Idaho Department of Water Resources

MALAD VALLEY GWMA, 2020 UPDATE

ONEIDA COUNTY, IDAHO

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2020 Update of Groundwater Conditions in the Malad Valley Groundwater Management Area

IDAHO DEPARTMENT OF WATER RESOURCES

The Idaho Department of Water Resources designates Critical Ground Water Areas (CGWAs) and Ground Water Management Areas (GWMAs) under Idaho Code §42-233a and §42-233b, respectively. A CGWA is all or part of a groundwater basin that does not have sufficient ground water to provide a reasonably-safe supply for irrigation or other uses at the current or projected rates of withdrawal. A GWMA is all or part of a groundwater basin that may be approaching the conditions of a CGMA. The Malad Valley GWMA was designated on November 4, 2015, based on local concerns regarding declining water levels. This report describes the status and trends of aquifer levels in the Malad Valley GWMA located primarily in Oneida County.

Introduction

The Idaho Department of Water Resources (IDWR) maintains a groundwater-level monitoring network in the Malad Valley GWMA which is located in Oneida County of southeastern Idaho. The monitoring network currently consists of 5 wells located on the valley floor, in the central and southern part of the GWMA (Figure 1).

The GWMA is located in southeastern Idaho on the Utah border, approximately 30 miles south of Pocatello, ID, and encompasses 500 square-miles of the Lower Bear-Malad River drainage basin. The GWMA covers the entire drainage basin within Idaho, including the surrounding mountains. Land surface elevations in the GWMA range from 4,400 to 9,300 feet (ft) with an average elevation of 5,590 ft; the average valley-bottom elevation is 4,650 ft. The 30-year (1991-2020) average annual precipitation at the Malad National Weather Service Climate station (NWS USC00105544) is 15.6 inches, and the region is classified as "warm humid continental climate" (Dfb, Koppen climate classification), where: (1) there is no significant difference in seasonal precipitation, (2) the average temperature of the coldest month is below 32 ^{O}F, (3) the average temperature for all months is below 71.6 ^{O}F, and (4) the average temperature is above 50 ^{O}F at least four months per year. The "humid" classification denotes the lack of a dry season in the Malad valley. IDWR records show that there are more than 150 surface water rights and 450 groundwater rights; however, there has never been an adjudication of water rights in the valley (IDWR, 2017).

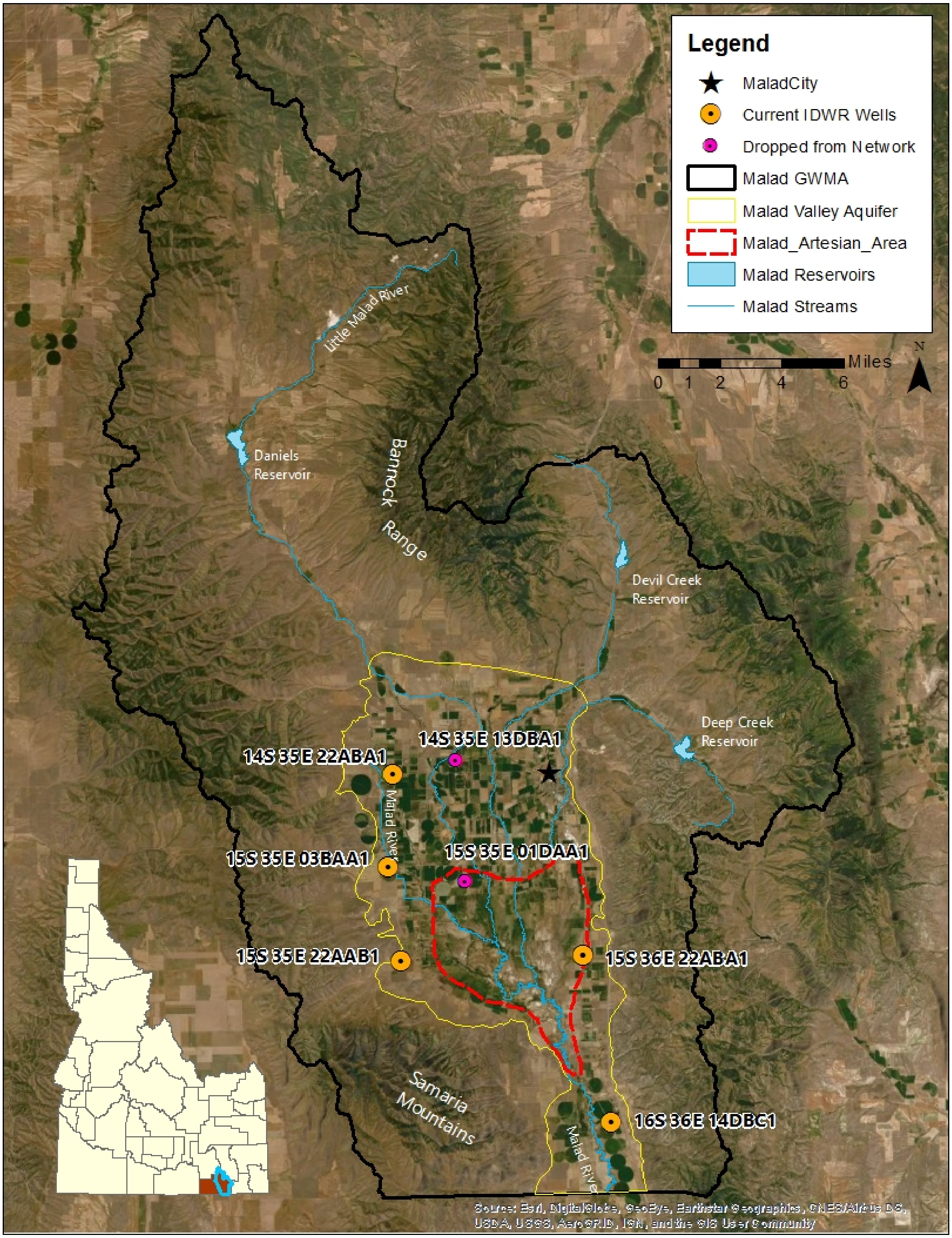

Figure 1. Location map for wells in the Malad Basin that are measured by IDWR.

Purpose and Scope

The purpose of this report is to describe the basin hydrogeology and water use, summarize the status of the Malad Valley GWMA groundwater-monitoring network, and present water-level data collected over the network's history.

Precipitation and Drought

Precipitation

Precipitation volumes for the Malad Valley GWMA were calculated from Oegon State University PRISM data (PRISM, 2004). The natural variation in annual precipitation tends to obscure the long-term precipitation signature; therefore, precipitation has been smoothed using a 3-year averaging window. Precipitation during the years 1945 through 2020 ranged from 350,000 to 960,000 acre-feet/year with an average of 540,000 acre-feet/year. Both the annual, and 3-year average precipitation volume on the GWMA are illustrated in Figure 2.

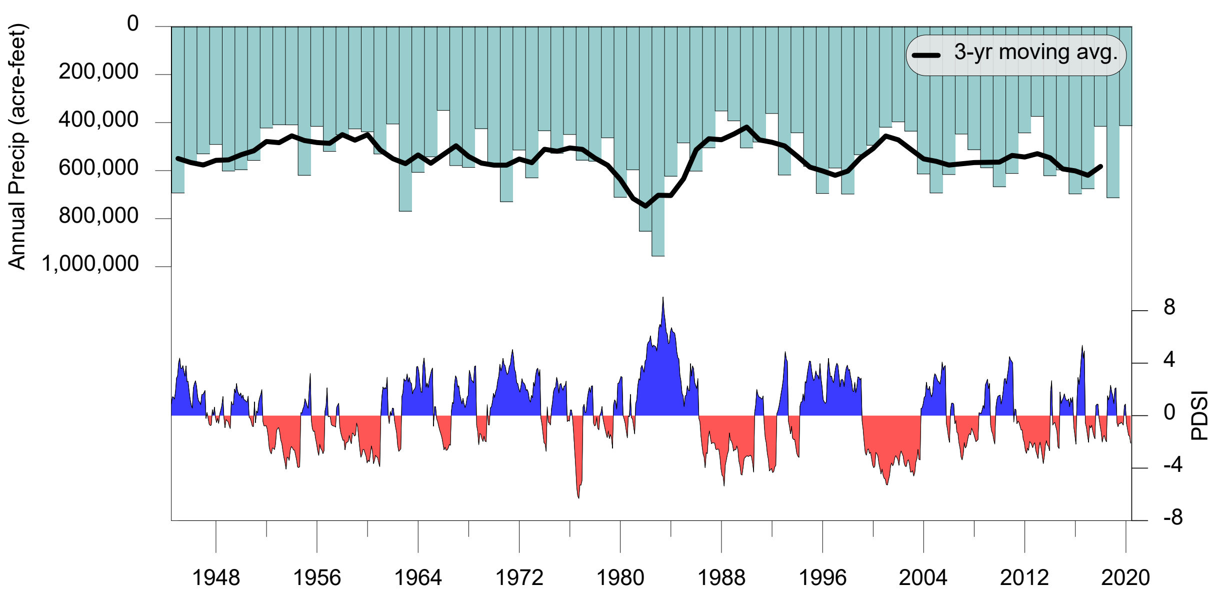

Figure 2. Precipitation and Palmer Drought Severity Index in the Malad GWMA.

Palmer Drought Severity Index

The Palmer Drought Severity Index (PDSI) is the most prominent index of regional drought severity (Dai, 2019). The index considers precipitation, potential evapotranspiration (ET), and soil moisture to determine drought severity using a physical water balance model, and it has proven to be most effective in determining long-term (several months to years) drought (Alley, 1984).

The PDSI is a standardized measure of aridity, and ranges from -10 to 10, with zero considered as normal. Drought is indicated by values of -2 or less, and values of 2 or greater are indicative of wet periods (Table 1).

Table 1. PDSI for the Malad Valley GWMA[1]

PDSI Classification	PDSI Value	1945-2020	1945-2020 Wet/Dry	2001-2020	2001-2020 Wet/Dry
Extremely Wet	$x \geq 4$	6%		4%	
Very Wet	$3 \leq x < 4$	8%	28%	3%	17%
Moderately Wet	$2 \leq x < 3$	14%		10%	
Near Normal	$-2 < x < 2$	46%	46%	50%	50%
Moderate Drought	$-2 \geq x > -3$	13%		15%	
Severe Drought	$-3 \geq x > -4$	9%	26%	11%	33%
Extreme Drought	$x \leq -4$	4%		6%	

[1]The Malad area is within the Idaho Eastern Highlands climate zone (NOAA, 2021).

Water Use

The overwhelming majority of water in the GWMA is due to infiltration of precipitation that falls within the drainage basin; however, up to 4,464 acre-feet/year of surface flow is imported from Birch Creek for irrigation north of Malad City. Surface water and groundwater provide water for irrigation, stock, municipal, commercial, industrial, and domestic water uses in the Malad GWMA. Irrigation is the predominant use in the basin based on listed water rights (Figure 3).

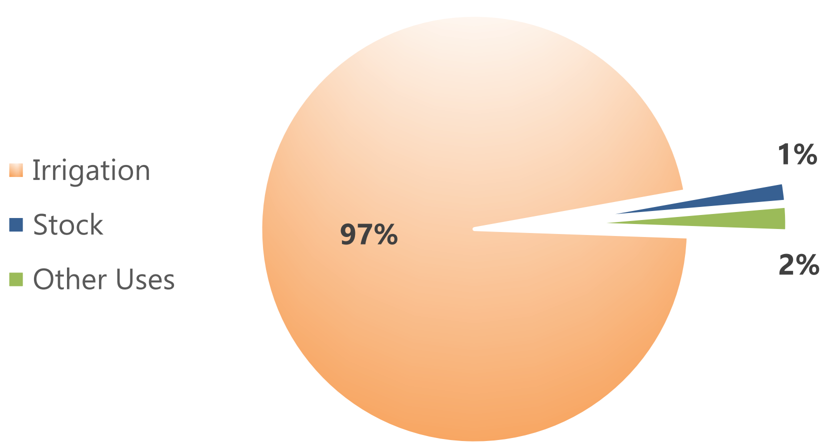

Figure 3. Percent of total allowable diversions by water use. The Other Uses category comprises municipal, commercial, industrial, and domestic uses.

Approximately 49,000 acres within the Malad GWMA are within the place of use (POU) for irrigation water rights (Figure 4), with about 26,000 acres served by only surface water sources, about 9,000 acres served by only groundwater sources, and about 13,000 acres with both surface and groundwater irrigation sources (i.e., mixed source).

