MEMO

State of Idaho
Department of Water Resources
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Date: August 28, 2015

To: Gary Spackman, P.E., Director

Cc: Sean Vincent, P.G., Hydrology Section Manager

From: Jennifer Sukow, P.E., P.G., Hydrology Section

Subject: Hydrology, hydrogeology, and hydrologic data, Big Wood & Little Wood Water Users Association delivery calls, CM-DC-2015-001 and CM-DC-2015-002

This memorandum responds to the Hydrology, Hydrogeology, and Hydrologic Data section of the Request for Staff Memoranda dated June 12, 2015. The Director requested Department staff review data and information in possession of the Department, and prepare a staff memorandum addressing the following:

1. Any hydrologic or hydrogeologic data or publications collected by or available to the Department that may assist the Director in understanding surface and ground water interactions in the Big and Little Wood River basins.

2. A conceptual description of the interaction between ground water and surface water in the Camas Creek drainage, the Big Wood River drainage, the Silver Creek drainage, the Little Wood River drainage, and any other hydrologic units that may be hydraulically connected to the ground water and surface water in the larger Big Wood River and Little Wood River basins.

3. Identification of diversion records for junior ground water pumping available to the Department.

4. Identification of methods and data available for analyzing consumptive use associated with junior ground water pumping.

5. Identification of any hydrologic or hydrogeologic methods or modeling tools that may be employed in analyzing the impacts of junior ground water pumping on calling senior-priority surface water right holders.

Section 1. Hydrologic or hydrogeologic data or publications

Hydrologic, geologic, and hydrogeologic reports

Hydrology and early irrigation development in the Big and Little Wood River drainages was described by Ross (1900). In 1902, Jay D. Stannard measured gains and losses in the Big Wood River, Silver Creek, and the Little Wood River (Ross, 1902). Between 1920 and 1922, S.H. Chapman discussed hydrology and the interaction of surface and groundwater in early watermaster reports pertaining to the Big Wood River, Silver Creek, and lower Little Wood River (Water Districts 7 & 11, 1920-1922). The Idaho Bureau of Mines and Geology published an early study of the hydrogeology of Camas Prairie (Piper, 1925). The geology of the Magic Reservoir area was described or mapped by Struhsacker et al. (1982), Leeman (1982), and Kauffman and Othberg (2007, 2008).

The U.S. Geological Survey (USGS) published several studies of the hydrology and hydrogeology of the Big Wood River, Little Wood River, Silver Creek, and Camas Creek basins. USGS studies of the Big Wood River basin include Stearns et al. (1938), Jones (1952), Smith (1959), Smith (1960), Schmidt (1962), Moreland (1977), Frenzel (1989), Skinner et al. (2007), Bartolino (2009), Bartolino and Adkins (2012), Hopkins and Bartolino (2013), and Bartolino (2014). USGS studies of the Little Wood River basin include Stearns et al. (1938), Jones (1952) and Smith (1960). The Silver Creek basin was investigated by Stearns et al. (1938), Jones (1952), Smith (1959), Smith (1960), Schmidt (1962), Moreland (1977), Skinner et al. (2007), Bartolino (2009), Bartolino and Adkins (2012), Hopkins and Bartolino (2013), and Bartolino (2014). The Camas Creek basin was investigated by Stearns et al. (1938), Jones (1952), Smith (1960), Walton (1962), Young (1978), and Young et al. (1978).

Publications by other organizations include Idaho Department of Water Resources (IDWR) studies of the Big Wood River area by Castelin and Chapman (1972) and Castelin and Winner (1975), reports describing a hydrologic and stream temperature model constructed for The Nature Conservancy (Loinaz, 2012a; Loinaz, 2012b), and reports describing a groundwater flow model constructed for The Nature Conservancy (Brockway and Kahlown, 1994; Wetzstein and others, 1999; Brown, 2000).

An excellent summary of previous work in the upper Big Wood River and Silver Creek basins is included in Bartolino and Adkins (2012). This report also provides an excellent description of the hydrogeologic framework of the Wood River Valley aquifer system. Bartolino and Vincent (2013) provide a short, concise summary of the hydrology and hydrogeology of the Wood River Valley aquifer system. Bartolino (2014) describes recent USGS investigations regarding groundwater levels and interaction between groundwater and surface water in the Wood River Valley.

The USGS, in collaboration with IDWR, is currently developing a MODFLOW numerical groundwater-flow model of the Wood River Valley aquifer system (Bartolino and Vincent, 2013). The USGS is scheduled to publish the model and supporting documentation in December 2015.

Hydrologic and hydrogeologic data

The USGS and Idaho Power Company (IPCO) collect, or have collected, continuous streamflow data at the sites listed in Table 1. Gage locations are shown in Figure 1. USGS data are available at http://waterdata.usgs.gov/nwis/sw. IPCO data are available at https://www.idahopower.com/OurEnvironment/WaterInformation/StreamFlow/stationList/basinstationList.cfm?selectS=3.

