Wood River Basin Hydrologic and Hydrogeologic Relationships
Prepared for the BWRGWMA Advisory Committee

IDWR Observations
March 17, 2021

Snow Water Equivalent (SWE)

1) Snowmelt runoff is the primary source of water for irrigation and other purposes in the Big Wood River basin. Based on snowpack measurements made by the U.S. Department of Agriculture Natural Resource Conservation Service (NRCS), the snow water equivalent (SWE) on March 15, 2021 for the Big Wood River basin was 78% of the median for the period 1981 to 2010.

Surface Water Supply Index (SWSI)

2) The Surface Water Supply Index (SWSI) is a predictive indicator of surface water availability in a basin compared to historic supply. The NRCS computes the SWSI by summing the two major sources of surface water supply for irrigation; streamflow from runoff and reservoir storage. According to the NRCS website, "*SWSI uses non-exceedance probabilities to normalize the magnitude of annual water supply variability between basins. The non-exceedance values are then rescaled to range from +4.1 (extremely wet) to -4.1 (extremely dry). A SWSI value of 0.0 indicates a median water supply as compared to historic occurrences.*"

Magic Reservoir Water Supply

3) At the beginning of each month, the NRCS publishes a SWSI for many of the irrigated basins in the western United States including the Big Wood River basin below Magic Reservoir. On March 1, 2021, the Big Wood SWSI for the most probable case (50% exceedance) was -2.2, which is in the bottom one-third of values for the period 1991 to 2020.

4) Based on an NRCS analysis of predicted runoff volumes for the Big Wood River and Camas Creek, IDWR estimates the probability that Magic Reservoir will fill this year is less than 30%.[1]

5) A notation at the top of the March 2021 SWSI table for the Big Wood River basin below Magic Reservoir states that the "*adequate water supply*" is 275 KAF. The corresponding SWSI is "*greater than 0.4*".

6) The Big Wood River basin SWSI was greater than 0.4 in 13 of the previous 30 years going back to 1991.

[1] Probability analysis and estimate completed by David Hokema, IDWR, March 2021.

7) During the previous 30 year period, Magic Reservoir filled to capacity (191.5 KAF) every year that the SWSI was greater than 0.4.

8) During years with a SWSI > 1.0, maximum reservoir fill typically occurs at the beginning of July. On years with a SWSI less than -1.0, maximum reservoir fill typically occurs at the beginning of May.

9) The shutoff date for irrigation water releases from Magic Reservoir can be determined by looking at the streamflow measurements at the Big Wood River below Magic Dam gage. Reservoir shutoff is typically seen as an abrupt, sustained decrease in the flow rate at the below Magic Dam gage from more than 500 cubic feet per second (cfs) to less than 10 cfs.

10) In each of the 13 years with a SWSI greater than 0.4, the shutoff date was either on September 25 or on one of the first few days in October (generally October 1).

11) In 12 of the 13 years with a SWSI greater than 0.4, there were early season releases from Magic Reservoir that caused flow at the below Magic gage to exceed the typical mid-season flow rate range of 800 to 1,000 cfs. Sustained releases above 1,000 cfs did not occur during any year with a SWSI less than or equal 0.4.

12) The duration of releases from Magic Reservoir varies each year. During an adequate water supply year, the period of reservoir releases generally includes the 147-day period from May 1 to September 25. Essentially uninterrupted reservoir releases extending into late September or early October occurred in 14 of the 30 previous years.

13) For a continuous release at a typical midseason rate of 900 cfs, one full reservoir volume (191.5 KAF) is depleted in 108 days. On years with an adequate water supply, the date of maximum reservoir fill occurs mid-summer (typically around July 1) and Magic Reservoir can sustain a 147-day irrigation season.

14) Reservoir storage on the shutoff date was approximately 25 KAF or greater in each of the 13 years with a SWSI of 0.4 or greater.

15) Reservoir storage on the shutoff date also exceeded 25 KAF in the four years with the highest SWSI values not meeting the NRCS's adequate water supply threshold (SWSI > 0.4). These years are 2005 (SWSI = -0.4), 2016 (SWSI = -0.1), 2009 (SWSI = 0.1), and 2010 (SWSI = 0.4). In each of these years, the reservoir failed to fill but the maximum fill was greater than 145 KAF. Also for these years, the shutoff date occurred sometime during September. An inadequate supply for both 2005 and 2016 is suggested by the fact that the irrigation season ended a few weeks early in both years. And in contrast to 2016, sustained releases didn't begin in 2005 until late May.