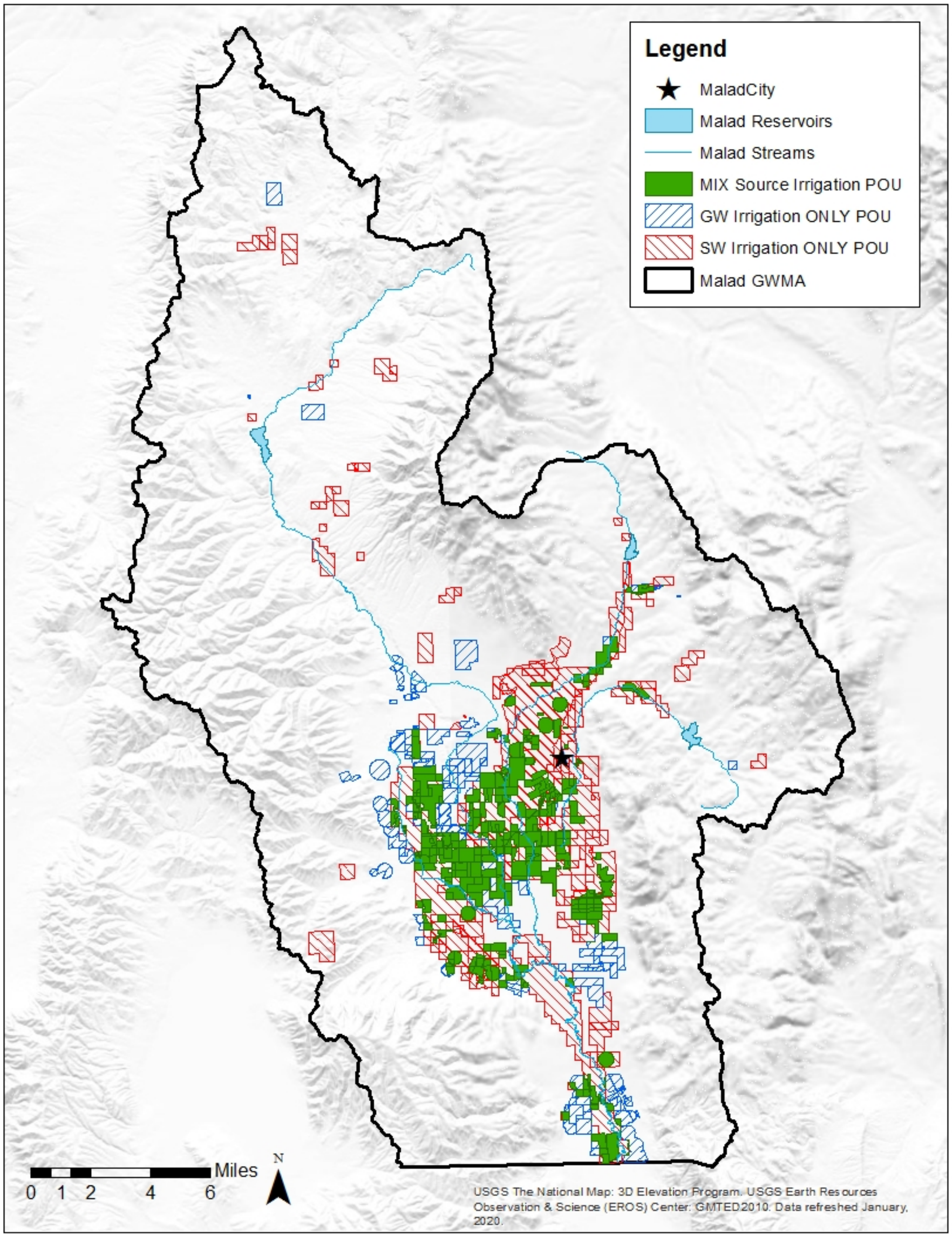

Figure 4. Water right POUs in the Malad Valley GWMA.

Actual irrigated acreage is less than the total POU acreage; however, there are currently no irrigated-lands delineations available for the Malad GWMA, and a different method is necessary to refine the irrigated-acreage estimate.

Crop irrigation requirement (CIR) represents the amount of water (in addition to precipitation) that must be applied to meet the evapotranspiration needs for a crop, and CIR has been calculated as evapotranspiration (Allen et. al., 2005) minus precipitation (PRISM, 2004) for this report. CIR can be used to differentiate irrigated from non-irrigated lands because CIR is generally much higher for irrigated land than non-irrigated land. Therefore, CIR data from nine years between 2010 and 2020 were visually compared with land cover rasters (USDA, 2021) and satellite imagery to delineate irrigated and non-irrigated lands. Areas with less than 300 millimeters of irrigation-season (April through October) CIR were assumed to be non-irrigated and were excluded from the analysis. Water right POUs were overlaid with the CIR data to estimate irrigated agricultural acreage. Areas that were both within the footprint of a POU and had at least 300 millimeters of CIR were classified as irrigated agriculture. This analysis suggests the actual irrigated area averages about 22,000 acres, with about 9,000 acres served by only surface water, about 5,000 acres served by only groundwater, and about 8,000 acres served by both surface and groundwater. Although these estimated irrigated areas are more representative than the listed POU acreage, they are broad estimates and are not intended to substitute for concerted delineation of irrigated lands.

Consumptive use has been evaluated by analysis of crop irrigation requirement data. The total consumptive use of irrigation water within the GWMA, calculated for nine irrigation seasons between 2010 and 2020, ranges from 10,000 to 37,000 AF per season with an average of approximately 20,000 AF per season. Consumptive use of irrigation water for lands irrigated wholly or partially with groundwater ranges from 8,000 to 25,000 AF per season, averaging approximately 14,000 AF with a crop irrigation requirement that ranges from 0.6 to 1.9 feet per season.

Hydrogeology

The Malad Basin is surrounded by mountains composed of crystalline, metamorphic, and consolidated sedimentary rocks. The Malad Valley floor consists of thick sequences (hundreds to thousands of feet) of lakebed and fluvial sediment that were deposited during repeated lake inundation and desiccation over the last 75,000 years (Morrison and Frye, 1965). Shoreline scars from the most recent of the ancient lakes (Lake Bonneville and Lake Provo) are visible throughout the valley. These sediment sequences overlie 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 in the Malad Valley constitute the main aquifer in the basin, and the water-bearing units are most likely alluvium that was deposited during periods without a lake Burnham, et al., 1969). Based on geophysical data, the depth of the sediments in the Malad Valley 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 surficial deposits of alluvium and lake sediments as illustrated in Figure 5. The alluvium is highly permeable, and most of the recharge to the aquifer occurs in areas where the alluvium is exposed at land surface. The fine-grained lacustrine sediments cap the alluvium on the valley floor in the central and southern parts of the basin, and serve as the principal confining unit. The confining unit produces artesian conditions across the valley in an area that begins a couple miles south Malad City and extends south toward the Idaho-Utah state border (Burnham, et al., 1969; Figure 5, Figure 6).

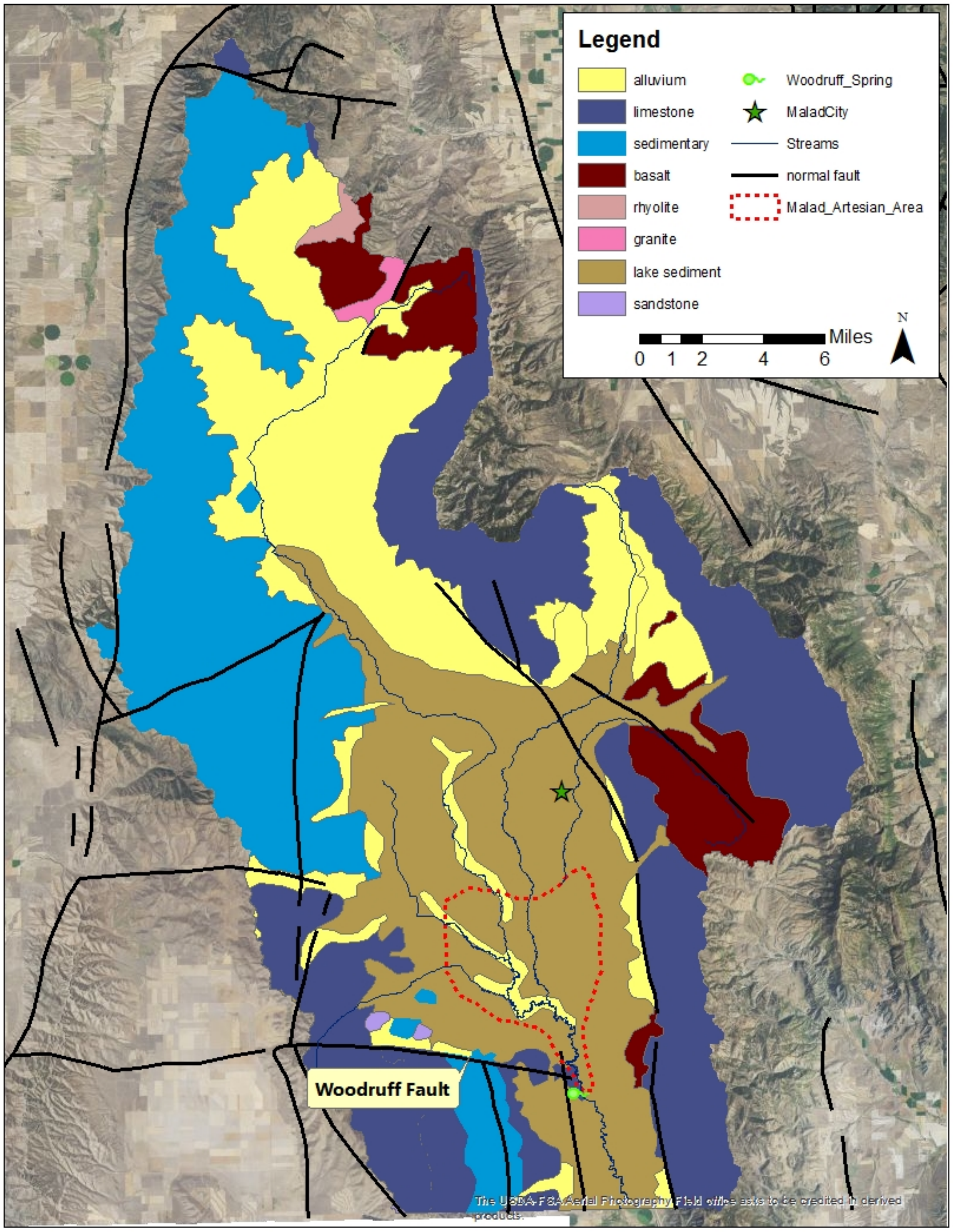

Figure 5. Generalized lithology in the Malad Valley GWMA.

The impermeable cap of lake sediments also confines the aquifer in the outlet gap, which is the area south of the Woodruff Fault (Figure 5); however, pressures are not great enough to cause flowing artesian conditions. The sediments appear to greatly limit recharge directly from the surface in this area. Water issuing from Woodruff Spring (Figure 5) is reported to be warm (89^{o} F) and highly saline, and the Malad River in this area is also saline (Burnham, et al., 1969; Mower and Nace, 1957; Pluhowski, 1970, http://nwis.waterdata.usgs.gov); however, driller's reports in the gap indicate the wells are accessing cold (50^{o} F), good quality water. This implies that most of the groundwater exiting the GWMA into Utah originates as recharge to the alluvial sediments in the northern area of the basin.

Artesian Area

The artesian area mentioned above covers about 25 square miles in the south-central part of the valley (Figure 1 and Figure 6). The water table is near or above land surface in this area, and evaporation of saline groundwater from the saturated land surface creates large areas of saline soil (Burnham et. al., 1969). Anecdotal evidence suggests that large areas with saturated and saline soils existed prior to irrigation in the Malad Valley, and despite the fact that hundreds of artesian wells in the area have decreased the potentiometric surface, flooding of large tracts of land with water from uncontrolled artesian wells and diverted surface water had enlarged the saturated area by thousands of acres by the 1950s (Mower and Nace, 1957).

In 1952, there were about 300 flowing artesian wells in the artesian area with an estimated discharge of approximately 13,000 acre-feet/year. An unmeasured quantity of water also leaks upward along the outside of the casings, or through leaky casings and fittings, of many wells (Mower and Nace, 1957). Although it is known that uncontrolled and leaky artesian wells still exist within the GWMA, the number of wells and volume of flow are not known.

