Year Trend	10-Year Significance
Precipitation	-18,268,440	Not Significant	-17,887,186	Not Significant

Wells with a long enough measurement history to calculate 10 and 20-year trends indicate that trends in water-level declines are higher (greater decline per year) in more recent years; although, not all calculated trends are significant.

Calculated trends in precipitation indicate that precipitation has been declining over the last 20 years. Furthermore, the declines in precipitation have slowed over the last 10 years as compared to the 20-year trend, which is opposite of what is observed in the water levels. However, it is important to note that neither trend in precipitation is significant (Table 11).

A comparison of water levels with annual precipitation indicates that the area wells may be exhibiting long-term fluctuations that correspond to precipitation, with a lag of approximately four years.

The water-level data that IDWR collects indicate a declining resource. However, the spatial coverage of the wells is generally limited to the central part of the basin. To adequately characterize the water resources, it is recommended that additional water-level data be collected in the northern, eastern and south-central basin. Furthermore, it is recommended that surface-water data be collected at four inflow, and two outflow sites.

References

Burnham, W.L., Harder, A.H., and Dion, N.P. 1969. Availability of ground water for large-scale use in the Malad Valley-Bear River areas of Southeastern Idaho – An initial assessment. U.S. Geological Survey Open-File Report 69-28, 40p.

Helsel, D.R., Meuller, D.K., and Slack, J.R. 2006. Computer program for the Kendall family of trend tests. U.S. Geological Survey Scientific Investigations Report 2005-5275, 4p.

Mower, R.W., and Nace, R.L. 1957. Water consumption by water-loving plants in the Malad Valley, Oneida County, Idaho. U.S. Geological Survey Water-Supply Paper 1412, 33p.

Pluhowski, E.J. 1970. Hydrology of the Upper Malad River Basin, Southeaster Idaho. U.S. Geological Survey Water-Supply Paper 1888, 89p.