16) Magic Reservoir held less than 15 KAF storage on the shutoff date in each of the 13 years with a SWSI less than -0.4. Moreover, the shutoff date for these 13 lowest SWSI years often occurred well before September 25; twice the shutoff occurred at the beginning of September, twice in August, seven times in July, once at the end of June, and once in May. The May shutoff occurred during 1992, which had the worst surface water supply during the previous 30-year period and a SWSI of -3.9. Note that reservoir releases were briefly resumed in June and August 1992. Intermittent reservoir releases also occurred during the 2004 irrigation season, which had the third lowest water supply and a SWSI of -3.4.

17) Water supply shortages, sometimes significant, likely occurred during the 13 lowest SWSI years for water users reliant primarily on Magic Reservoir storage water.

18) During the period 1991 to 2020, the years with the most similar total supplies to the 50% exceedance forecast for this year (2021) are 2014 (SWSI = -2.3) and 2002 (SWSI = -2.0). In both analog years, maximum reservoir fill was less than 100 KAF, the shutoff date occurred in mid-July, and the reservoir was essentially empty on the shutoff date.

The WRWC Model

19) The predictive model developed by Dr. Kendra Kaiser for the Wood River Water Collaborative (WRWC) provides forecasts for irrigation season streamflow, total volume, and runoff timing for gages on the Big Wood (Hailey, Stanton Crossing), Silver Creek, and Camas Creek. The WRWC model also estimates annual diversions and curtailment dates for three water right priorities on each reach (Big wood above Stanton, Big Wood below Magic Reservoir, and Silver Creek). The WRWC model, like those used for NRCS water supply forecasts, is a suite of statistical models based on linear regressions between streamflow and predictive variables such as SWE, precipitation, antecedent streamflow, and climate teleconnection index. The curtailment date prediction is an attempt to automate a process that IDWR manually performs using NRCS runoff volume forecasts.

20) IDWR staff downloaded and ran the WRWC model and then compared WRWC model output with NRCS forecasts for runoff volume at the Big Wood at Hailey gage (no other gage sites are included in both forecast models). IDWR also contacted Dr. Kaiser and learned that the WRWC model is still in development and that modifications to the code are being made based on input from the WRWC. For this reason, IDWR has relied on NRCS forecasts for our water supply assessments.

AFRD#2 and the American Falls Reservoir Water Supply

21) The American Falls Irrigation District #2 (AFRD#2) place of use is almost identical to the Big Wood Canal Company (BWCC) place of use.

22) AFRD#2 has a contract with the United States Bureau of Reclamation (USBR) for 393,550 acre-feet (AF) of storage space in American Falls Reservoir. Based in part on the joint USBR and United States Army Corps of Engineers forecast for the period March 1 through July 31, the USBR is projecting that American Falls Reservoir will fill this year on or about April 1.

23) According to Water District 01 records, AFRD#2 has had a full (100%) storage allocation in 29 of the previous 30 years. AFRD#2 had an 82% allocation in 2004.

24) In contrast, Magic Reservoir has filled or substantially filled (i.e., maximum fill of > 170 KAF) in only 14 of the last 30 years. As a consequence, American Falls Reservoir is more reliable than Magic Reservoir as a source of irrigation water in the BWCC/AFRD#2 project area.

Magic Reservoir Inflows

25) Magic Reservoir inflow primarily comes from the Big Wood River and Camas Creek. On average, approximately 1/3 of the reservoir inflow comes from Camas Creek. After the snowmelt runoff period, flow occurs in the lower reaches of Camas Creek as the result of gains from the Camas Prairie aquifer system. Measured groundwater gains range from 1.3 to 2.8 cfs above USGS stream gage 13141500, and 2.7 to 6.9 cfs below the gage (Moody, 2018; Moody, 2020; Young, 1978).

Consumptive Groundwater Use

26) Because of groundwater/surface water communication, consumptive groundwater use reduces aquifer reach gains in Camas Creek. Similarly, consumptive groundwater use in the Wood River Valley reduces flow in the Big Wood River and in Silver Creek.

27) Assuming 85% of the diverted volume is consumptively used, IDWR estimates that the average annual groundwater consumptive use during the period 2016 to 2019 was approximately 8,900 AF on the Camas Prairie and 38,000 AF in the Wood River Valley.