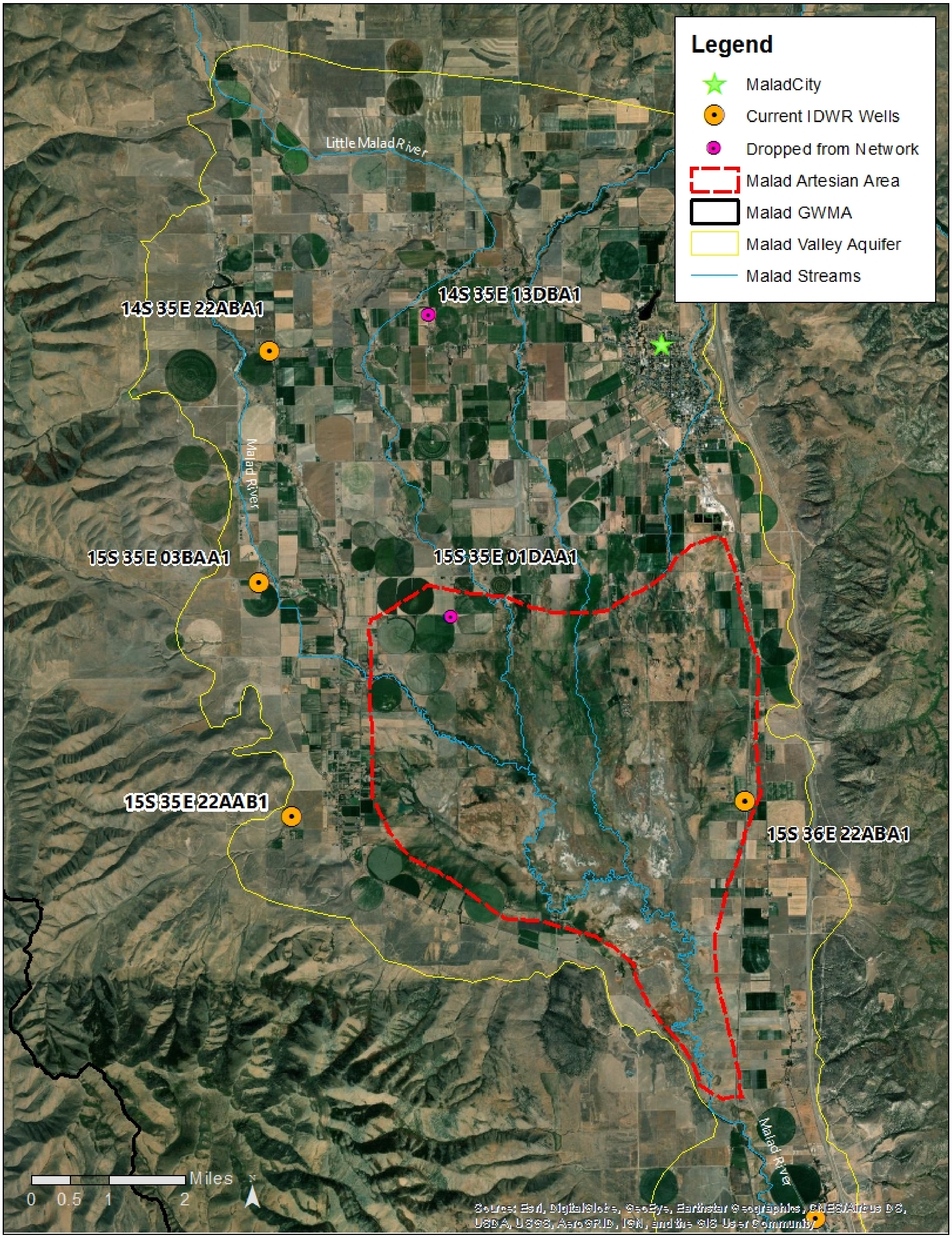

Figure 6. Approximate location of the artesian area in south-central Malad Valley.

Aquifer Conditions

The Malad Basin regional aquifer is the thick sequence of unconsolidated alluvial deposits of gravel and sand, interbedded with silt and clay that underlie the Malad Valley and principal tributary valleys. The Malad valley aquifer is the primary aquifer in the basin, and is bounded by the bedrock of the surrounding mountains, except in the northwest where alluvium in the Little Malad Valley transmits recharge to the valley fill aquifer in the Malad Valley, and in the south where alluvium provides an outlet for aquifer discharge (Figure 2 and Figure 3; Burnham, et al., 1969).

Aquifer Recharge

The vast majority of groundwater in the valley-fill reservoir is derived from the infiltration of precipitation that falls within the drainage basin.

The alluvial fans surrounding the valley floor are the principal zones of recharge for the aquifer system (Figure 7). Pluhowski analyzed soil samples from the alluvium, and the samples indicate that the upper zone of the alluvium is significantly coarser than the base. Therefore, most recharge occurs as runoff on the upper slopes of the alluvial apron and in the Little Malad River Valley (Pluhowski, 1970). Runoff from the Little Malad River and the flanks of the Bannock Range provide most of the recharge to the valley-fill reservoir (Figure 1; Figure 5; Burnham, et al., 1969).

Recharge also occurs as canal and stream leakage, incidental recharge of excess irrigation, and direct precipitation in the northern part of the Malad Valley floor, where the aquifer is unconfined. Recharge by direct precipitation is generally minimal because much of the water is retained as soil moisture (Pluhowski, 1970); however, significant amounts of recharge may occur due to direct precipitation on the upper parts of the alluvial apron and the northern area of the valley floor during wet years (Burnham, et al., 1969).

Some minor recharge occurs in the alluvial stream channels of Deep and Devil Creek; however, most of the precipitation in these areas is impounded for irrigation, and the streams flow over low permeability soils that limit recharge below the dams (Figure 1; Burnham, et al., 1969). Minor amounts of recharge occur in the mountain areas, particularly the Samaria Mountains, where water moves through bedrock fractures and solution openings to discharge either from springs or directly into the valley-fill aquifers through subsurface connections (Figure 1; Burnham et al, 1969).

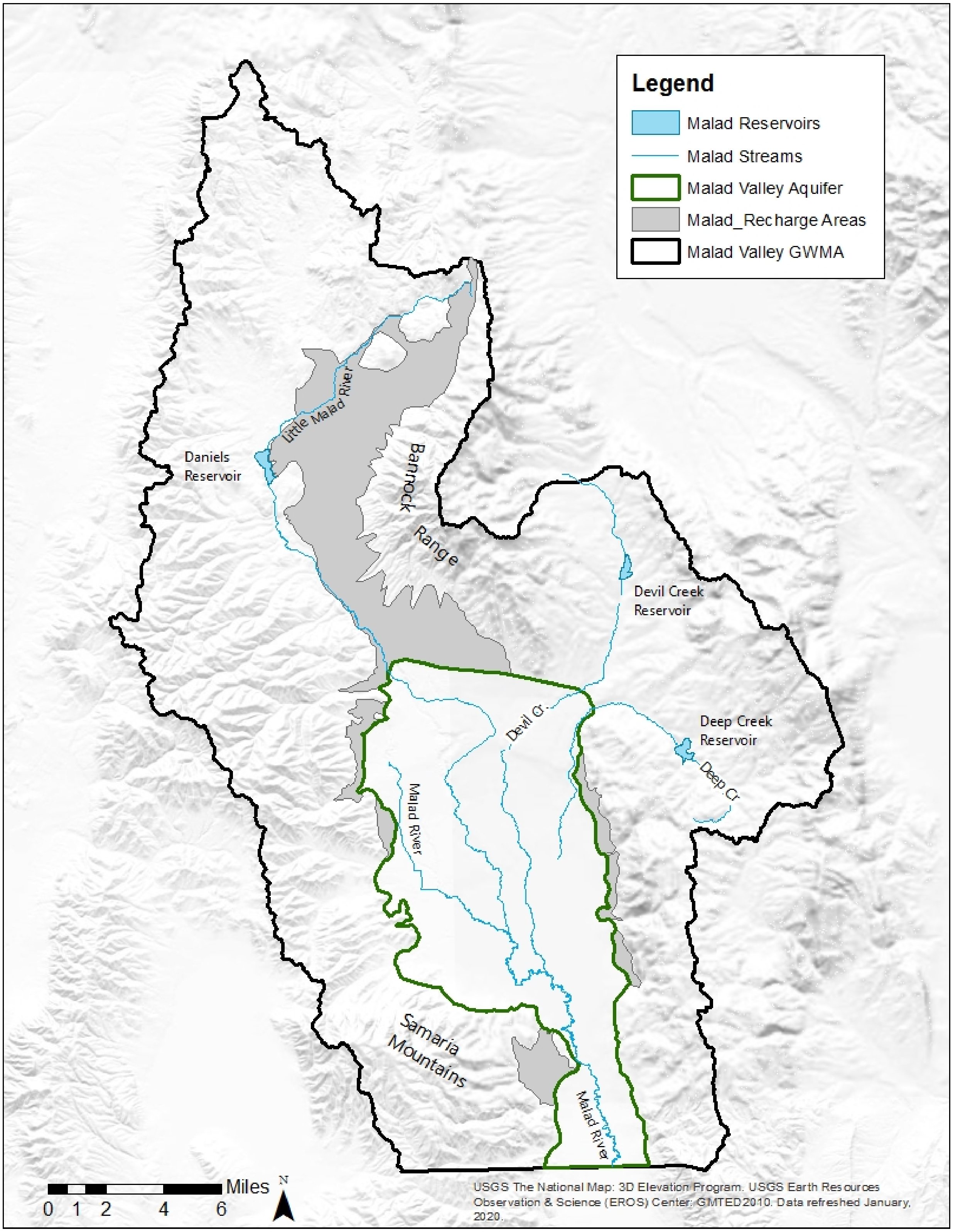

Figure 7. Approximate locations of recharge areas for the Malad Valley.

The confined aquifer is recharged in areas where the sand and gravel layers crop-out around the border of the valley, and by downgradient groundwater movement from the unconfined aquifer (Pluhowski, 1970).

Aquifer Outflow

Outflow from the Malad aquifer system in Idaho occurs as springs, discharge into gaining reaches of the Malad River, groundwater withdrawals to support agricultural ET, native vegetation ET, flow from uncontrolled wells, and groundwater underflow into Utah.

Groundwater Flow

Determining groundwater flow direction requires water-level data from multiple wells, distributed across the areal extent of the aquifer; however, the five wells currently in the monitoring network are not adequate for calculating representative groundwater flow direction (APPENDIX A, Figure 26). Therefore, depths-to-water from well driller's logs were used to supplement the water levels from the monitoring network (APPENDIX A, Figure 27). The use of driller's data increases the uncertainty of the contours, but the overall flow direction is better represented. Groundwater in the Malad Valley aquifer generally flows from north to south, with primary flow along the periphery toward the center of the basin (Figure 8).

There are currently no water-level measurements in the tributary valleys available to map groundwater flow; however, Pluhowski (1979) concluded that groundwater generally follows the slope of the tributary valleys (Figure 8).

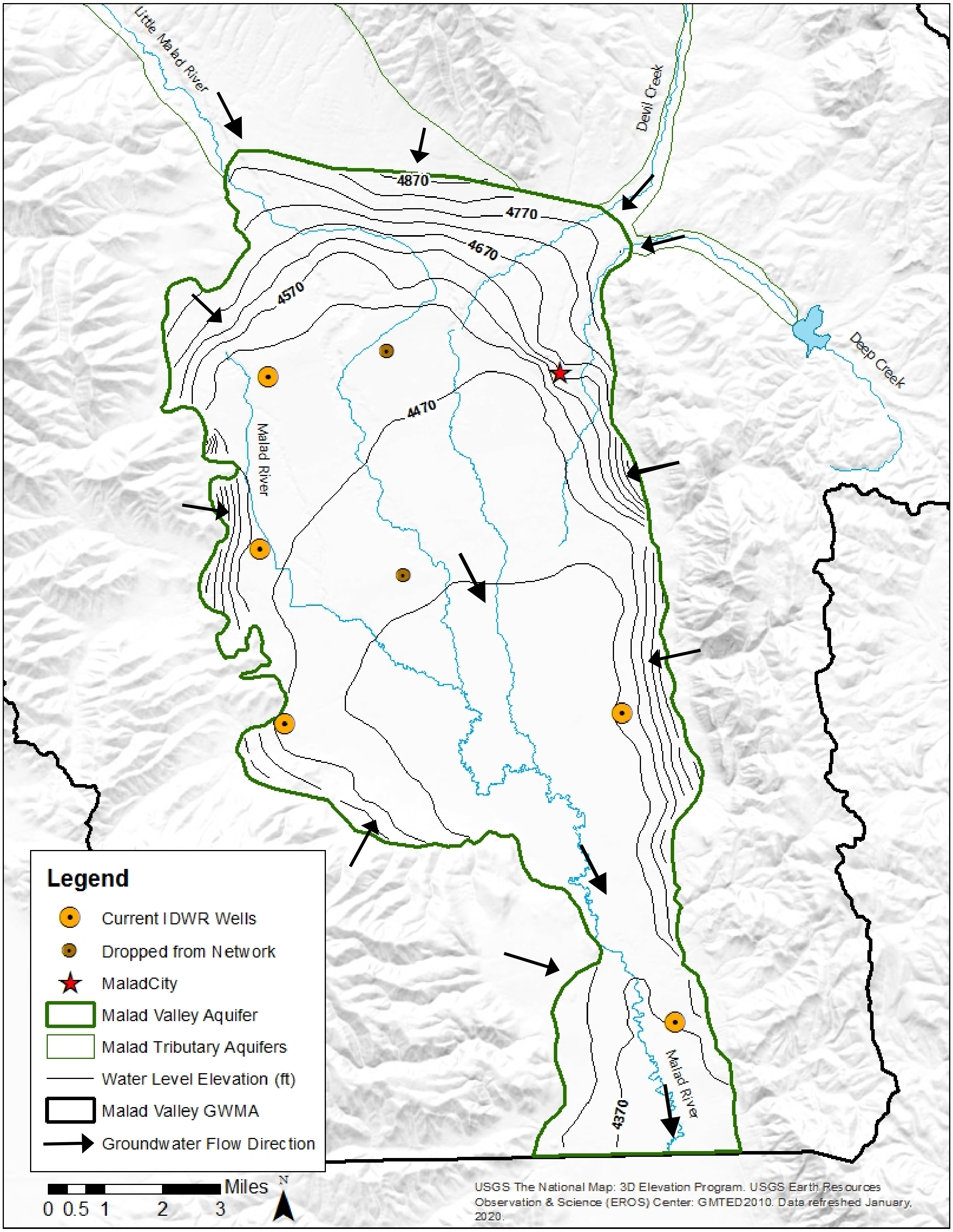

Figure 8. Groundwater flow in the Malad Valley aquifer.

Water Level Monitoring

Historically, up to seven wells have been measured regularly as part of the Malad Valley monitoring network. The wells are located on the valley bottom, in the center and southern part of the GWMA (Figure 1). The wells are generally completed in sediments and derive water from gravel layers. The land-surface elevation and depth-of-completion for the wells are listed in Table 2.

Table 2. Well completion information.

Well Number	Elevation (ft)	Total Depth (ft)	Open Interval (ft)	Production Elevation (ft)[1]	Monitoring Start Date	Monitoring End Date
14S 35E-13DBA1[2]	4,646	289	114-289	4,445	Oct 1943	Mar 2018
14S 35E-22ABA1	4,670	315	305-315	4,360	Aug 2006	Apr 2021
15S 35E-01DAA1[3]	4,453	329	187-275	4,222	Aug 1943	Nov 2017
15S 35E-03BAA1	4,565	120	90-120	4,460	Jun 2007	Oct 2020
15S 35E-22AAB1	4,575	229	NA	4,346	Jun 1963	Apr 2021
15S 36E-22ABA1	4,419	100	NA	4,319	Aug 1943	Apr 2021
16S 36E-14DBC1	4,455	81	61-81	4,384	Jun 1991	Apr 2021

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

[2] Well was dropped in 2018 due to lack of water.

[3] Well was dropped in 2017 due to lack of access.

The network currently consists of five wells. Wells 14S 35E-13DBA1 and 15S 35E-01DAA1 have been dropped from the network due to lack of water and access restrictions, respectively. It is important to note that the dropped wells had been monitored consistently since 1943, which is the earliest year with water-level data. The locations of the wells, and length and consistency of the water-level record, made these very important monitoring wells.

Water-level measurements are taken manually with a calibrated electric tape in four of the wells, and with a calibrated pressure gage in the one flowing artesian well that remains in the network (Well 15S 35E 22AAB1). No Malad GWMA monitoring wells are equipped with data loggers that allow for continuous monitoring of water levels.

The Malad Valley Groundwater Management Plan (IDWR, 2017) calls for water-level measurements four times per year; however, the wells have been measured fewer than four times per year, and on a sporadic interval, since 2017.

Hydrographs

IDWR monitored water levels in seven Malad Basin wells until 2017 (Figure 1). There are currently five wells in the monitoring network, and the elevations and depth-of-completion of the wells are listed in Table 2.

The groundwater-data records in the Malad Basin begin on various dates and continue until April of 2021, and the following hydrographs illustrate all of the water-level data collected from the wells that IDWR 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 (green markers), irrigation season measurements occur in May, June, July, August or September (blue markers), and fall-season measurements occur in October, November or December (tan markers). It is important to note that very few measurements occur in November, December, January, or February.

<u>Well 14S 35E 13DBA1</u>

Well 14S 35E 13DBA1 is not actively monitored by IDWR and is located approximately three miles west-northwest of Malad City on N 3400W, about 0.4 miles north of W 1000N. A driller's report is not available for this well. The period of record begins in the fall of 1943 and ends in the spring of 2018 (Table 2). 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 (Figure 9). Both the period-of-record and 20-year trends indicate statistically significant declining water levels (Table 3).

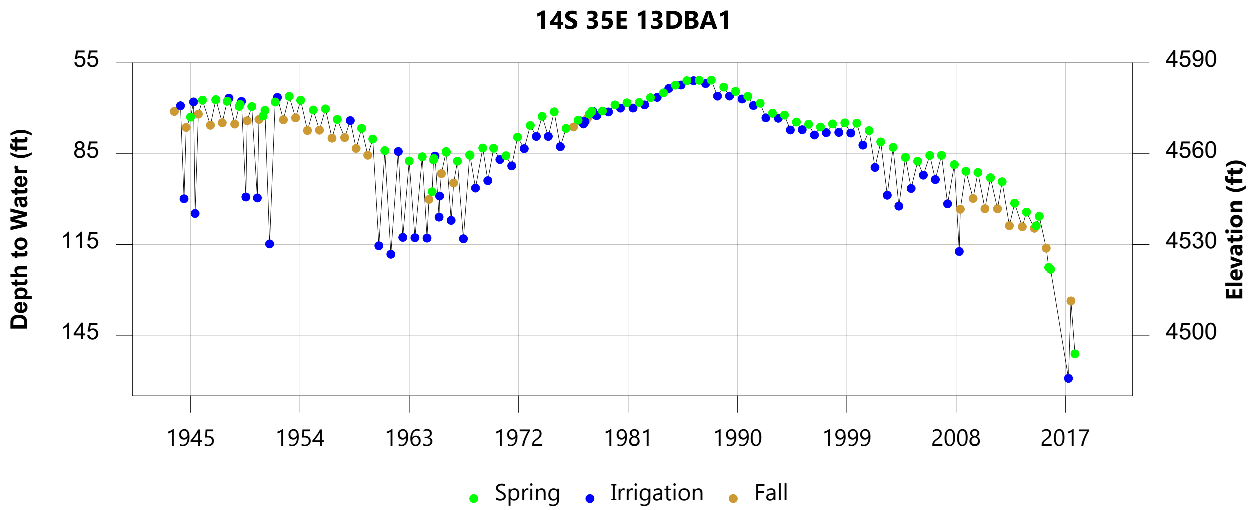

Figure 9. Water levels in well 14S 35E 13DBA1.

Water levels in this well began to decline rapidly beginning in 2016, and the well went dry in 2018. This decline appears to be related to the piping of approximately seven miles of the St. John's Irrigation Company canal, which is approximately 0.25 miles from the well (Figure 10). This well has been dropped from the monitoring network due to lack of water.

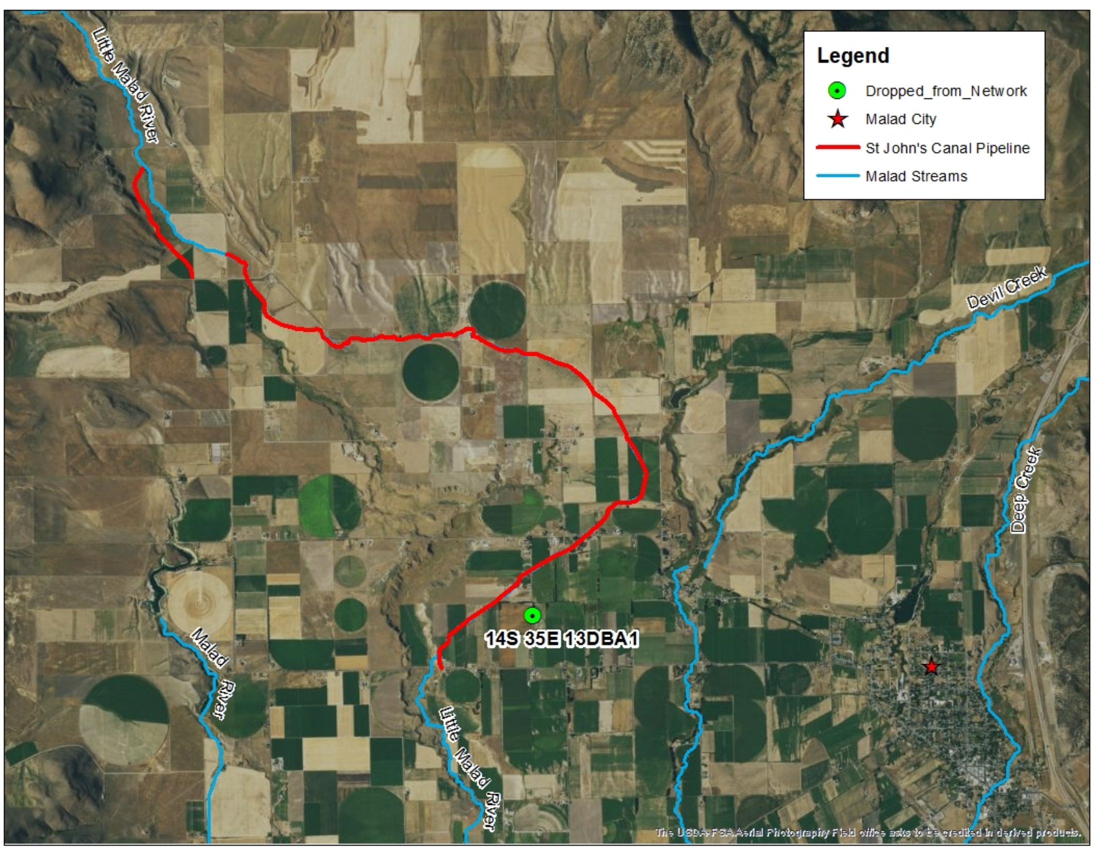

Figure 10. Piped section of St John's Canal in relation to dry well 14S 35E 13DBA1.

Well 14S 35E 22ABA1

Well 14S 35E 22ABA1 is actively monitored by IDWR and is located approximately five miles west of Malad City on the southwest corner of W 1000 N and N 3400 W. The driller's report indicates that the well obtains water from a gravel layer located approximately 300 feet below ground surface. The period of record begins in the summer of 2006 and continues into the spring of 2021 (Figure 11). 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, only the 2011-2021 water-level trend has been calculated. The trend indicates declining water levels over the period of record; however, it is not statistically significant, and only limited conclusions can be drawn (Table 3).

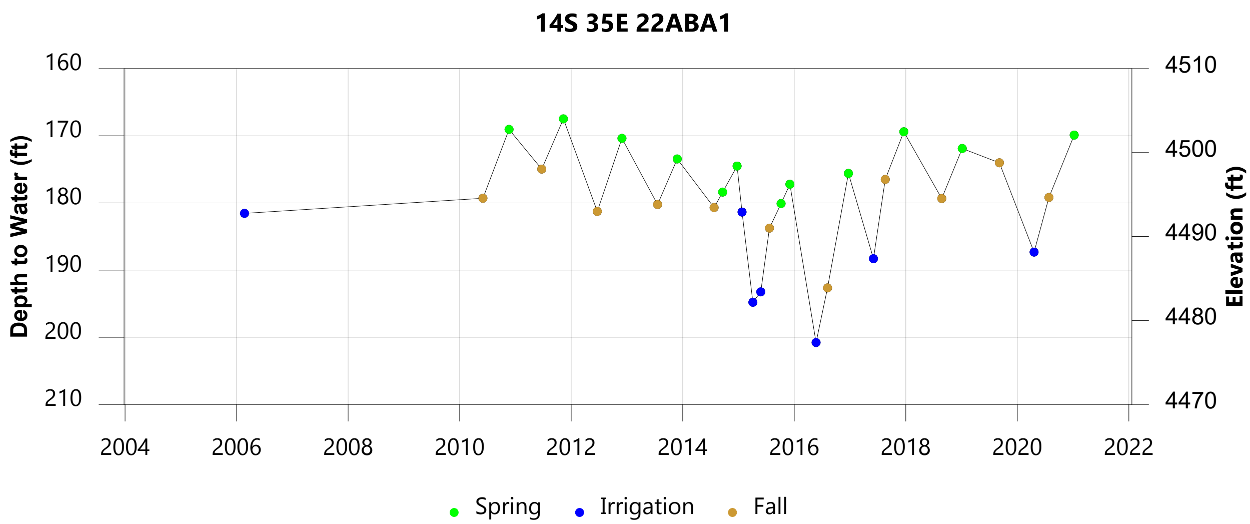

Figure 11. Water levels in well 14S 35E 22ABA1.