Big Wood River Groundwater Management Area ("BWRGWMA")

28) The BWRGWMA, as shown in Figure 1 below, includes the Camas Creek/Camas Prairie drainage area above Magic Reservoir, the upper Big Wood River Valley above Magic Reservoir, and the Bellevue Triangle-Silver Creek drainage area between Bellevue and Picabo. Groundwater in the Wood River Valley and Bellevue Triangle-Sliver Creek areas comprise the Wood River Valley aquifer system which is located within Water District 37 ("WD37"). The Camas Prairie is underlain by an aquifer system located within Water District 37B ("WD37B").

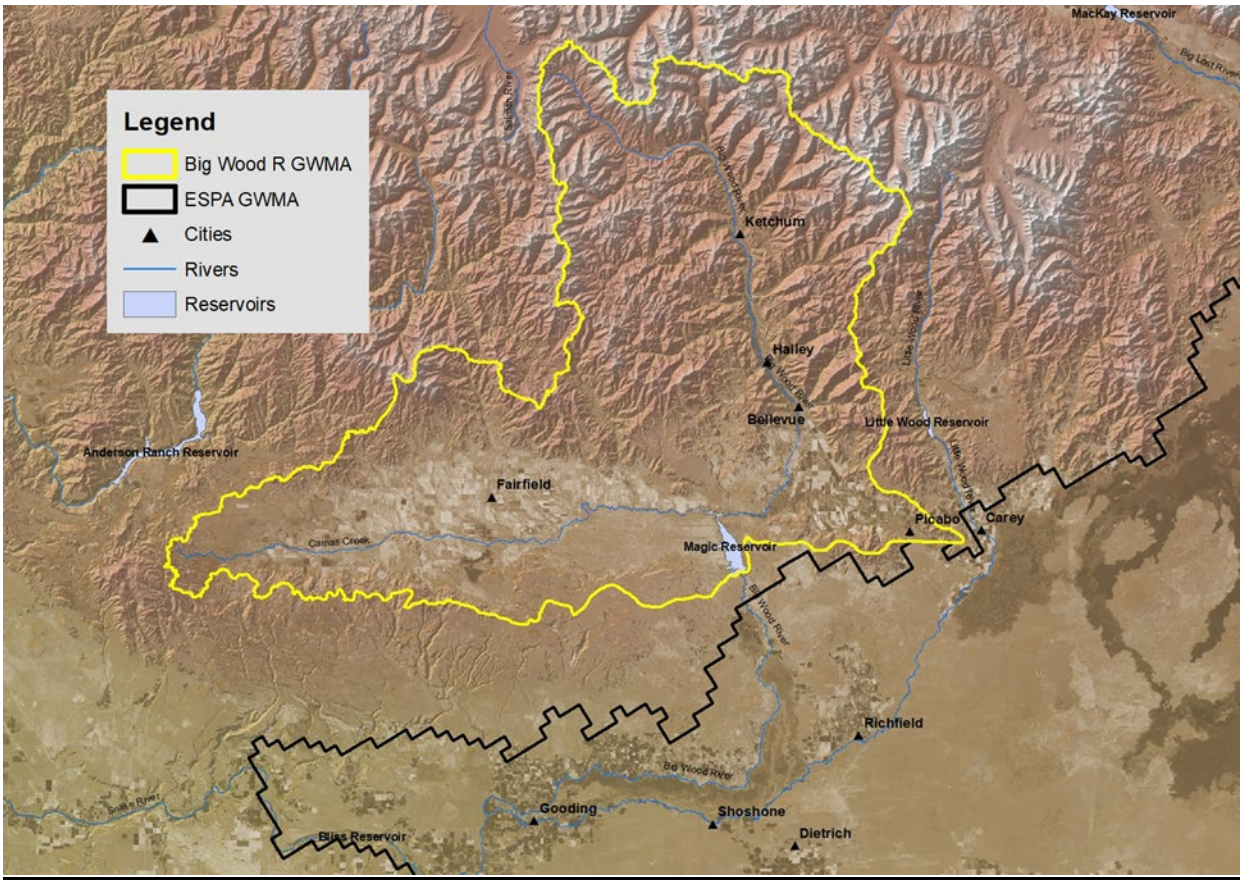


Figure 1. Big Wood River GWMA

BWRGWMA Groundwater Use

29) WD37 and WD37B are responsible for measuring and reporting groundwater use within the BWRGWMA. Both water districts report groundwater use to IDWR using IDWR's Water Measurement Information System ("WMIS").

30) Total annual reported groundwater diversions in the BWRGWMA and WD37 over the past five years has ranged from 33,673 AF in 2017 (a wet year) to 49,607 AF in 2020 (a dry year). *See Figure 2.* The total average annual groundwater diversions for the five year period is 40,764 AF. Most groundwater is used for irrigation of agriculture crops. In 2020, total municipal ground water diversions in WD37/BWRGWMA was over 8,300 AF, including about 5,300 AF diverted by the cities of Bellevue, Hailey, and Ketchum, and about 3,000 AF diverted by the Sun Valley Water and Sewer District. IDWR estimates about an additional 5,400 AF of groundwater is diverted per year within the Wood River Valley aquifer system by domestic wells that are exempt from water right and measurement requirements (includes estimate of exempt domestic irrigation use of one-half acre or less).

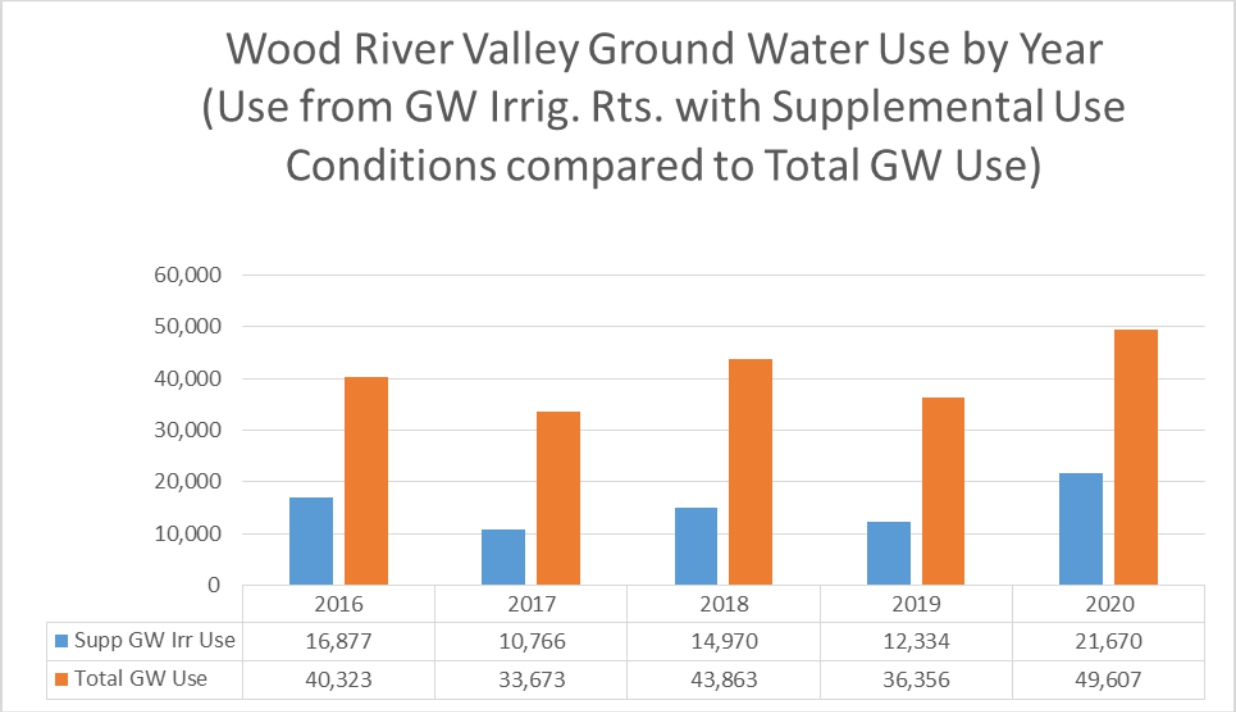
31) Annual reported groundwater diversions in WD37B from 2016 through 2020 has ranged from 9,122 AF (2017) to 11,940 AF (2018). Average groundwater diversions for the five year period was about 10,300 AF. Nearly all of the WD37B groundwater diversions is for

agricultural irrigation. IDWR estimates that exempt domestic wells in the Camas Prairie divert more than 800 AF of groundwater per year.