Well 15S 35E 01DAA1

Well 15S 35E 01DAA1 is not actively monitored by IDWR and is located approximately 4.5 miles south-southwest of Malad City on the southwest corner of W Chugg Road and Smith Lane. A driller's report is not available for this well. The period of record begins in the summer of 1943 and ends in the fall of 2017 (Figure 12). 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 period-of-record and 20-year trends indicate statistically significant declining water levels (Table 3).

The well head was reconfigured in 2017 and is no longer measurable. This well has been dropped from the monitoring network due to loss of access.

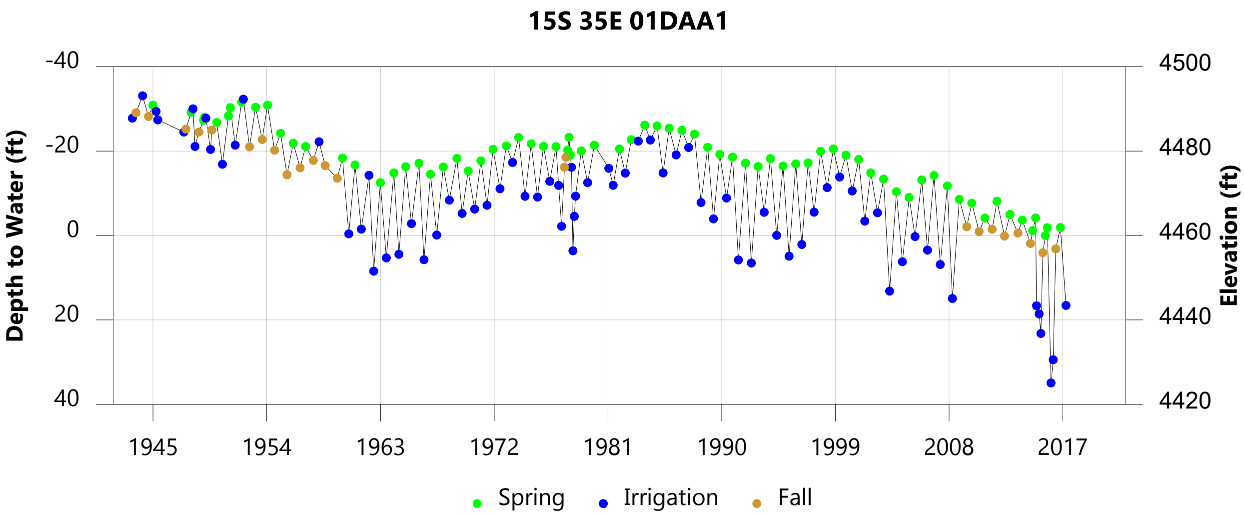

Figure 12. Water levels in well 15S 03E 01DAA1

Well 15S 35E 03BAA1

Well 15S 35E 03BAA1 is actively monitored by IDWR and is located approximately six miles west-southwest of Malad City just south of the intersection of N Edwards Road and State Highway 38. The driller's report indicates that the well obtains water from a zone of gravel and broken sandstone located approximately 90-120 feet below ground surface. The period of record begins in the summer of 2007 and continues the fall of 2020 (Figure 13). 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, only the 2011-2021 water-level trend has been calculated. The trend indicates declining water levels over the period of record (Table 3); however, it is not statistically significant, and only limited conclusions can be drawn.

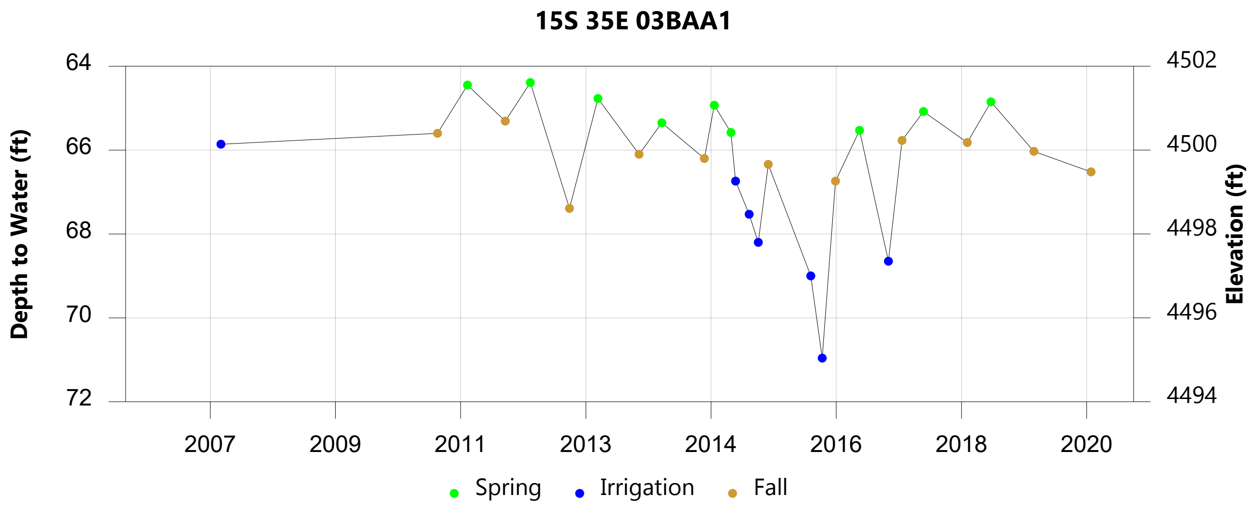

Figure 13. Water levels in well 15S 35E 03BAA1

Well 15S 35E 22AAB1

Well 15S 35E 22AAB1 is actively monitored by IDWR and is located approximately 7.8 miles southwest of Malad City just south of the intersection of N Edwards Road and State Highway 38. A driller's report is not available for this well. The period of record begins in the summer of 1963 and continues to the spring of 2021 (Figure 14). 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 period-of-record and 20-year trends indicate declining water levels (Table 3); however, only the 20-year trend is statistically significant.

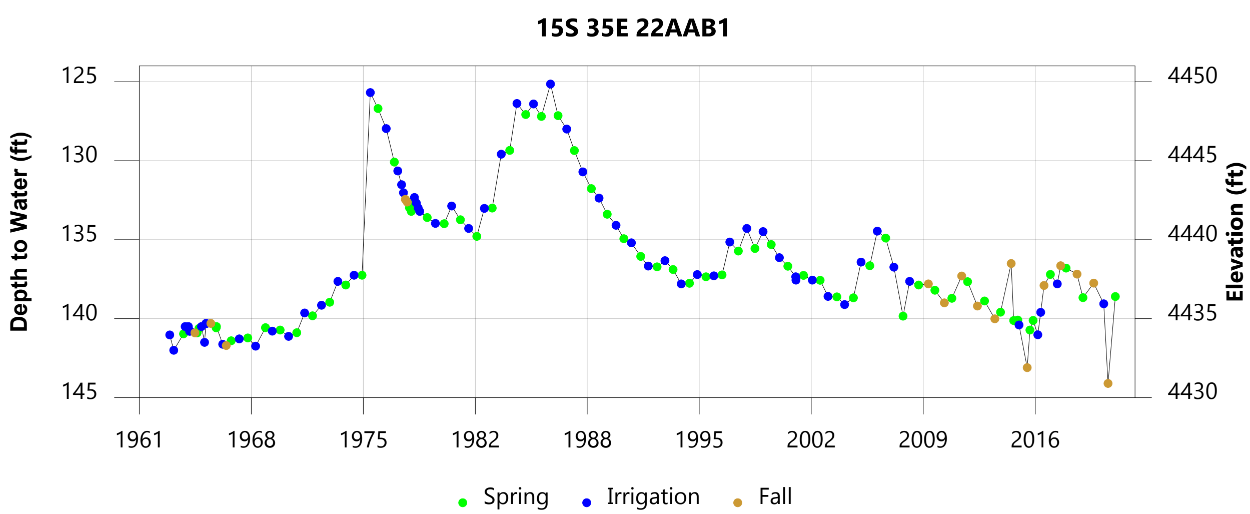

Figure 14. Water levels in well 15S 35E-22AAB1.

Well 15S 36E 22ABA1

Well 15S 35E 22AAB1 is actively monitored by IDWR and is located approximately six miles south of Malad City on the southwest corner of 5000 S and Cherry Creek-Woodruff Road. A driller's report is not available for this well. The period of record begins in the fall of 1943 and continues to the spring of 2021 (Figure 15). Depth-to-water in this well is above ground surface, and despite water-level declines, this well continues to flow due to artesian pressure. Both the period-of-record and 20-year trends indicate declining water levels (Table 3); however, only the period-of-record trend is statistically significant.

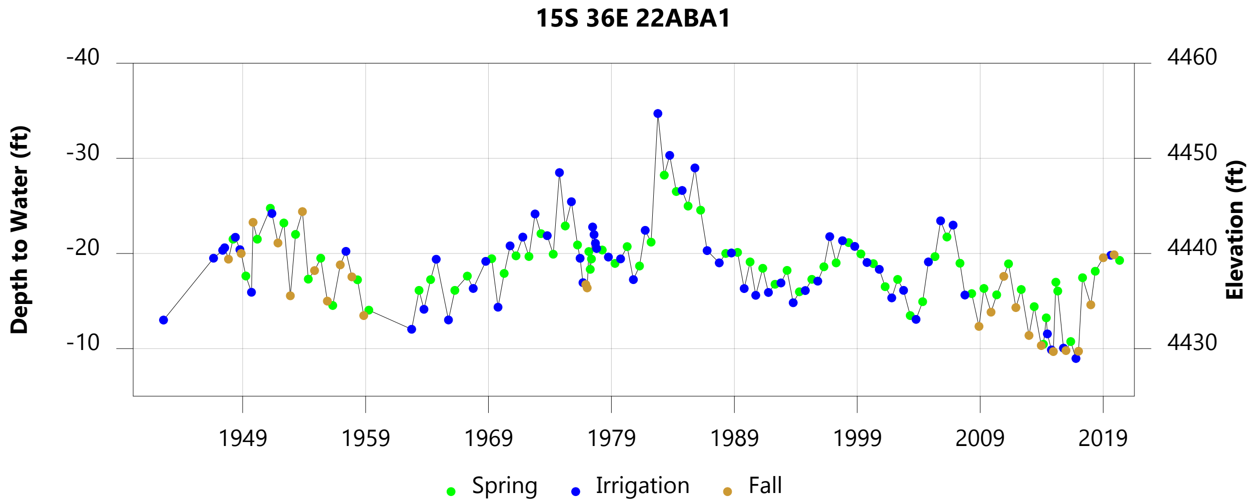

Figure 15. Water levels in well 15S 36E-22ABA1. Negative depths indicate that the water level is above land surface.

Well 16S 36E 14DBC1

Well 16S 36E 14DBC1 is actively monitored by IDWR and is located approximately 11.5 miles south of Malad City on Woodruff Lane approximately 0.4 miles west of Interstate 15. The driller's report indicates that the well casing is perforated from 68 – 81 feet below ground surface, and obtains water from a gravel layer. The period of record begins in the summer of 1991 and continues to the spring of 2021 (Figure 16). 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, spring-season measurements are not available until 2011. Therefore, only the 2011-2021 water-level trend has been calculated. The trend indicates declining water levels (Table 3); however, it is not statistically significant, and only limited conclusions can be drawn.

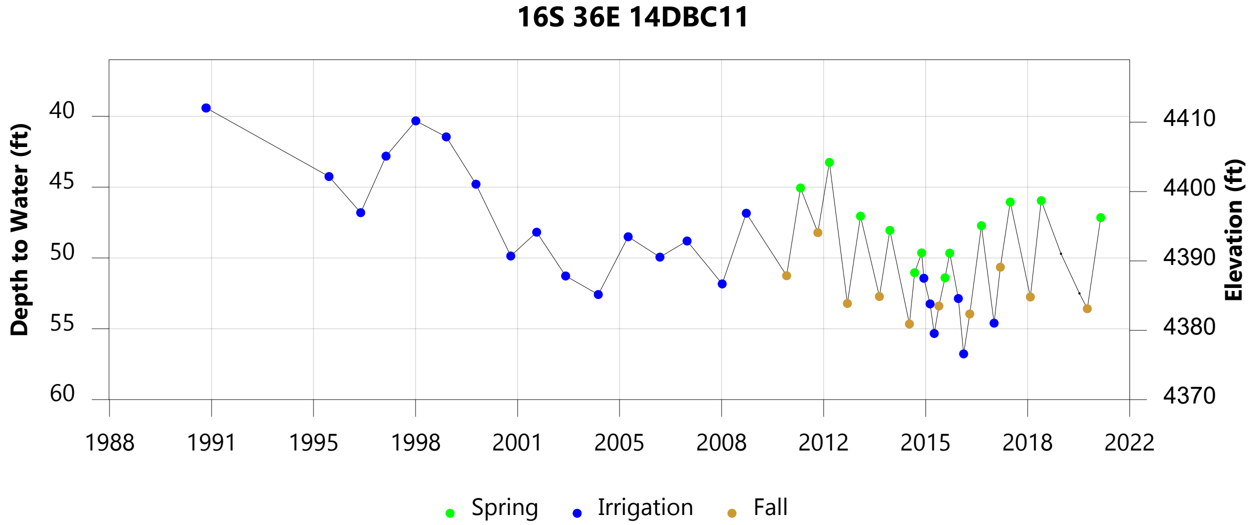

Figure 16. Water levels in well 16S 36E-14DBC1.

Water-Level Trends

Calculating a linear trend for a set of water-level data is a simple way to describe long-term water-level changes. However, a calculated trend is not always representative of the behavior if there are frequent and/or large water-level fluctuations, and/or if the calculated trend is small. Therefore, a statistical assessment of the calculated trend is an important step in determining the general water-level behavior over time. A statistically significant trend indicates that there is a non-zero trend in the data (at the chosen confidence interval), and the calculated trend is the best linear representation of changes over time. Lack of statistical significance indicates that the trend cannot be considered different than zero, and the calculated trend does not adequately represent changes over time. The significance in water-level trends has been set to 95% probability; therefore, any trend with a p-value less than 0.05 is considered to be significant.

Trends in water-level changes have been calculated for the entire period-of-record of each well, and the most recent 20-years for wells with adequate data, using the Mann-Kendall (MK) test (Hirsch and Slack, 1984). The MK test was developed by the U.S. Geological Survey (USGS) and is the most frequently used test for trend in environmental sciences (Helsel and others, 2006).

A linear trend facilitates assessment of long-term changes independent of short-term water level fluctuations. However, it is difficult to calculate a trend that describes the state of the aquifer using data from all months because some of the variability is due to water use. Spring-season water levels are often the best indication of aquifer conditions because they are temporally distant from the previous irrigation season, and less impacted by current or upcoming irrigation-season water use. All water-level trends presented in Table 3 have been calculated using only spring-season water levels.

Table 3. Water-level trends for spring-season measurements. Statistically significant trends are identified in bold.

Well Number	Period of Record	Period of Record Trend (ft/year)	Period of Record p-value	20-year Trend (ft/year)	20-Year p-value
14S 35E-13DBA1[1]	1945-2018	**-0.20**	**0.00**	**-1.85**	**0.00**
14S 35E-22ABA1	2011-2021[3]	-0.32	0.37	NA	NA
15S 35E-01DAA1[2]	1945-2017	**-0.27**	**0.00**	**-0.99**	**0.00**
15S 35E-03BAA1	2011-2019[4]	-0.08	0.27	NA	NA
15S 35E-22AAB1	1964-2021	-0.02	0.69	**-0.11**	**0.03**
15S 36E-22ABA1	1949-2021	**-0.05**	**0.00**	-0.09	0.26
16S 36E-14DBC1	2011-2021[5]	-0.14	0.65	NA	NA

[1] Well was dropped in 2018 due to lack of water.

[2] Well was dropped in 2017 due to lack of access.

[3] Full period of record is 2006-2021. Spring-season measurements available for 2011-2021.

[4] Full period of record is 2007-2020. Spring-season measurements available for 2011-2019.

[5] Full period of record is 1991-2021. Spring-season measurements available for 2011-2021.

All wells in the IDWR network exhibit declining water levels over the period of record, and trends in wells with enough data are also declining over the most recent 20-years. Not all trends are statistically significant (Table 3).

Water levels Compared with PDSI

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 PDSI (Figure 17– Figure 23).

It appears via visual inspection that water levels in the Malad Basin tend to follow changes in climate; however, water-level changes lag behind PDSI changes in several wells. Water-level increases that occurred from the 1970’s to 1980’s correspond to a period of very wet/extremely wet PDSI classifications.

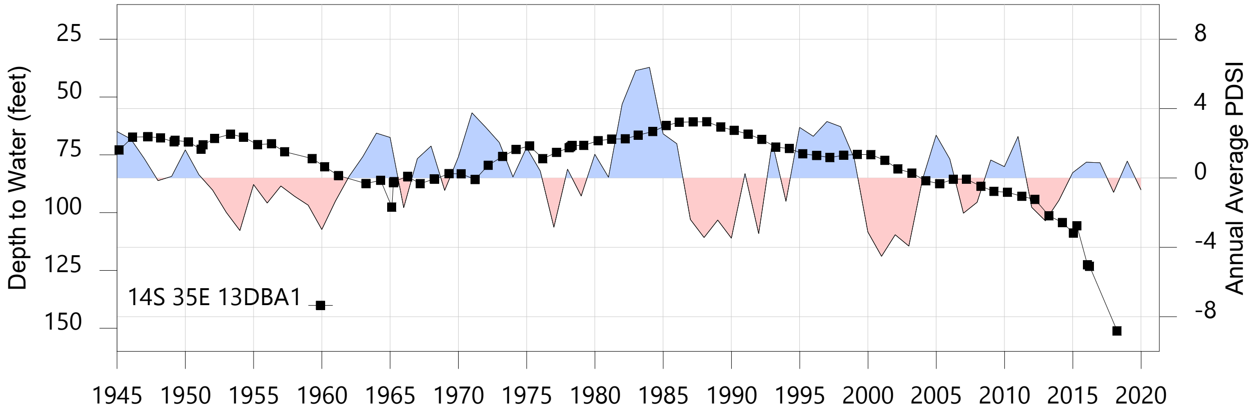

Figure 17. Well 14S 35E 13DBA1 depth to water and PDSI.

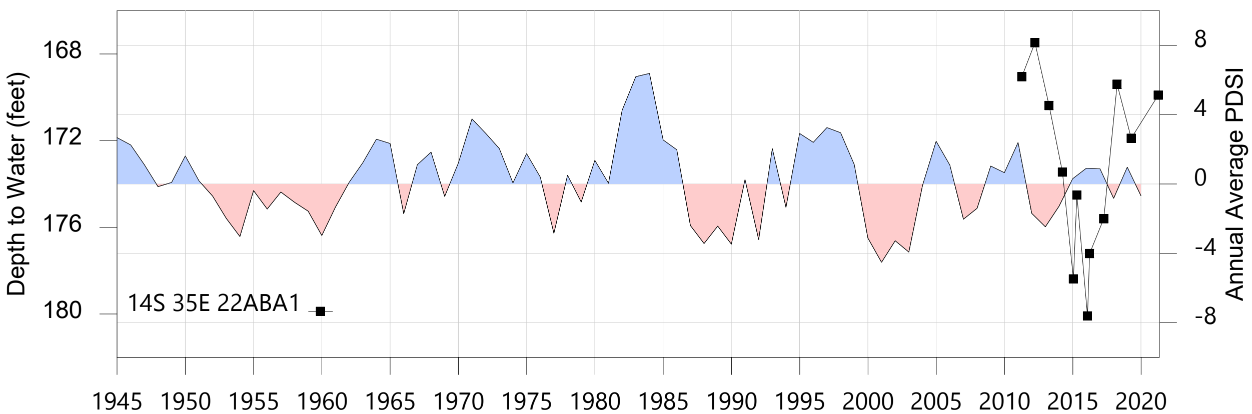

Figure 18. Well 14S 35E 22ABA1 depth to water and PDSI.

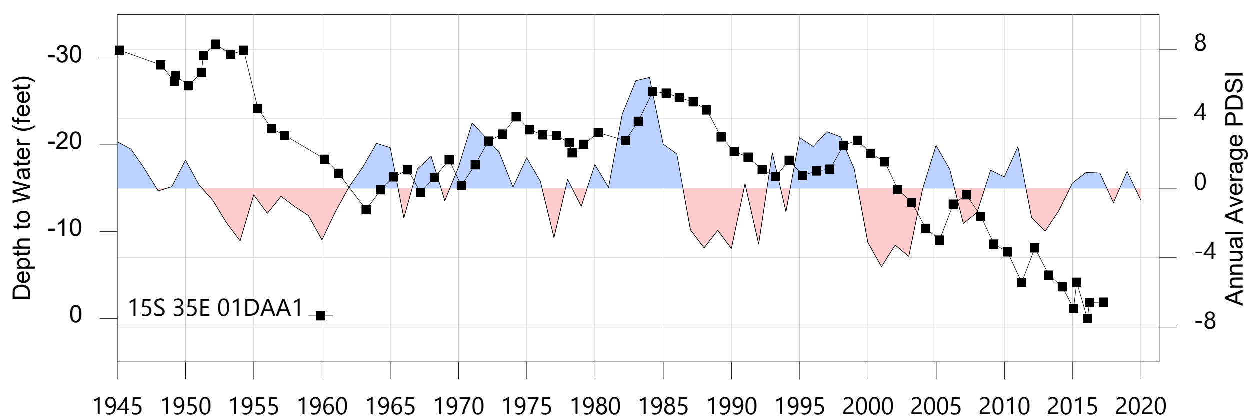

Figure 19. Well 15S 35E 01DAA1 depth to water and PDSI.

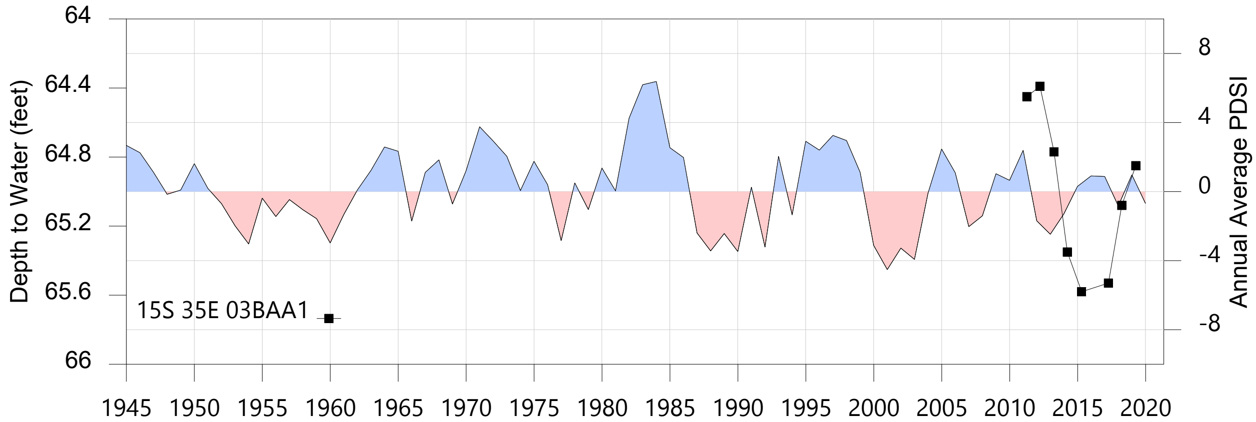

Figure 20. Well 15S 35E 03BAA1 depth to water and PDSI.

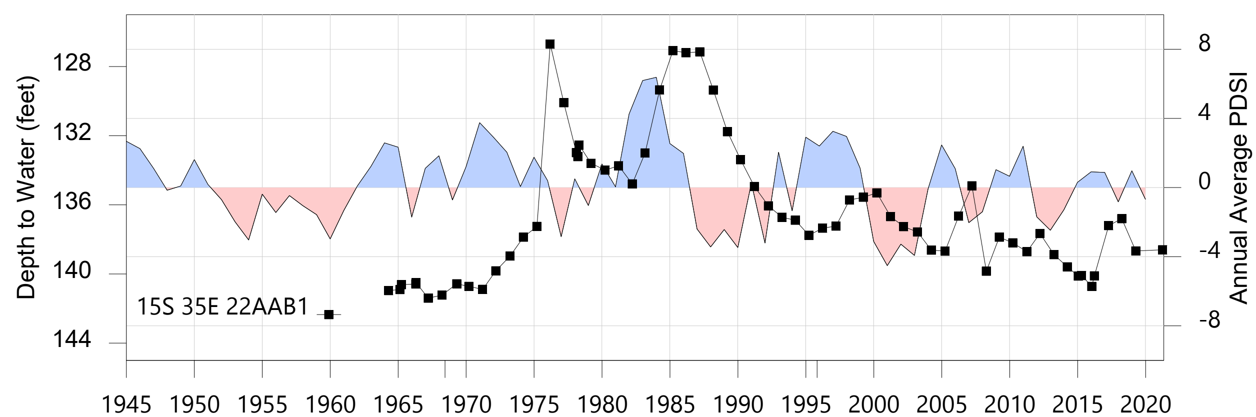

Figure 21. Well 15S 35E 22AAB1 depth to water and PDSI.