Supplemental Groundwater Use:

32) Water is diverted from a number of groundwater irrigation wells within the BWRGWMA and WD37 to supplement surface water sources. Most of the supplemental groundwater irrigation wells and rights are located in the Bellevue Triangle area and groundwater irrigates lands that are the place of use for water rights authorizing diversion the Big Wood River or Silver Creek and tributaries. More than 140 groundwater irrigation rights in the BWRGWMA include conditions that require full beneficial use of surface water available under surface water rights that are appurtenant to the same land. Some groundwater irrigation rights in the BWRGWMA may supplement surface water sources but lack specific conditions requiring full beneficial use of available surface water rights and sources. Only one groundwater irrigation right in WD37B includes a supplemental use condition.

33) Groundwater diversions from irrigation wells authorized by groundwater rights in WD37 having supplemental use conditions account for about one-third or more of the total groundwater diversions in WD37. The graph and table below shows supplemental groundwater diversions compared to total groundwater diversions in WD37/Wood River Valley from 2016 through 2020.



	2016	2017	2018	2019	2020
Supp GW Irr Use	16,877	10,766	14,970	12,334	21,670
Total GW Use	40,323	33,673	43,863	36,356	49,607

Figure 2. Wood River Valley Groundwater Diversions by Year, including Supplemental Groundwater Diversions

Continuous Curtailment Model Run – Wood River Valley Aquifer

34) A simulation of continuous curtailment of groundwater consumptive use from 1995 through 2014 using Version 1.1 of the Wood River Valley Groundwater Flow Model predicted average annual increases in streamflow of 15,200 AF in Silver Creek, 8,400 AF in the Wood River above the Dry Bed, and 3,500 AF in the Wood River below the Dry Bed.

35) During the April through September irrigation season, the groundwater flow model predicted streamflow increases of 9,500 AF in Silver Creek, 5,500 AF in the Wood River above the Dry Bed, and 1,700 AF in the Wood River below the Dry Bed. During the October through March non-irrigation season, the groundwater flow model predicted average increases in streamflow of 5,700 AF in Silver Creek, 2,900 AF in the Wood River above the Dry Bed, and 1,800 AF in the Wood River below the Dry Bed.

36) During years with lower surface water supply and higher evapotranspiration, the predicted impacts of continuous curtailment on streamflow were higher than the curtailment period annual averages that were previously described in observation 34. For example, during the 2002 calendar year, the groundwater-flow model predicted increases in streamflow of 19,900 AF in Silver Creek, 10,000 AF in the Wood River above the Dry Bed, and 5,000 AF in the Wood River below the Dry Bed. During the 2014 calendar year, the groundwater-flow model predicted increases in streamflow of 23,500 AF in Silver Creek, 11,100 AF in the Wood River above the Dry Bed, and 6,700 AF in the Wood River below the Dry Bed.

Significance of Continuous Curtailment on Below Magic Water Supplies

37) If distributed evenly through the year, the modeled average annual increase in Silver Creek (15,200 AF) equates to 21 cfs, which is approximately 17% of the average flow rate in Silver Creek at the Sportsman's Access gage during the 2020 water year (126.2 cfs).

38) The predicted average annual benefit to the below Dry Bed reach of the Wood River (3,500 AF) is 1.8% of the capacity of Magic Reservoir (191,500 AF). For a typical reservoir release rate of 900 cfs, an additional 3,500 AF in the reservoir could be used to extend a shortened irrigation season by 2 days. During the previous 30 years, the irrigation season for Magic Reservoir water users was cut short approximately half the time.

39) The Dry Bed of the Big Wood River between Glendale Road and Heart Rock Ranch generally flows during snowmelt runoff until all flow is diverted into the Bypass Canal. During development of Version 1.1 of the Wood River Valley Groundwater Flow Model, IDWR reviewed Landsat photos and Water District 37 records to determine when the Dry Bed was flowing or dry during the 1995 through 2014 model simulation period. This analysis indicated the Dry Bed was flowing during 48% of the irrigation season months and 27% of the non-irrigation season months. The Dry Bed was dry during 52% of the irrigation season months and 73% of the non-irrigation season months.

40) When Big Wood Canal Company ceases delivery of storage for irrigation out of Magic Reservoir, delivery of natural flow rights directly out of the Big Wood River below Magic Reservoir also ceases.