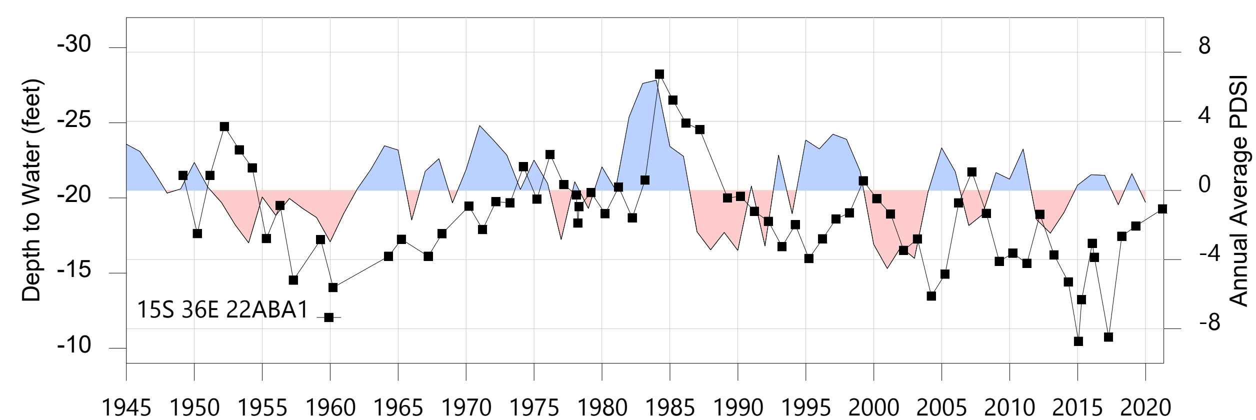

Figure 22. Well 15S 36E 22ABA1 depth to water and PDSI.

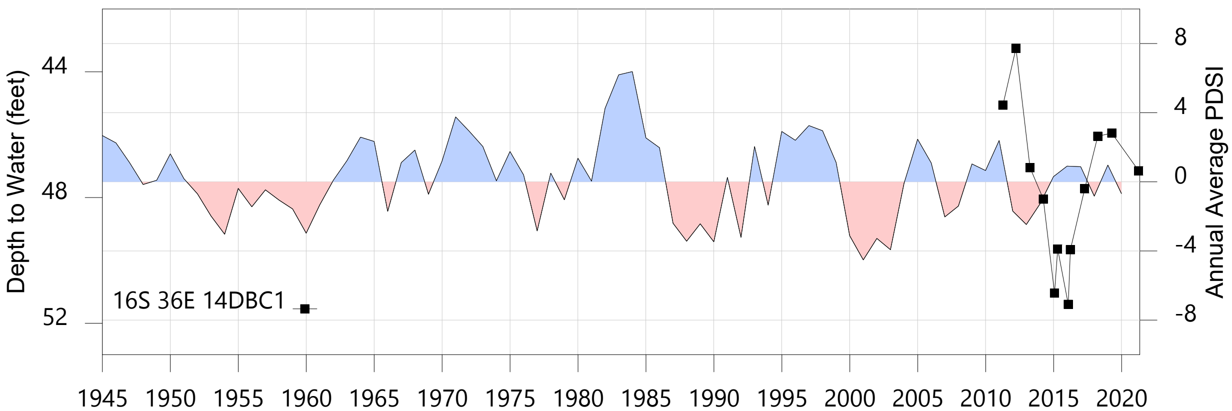

Figure 23. Well 16S 36E 14DBC1 depth to water and PDSI.

Trends in precipitation and PDSI were calculated for the period 1945 – 2020 and the most recent 20-year period using the Mann-Kendall test for trend.

PDSI exhibits a very small decreasing trend for the 1945 – 2020 period, and a small increasing trend over the most recent 20 years (Table 4). Neither of the PDSI trends are statistically significant.

Precipitation exhibits a very small increasing trend for the 1945 – 2021 period, and a small increasing trend over the most recent 20 years (Table 4). Neither of the precipitation trends are statistically significant.

Although the trends in PDSI and precipitation are not statistically significant, it is interesting that both the long and 20-year trends in precipitation, and the 20-year trend in PDSI are increasing, while all of the trends in water levels are all decreasing.

Table 4. Trends for spring-season water levels, precipitation, and PDSI. Statistically significant trends are identified in bold.

Well Number	Period of Record	Period of Record Trend[6, 7, 8]	Period of Record p-value	20-year Trend[6, 7, 8]	20-Year p-value
14S 35E-13DBA1[1]	1945-2018	**-0.20**	**0.00**	**-1.85**	**0.00**
14S 35E-22ABA1	2011-2021[3]	-0.32	0.37	NA	NA
15S 35E-01DAA1[2]	1945-2017	**-0.27**	**0.00**	**-0.99**	**0.00**
15S 35E-03BAA1	2011-2019[4]	-0.08	0.27	NA	NA
15S 35E-22AAB1	1964-2021	-0.02	0.69	**-0.11**	**0.03**
15S 36E-22ABA1	1949-2021	**-0.05**	**0.00**	-0.09	0.26
16S 36E-14DBC1	2011-2021[5]	-0.14	0.65	NA	NA
Precipitation	1945-2021	500	0.35	5,000	0.28
PDSI	1945-2020[9]	-0.006	0.52	0.13	0.16

[1] Well was dropped in 2018 due to lack of water.

[2] Well was dropped in 2017 due to lack of access.

[3] Full period of record is 2006-2021. Spring-season measurements available for 2011-2021.
[4] Full period of record is 2007-2020. Spring-season measurements available for 2011-2019.
[5] Full period of record is 1991-2021. Spring-season measurements available for 2011-2021.
[6] Water-level trends are acre-feet/year.
[7] Water-level trends are ft/year.
[8] PDSI trends are unitless.
[9] PDSI data for 2021 were not available at the time of analysis.

Conclusions and Recommendations

Precipitation within the watershed provides virtually all the available water in the Malad GWMA; only minor amounts of water are imported from Birch Creek. Recharge occurs primarily in the alluvial fans that surround the Malad Valley, predominantly the alluvium in the Little Malad Valley. Discharge from the GWMA includes groundwater pumping to support irrigated consumptive use, evapotranspiration from natural vegetation, gaining reaches of the Malad River, and underflow out of the basin.

Data available regarding aquifer conditions in the Malad Valley aquifer system are limited. IDWR currently monitors aquifer water level in only five wells, and only three of these wells have sufficient records to evaluate long-term water-level trends. IDWR does not currently measure streamflow in the GWMA; however, a new USGS gaging station will be added on the Malad River in the fall of 2021.

A comparison of water levels with annual precipitation and PDSI indicates that the area wells exhibit long-term fluctuations that correspond to precipitation, with variable lag-times between changes in precipitation and changes in water levels.

Trends in precipitation are positive over the 1945 –2020 and 2001 – 2020 periods, but not statistically significant. Trends in PDSI are declining, but extremely small for the period 1945 – 2020, and increasing over the 2001 – 2020 period, but the trends in PDSI are not statistically significant. All water levels exhibit declining trends, but only a few are statistically significant.

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, and that surface-water data be collected at two outflow sites in the far southern part of the valley.

Additional Wells

IDWR currently monitors water levels in five Malad GWMA wells; two wells were lost from the network due to lack of water and lack of access. The wells currently in the network are not adequate to characterize the aquifer system, and there are several data needs that should be addressed in order to provide the necessary information for water-resource decision making.

There are three areas with little or no groundwater information in the Malad GWMA. These areas are illustrated in Figure 24 and listed below in priority order:

- Well 15S 35E 01DAA1 – The well head was reconfigured in 2017 and water-level measurements are no longer possible. This well is located at the northern boundary of the artesian area, and has a long record. The location and length of record made this a key well in the network. Working with the well owner to allow for measurement access may provide the most benefit in terms of understanding the aquifer behavior.

- Artesian Area (Zone 1) – This is an area in which water levels are above land surface. IDWR currently monitors one flowing well located on the southeastern fringe of the area. 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 controlled. This area has the need for more monitoring, as well as an inventory of flowing wells and their construction status.

- Central Area (Zone 2) – Most of the population of the Malad Valley lives in this area, and the majority of the irrigation occurs in this area. Three of the four surface-water inflows enter the main aquifer here. No current water-level monitoring is occurring in this area.

- Daniels Reservoir Area (Zone 3) – There are no water-level data in this area, but only about 450 acres of groundwater irrigated land. Additional data will allow for both the monitoring of water levels over time and determination of the groundwater flow direction. However, due to the paucity of groundwater use, this area is of lowest priority.

The areas described above are general priorities, and are not meant to exclude monitoring of wells located outside of these boundaries.

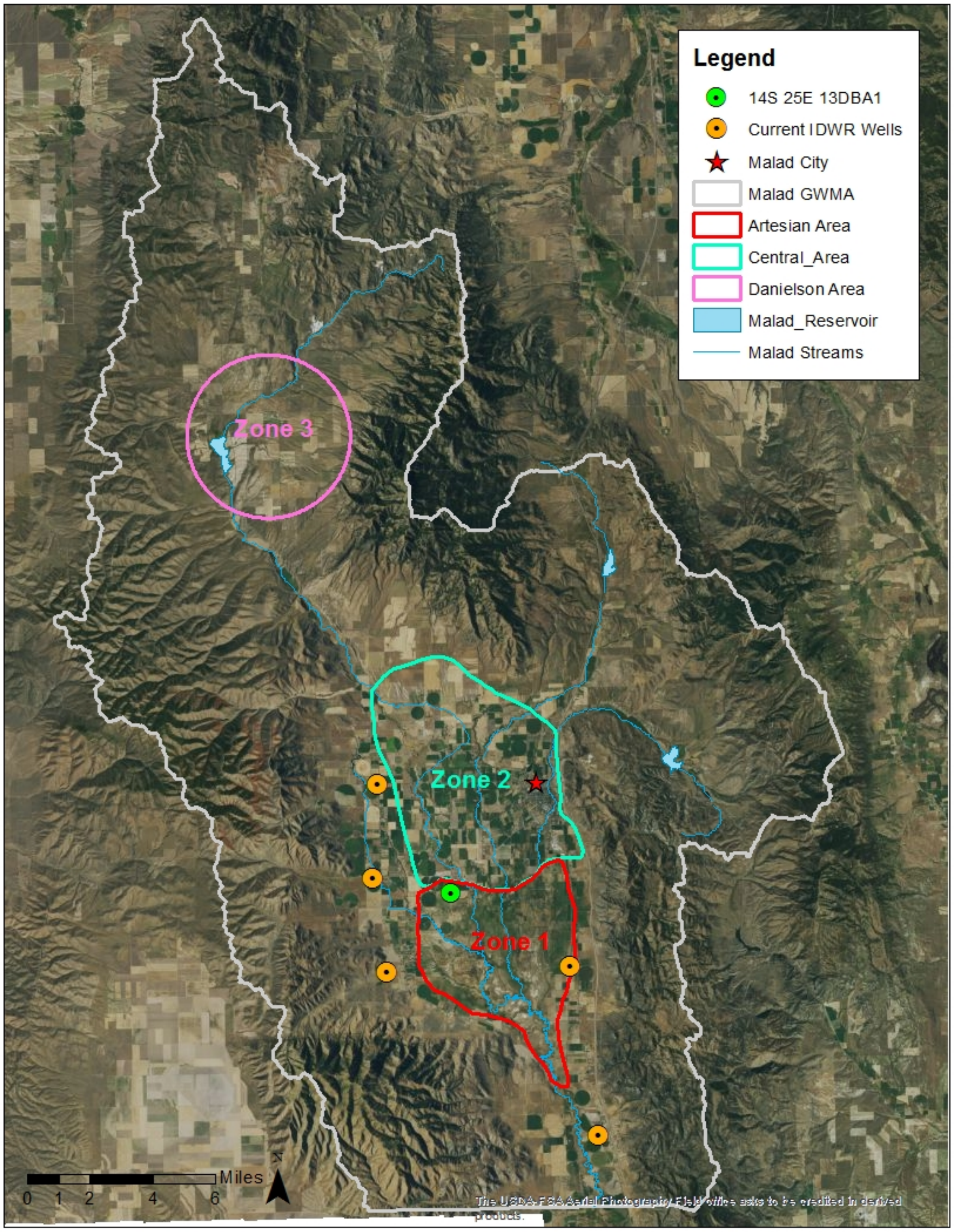

Figure 24. Locations of proposed areas for additional water-level data collection.

Additional 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 Valley water supply: the Little Malad

River, the Malad River, Devil Creek, and Deep Creek. There are two sites that are important for determining outflow from the basin: discharge from Woodruff Springs, and discharge of the Malad River just south of Woodruff Springs. Potential locations are based on previously located USGS gages. Suggested locations for surface-water measurement are illustrated in Figure 25 and listed below:

- Malad River at Woodruff (previously USGS #10125500) – This site is located on the Malad River, south of Woodruff, ID, and is the last gage location before the Malad River exits Idaho. This gage would measure surface-water outflow from the basin; thus, reinstalling a gage at this location would allow for the calculation of the water budget for the GWMA. Discharge from Woodruff Spring may be necessary to calculate the actual discharge from the Malad Basin.

- Woodruff Spring (previously USGS #420322112144101) – This site (aka Woodruff Hot Spring) would measure the flow from Woodruff Spring. The majority of the discharge form Woodruff Spring appears to be groundwater from the basin aquifer; however, a portion of the discharge is out-of-basin geothermal water that moves up the Woodruff fault. This site, in conjunction with a gage on the Malad River at Woodruff, is necessary for calculating the outflow from the Malad Basin.

- Little Malad River ab Elkhorn Res. Nr Malad City (previously USGS #10119000) – This site is located on the Little Malad River downstream of the Daniels Reservoir and would capture the Little Malad River flow below Daniels Reservoir, as well as some spring discharge. 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 (previously USGS #10118200) – This site is located on the Malad River just downstream of the source at Malad Springs. It is unclear how much of the discharge from the springs originates as seepage from the Little Malad River. The USGS conducted annual miscellaneous measurements from 2006-2010, and additional miscellaneous measurements may help with calculating the water budget for the GWMA.

- Devil Creek ab Evans Dividers nr Malad City (previously USGS #10123000) – This site is located on Devil Creek below Devil Creek Reservoir. This site 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 site is located on Devil Creek just below the reservoir, which is an important source of water for Malad City. This gage would measure surface-water inflow from Devil Creek.

All 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 Spring and the Malad River at Woodruff gage. IDWR is working with the USGS to reinstall the Malad River at Woodruff gage in late 2021 or 2022.

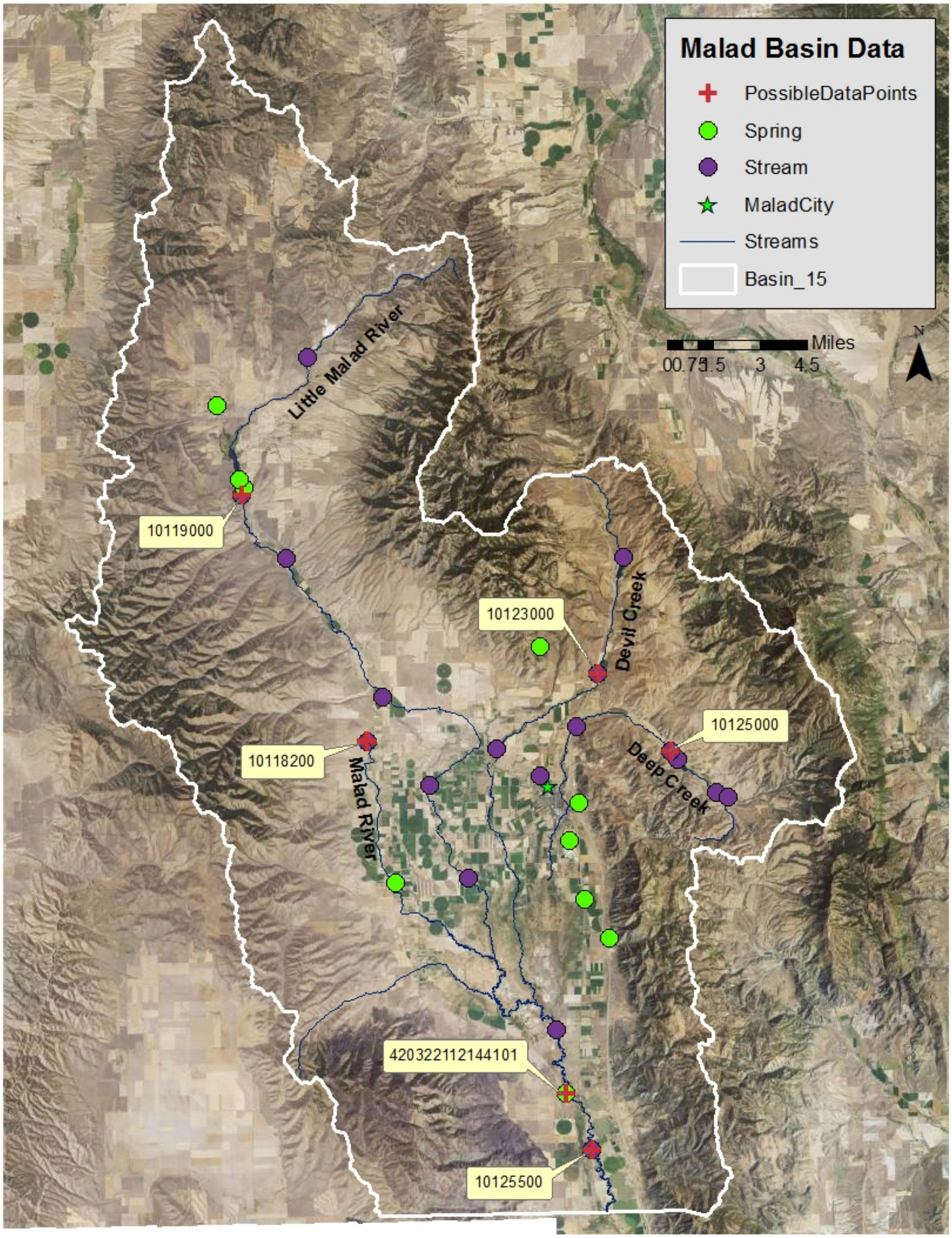

Figure 25. Locations of proposed surface-water gage locations.

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APPENDIX A

Groundwater Contours

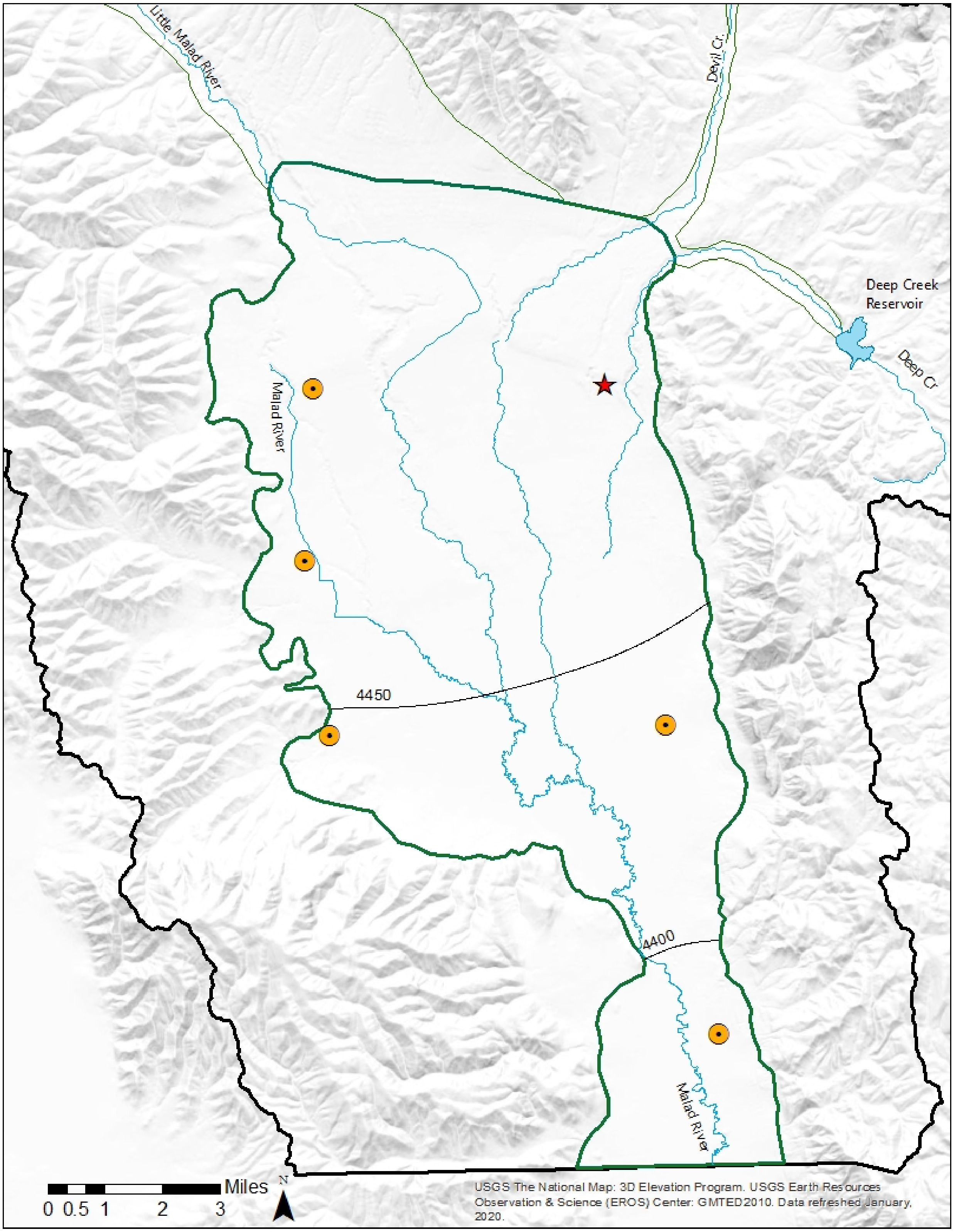

Figure 26. Groundwater contours using the current IDWR network wells

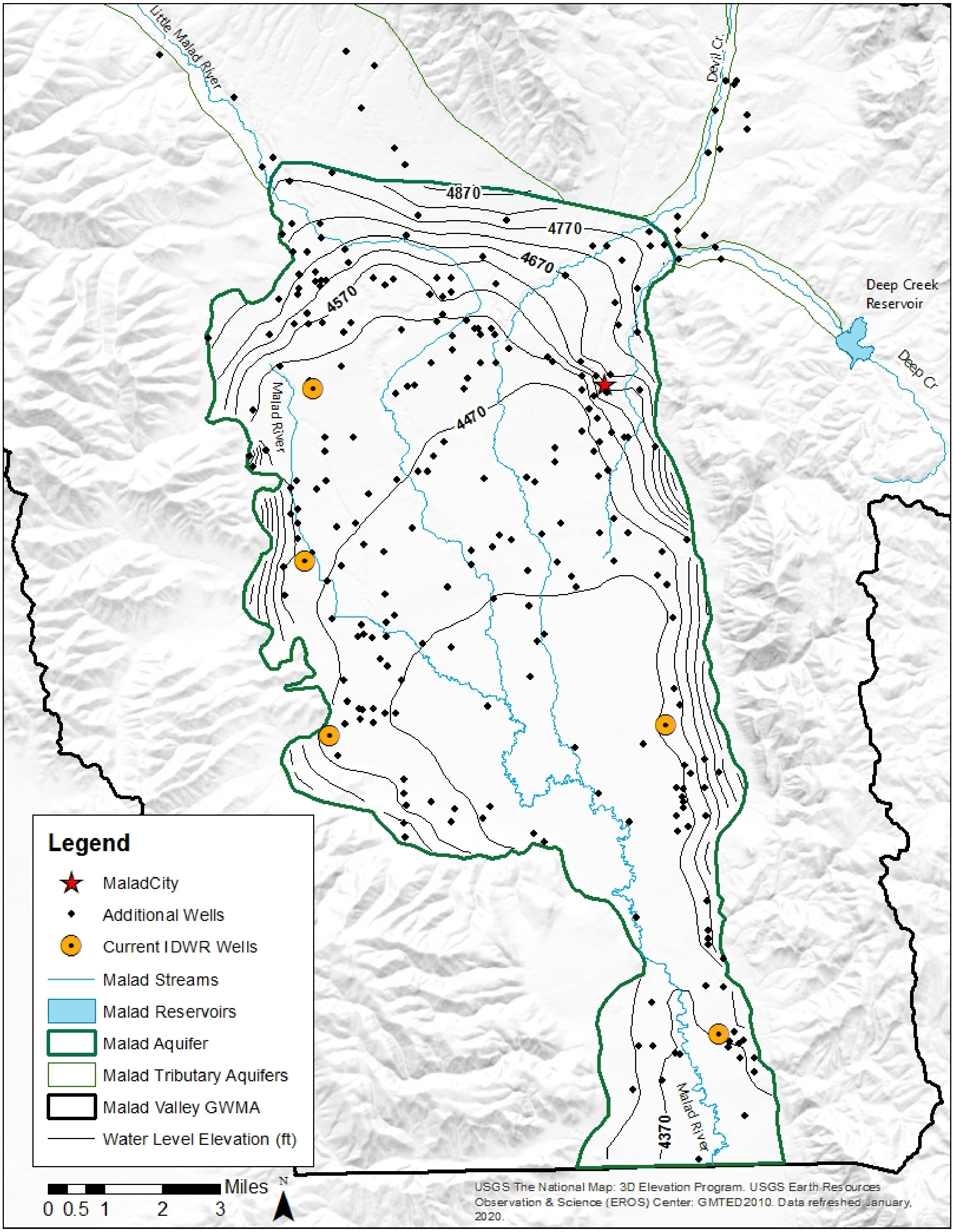

Figure 27. Locations of wells used to supplement IDWR network data.