Predicted Impacts of Curtailed Groundwater Use – Analog Years

41) The Wood River Valley Groundwater-Flow Model predicted impacts to stream flow in 2014 and 2002 in response to pumping groundwater in the Bellevue Triangle and in areas of the Big Wood River Valley upstream of the Bellevue Triangle are shown in Tables 1 and 2 below. The responses are shown on a monthly time step in average cfs, April through September.

Table 1. 2014 Groundwater Model Depletions

Month-Year	Depletions (cfs)	
	Silver Creek	Big Wood blw Dry Bed (incl. Willow Creek)
Apr-14	5.2	1.2
May-14	15.1	2.8
Jun-14	29.9	4.8
Jul-14	43.0	9.4
Aug-14	43.8	12.2
Sep-14	39.1	11.6

Table 2. 2002 Groundwater Model Depletions

Month-Year	Depletions (cfs)	
	Silver Creek	Big Wood blw Dry Bed (incl. Willow Creek)
Apr-02	7.0	1.3
May-02	13.8	2.2
Jun-02	23.0	2.7
Jul-02	36.6	4.8
Aug-02	38.0	7.8
Sep-02	34.4	9.2

Impacts of Modeled Groundwater Curtailment on Calculation of Water Right Priority Cuts

42) The WD37 watermaster makes separate water right priority cut determinations on the Big Wood River above and below Magic Reservoir, and on Silver Creek/Little Wood River. An explanation of priority cut determinations for all three river systems is given by the watermaster via correspondence to IDWR dated June 16, 2015, which is attached to, and summarized in an IDWR memorandum dated August 31, 2015, and available on IDWR's

website at: https://idwr.idaho.gov/files/legal/CM-DC-2015-001/CM-DC-2015-001-20150831-Staff-Memo-Attachments-BWLWWUA-Calls.pdf

The 2015 IDWR memo also generally describes the delivery systems for the Big Wood and Little Wood River systems, including delivery of storage water from Magic Reservoir.

43) The WD37 watermaster records show natural flow water rights with the following priority dates were curtailed during the 2014 irrigation season:

- Big Wood River below Magic Reservoir
    - On June 23, 2014, rights were cut to the May 1, 1900 priority date
    - On July 1, 2014, rights were cut to the June 15, 1890 priority date
    - On July 7, 2014, all rights were shut off, and the reservoir gates were shut off on July 17, 2014.

- Little Wood River and Silver Creek
    - Rights were cut to the April 1, 1887 and April 1, 1885 priority dates on May 20 and May 27 respectively
    - Rights were cut to the April 1, 1884 priority date on June 27
    - Rights were cut to the September, 1883 and April 6, 1883 priority dates on July 8 and July 17, respectively. The 1883 Little Wood priority rights are among the most senior priority rights on the river.

44) Using 2014 as an analog year, modeled curtailment of groundwater in the Wood River Valley would impact natural flow priority right deliveries on the Big Wood River and Little Wood River/Silver Creek as follows:

- Big Wood River below Magic Reservoir
    - Modeled curtailment of groundwater would add 4.8 cfs to the deliverable supply in June. Based on IDWR's review of priority rights, the priority cut on June 23, 2014 should have been about 10% of the May 15, 1897 priority rights. The additional 4.8 cfs of deliverable supply from groundwater curtailment would have advanced the priority cut to about 15% of the May 15, 1897 priority rights.
    - Based on IDWR's review of priority rights, the priority cut on July 1, 2014 should have been July 1, 1889. Modeled curtailment of groundwater would add 9.4 cfs to the deliverable supply and advance the priority cut to about 90% of the June 15, 1890 priority right (the next priority after July 1, 1889).
    - On July 7, 2014 when all rights below Magic were shut off, modeled curtailment of groundwater would add only 9.4 cfs to the river, making the total deliverable supply below Magic only 26 cfs, which is insufficient for delivery to right holders for beneficial use.

- Little Wood River and Silver Creek
    - Modeled curtailment of groundwater would add 15.1 cfs of flow to Silver Creek in May 2014. According to the WD37 watermaster, Kevin Lakey, this additional increase in flow could have advanced the priority cut on both May 20 (April 1, 1887 priority) and May 27 (April 1, 1885 priority) to April 1, 1890.
    - Modeled curtailment of groundwater would add 29.9 cfs of flow to Silver Creek in June 2014. According to the watermaster, the additional flow could have advanced the priority cut on June 27, 2014 from April 3, 1884 to April 5, 1885.
    - Modeled curtailment of groundwater would add 43 cfs of flow to Silver Creek in July 2014. According to the watermaster, the additional flow could have advanced the priority cut on both July 8 and 17, 2014 from September 9, 1883 and April 6, 1883, respectively, to May 31, 1885.
    - Modeled curtailment of groundwater would add 43.8 cfs of flow to Silver Creek in August 2014. According to the watermaster, the additional flow could have advanced the 1883 priority cuts in August to 1886 priority rights.

45) Using 2002 as an analog year, modeled curtailment of groundwater in the Wood River Valley would impact natural flow priority right deliveries on the Big Wood River and Little Wood River/Silver Creek as follows:

- Big Wood River below Magic Reservoir
    - Magic Reservoir was shut off on or about July 15, 2002, thus making delivery of reservoir inflow unavailable for delivery of natural flow rights below the reservoir. Modeled curtailment of groundwater at this time would add only 4.8 cfs to the river and reservoir inflow, making the total deliverable supply below Magic only 28 cfs, which is insufficient for delivery to right holders for beneficial use.

- Little Wood River and Silver Creek
    - From July 23 through September 30, 2002, natural flow water rights on the Little Wood River and Silver Creek were cut to 1883 priority dates. Modeled curtailment of groundwater would add 36.6 cfs, 38 cfs and 34.4 cfs of flow to Silver Creek respectively in July, August and September. According to the watermaster, the additional flow across the three months could have advanced the 1883 priority cuts to 1884 and 1885 priority dates.

Conclusions

1) During years when Magic Reservoir fills, the water supply for irrigators relying primarily on water from the reservoir generally is adequate and extends through the end of the irrigation season. Magic Reservoir completely or substantially fills about half the time.

2) During years when Magic Reservoir doesn't fill, the surface water supply generally is inadequate, sometimes by a significant amount.

3) Magic Reservoir will most likely not fill for the 2021 irrigation season.

4) Magic Reservoir is filled primarily by inflows from Camas Creek and the Big Wood River. Both Camas Creek and the Big Wood River are hydraulically connected to aquifer systems in the Big Wood Ground Water Management Area and are depleted by consumptive groundwater pumping.

5) AFRD#2 will very likely have a full allotment of storage from American Falls Reservoir this year, and water users relying primarily on AFRD#2 storage water will most likely have an adequate water supply.

6) American Falls Reservoir storage delivers a considerably more reliable water supply than Magic Reservoir delivers.

7) The benefits of consumptive groundwater pumping curtailment in the Wood River Valley were evaluated with version 1.1 of the Wood River Valley groundwater flow model. For continuous curtailment extending from 1995 to 2014, the model predicts average annual increases in streamflow of 15,200 acre-feet (AF) in Silver Creek, 8,400 AF in the Wood River above the Dry Bed, and 3,500 AF in the Wood River below the Dry Bed, which is the reach of the Wood River that flows into Magic Reservoir.

8) Water supplies in 2014 and 2002 are similar to the 2021 forecasted water supply as reported by the NRCS March 1 SWSI. In both 2014 and 2002, Magic Reservoir was shut off in mid-July, thereby ceasing the delivery of reservoir inflows for natural flow rights on the Big Wood River located below the reservoir. Also in both years, natural flow water rights on the Little Wood River and Silver Creek were curtailed to 1883 priority dates.

9) The Wood River Valley groundwater flow model predicts increases in streamflow on a monthly time step for years 1995 to 2014. The groundwater model predicts that curtailment of groundwater in the Wood River Valley in 2014 and 2002 increases the flow of Silver Creek by 15 to 44 cfs during the 2014 irrigation season, and by 34 to 38 cfs during the 2002 irrigation season. The model also predicts that curtailment of groundwater in the Wood River Valley increases flows to the Big Wood River above Magic Reservoir by 2.8 to 12.2 cfs in 2014, and by 2.2 to 9.2 cfs in 2002. In years similar to 2014 and 2002 when Magic Reservoir is shut off in mid-July, inflows to the reservoir, including any additional inflow resulting from curtailment of groundwater, cannot be delivered to the holders of senior priority natural flow rights below the reservoir.