Site Number	Site Name	Dates	Agency
13135500	Big Wood River nr Ketchum	6/1948-9/1971; 4/2011-present	USGS
13135520	North Fork Big Wood River nr Sawtooth NRA HQ	4/2011-present	USGS
13137000	Warm Springs Creek nr Ketchum	1/2011-present	USGS
13137500	Trail Creek at Ketchum	11/2010-present	USGS
13138000	East Fork Big Wood River at Gimlet	10/2010-present	USGS
13139510	Big Wood River at Hailey, total flow	7/1915-present	USGS
13140800	Big Wood River at Stanton Crossing	9/1996-present	USGS
13140900	Willow Creek nr Spring Creek Ranch	6/2000-present	IPCO
13141000	Big Wood River nr Bellevue	7/1911-9/1996	USGS
13141500	Camas Creek nr Blaine	6/1912-present	USGS
13142000	Magic Reservoir nr Richfield (storage)	4/1909-present	USGS
13142500	Big Wood River bl Magic Dam nr Richfield	4/1911-present	USGS
13150430	Silver Creek at Sportsman Access	10/1974-9/2006; 10/2007-present	USGS
13150500	Silver Creek nr Hwy 20 nr Picabo	6/1920-12/1962	USGS
13151000	Little Wood River nr Richfield	1/1911-9/1972	USGS
13151500	Little Wood River at Shoshone	4/1922-12/1959	USGS
13152500	Malad River nr Gooding	3/1916-present	USGS

Table 1. Period of record for continuous recording gaging stations.

Figure 1. USGS and IPCO streamflow gaging stations.

Water District 37 and its predecessors monitor streamflow at additional sites on the Little Wood River and Big Wood River from April through September each year. Bound watermaster reports containing the additional streamflow data are available for inspection at the IDWR State Office (Water Districts 7 & 11, various years, 1920-1970; Water Districts 37 & 37M, various years, 1971-2013). In 2014, IDWR began gaging stage in the Little Wood River year-round at water district station 10 (formerly USGS station 13151000) and at water district station 54 (Figure 2). IDWR reestablished year-round gaging to obtain data on seepage from the Little Wood River to the Eastern Snake Plain Aquifer (ESPA) during the winter months. IDWR has not yet processed the data. Raw stage data are included in the supplemental files accompanying this memorandum.

Figure 2. Watermaster gaging stations with year-round gages installed by IDWR.

Surface water diversions from the Big Wood River, Silver Creek, and the lower Little Wood River have been recorded by water districts since 1920. Bound watermaster reports are available for inspection at the IDWR State Office (Water Districts 7 & 11, various years, 1920-1970; Water Districts 37 & 37M, various years, 1971-2013).

Groundwater level measurements collected by the USGS are available at http://nwis.waterdata.usgs.gov/id/nwis/gwlevels. Groundwater level measurements collected by both the USGS and IDWR are stored in IDWR's database and are available at http://idwr.idaho.gov/hydro.online/gwl/. Bartolino (2014) provides a recent evaluation of groundwater level measurements in the Wood River Valley aquifer system. Bartolino (2014) compared water level measurements collected in over 90 wells in October 2006 and October 2012. Bartolino (2014) also evaluated long term water level trends at five wells measured semi-annually. IDWR increased the frequency of water level monitoring at representative sites in the Wood River Valley between 2012 and 2014.

IDWR staff compiled selected groundwater level measurements in the Camas Prairie aquifer system for this memorandum. Sixteen Camas Prairie wells were measured at least 50 times by the USGS or IDWR between 1944 and 2013. Well locations and selected hydrographs are shown on Attachment A[1].

Well drillers' logs filed with IDWR are available for numerous wells in the Wood River Valley and Camas Prairie. A shapefile of approximate well locations is available at http://idwr.idaho.gov/GeographicInfo/GISdata/wells.htm. Drillers' logs are available at http://idwr.idaho.gov/WaterManagement/WellInformation/DrillerReports/dr_default.htm.

Section 2. Conceptual description of interaction between groundwater and surface water

Overview

Aquifers underlying the Wood Rivers area include the Camas Prairie aquifer system, the Wood River Valley aquifer system, the ESPA, and small local aquifers in the upper Little Wood River valley. Figure 3 illustrates the general location of the primary aquifers and denotes stream reaches where gains from groundwater or losses to groundwater have been documented. Figure 3 also denotes perched reaches, where the rivers lose water to groundwater at a rate independent of groundwater elevation. The delineation of gaining, losing, and perched reaches is approximate. Transitions between gaining, losing, and perched reaches may move upstream or downstream seasonally and year to year with fluctuations in streamflow, aquifer recharge, and groundwater withdrawals. Figure 3 also shows intermittent reaches of the Big and Little Wood Rivers. These reaches generally lose water to the aquifer when water is flowing in the rivers, but are dry during low water periods because of diversions and/or seepage losses.

[1] Water level data used to generate hydrographs are provided in supplemental files accompanying this memorandum.

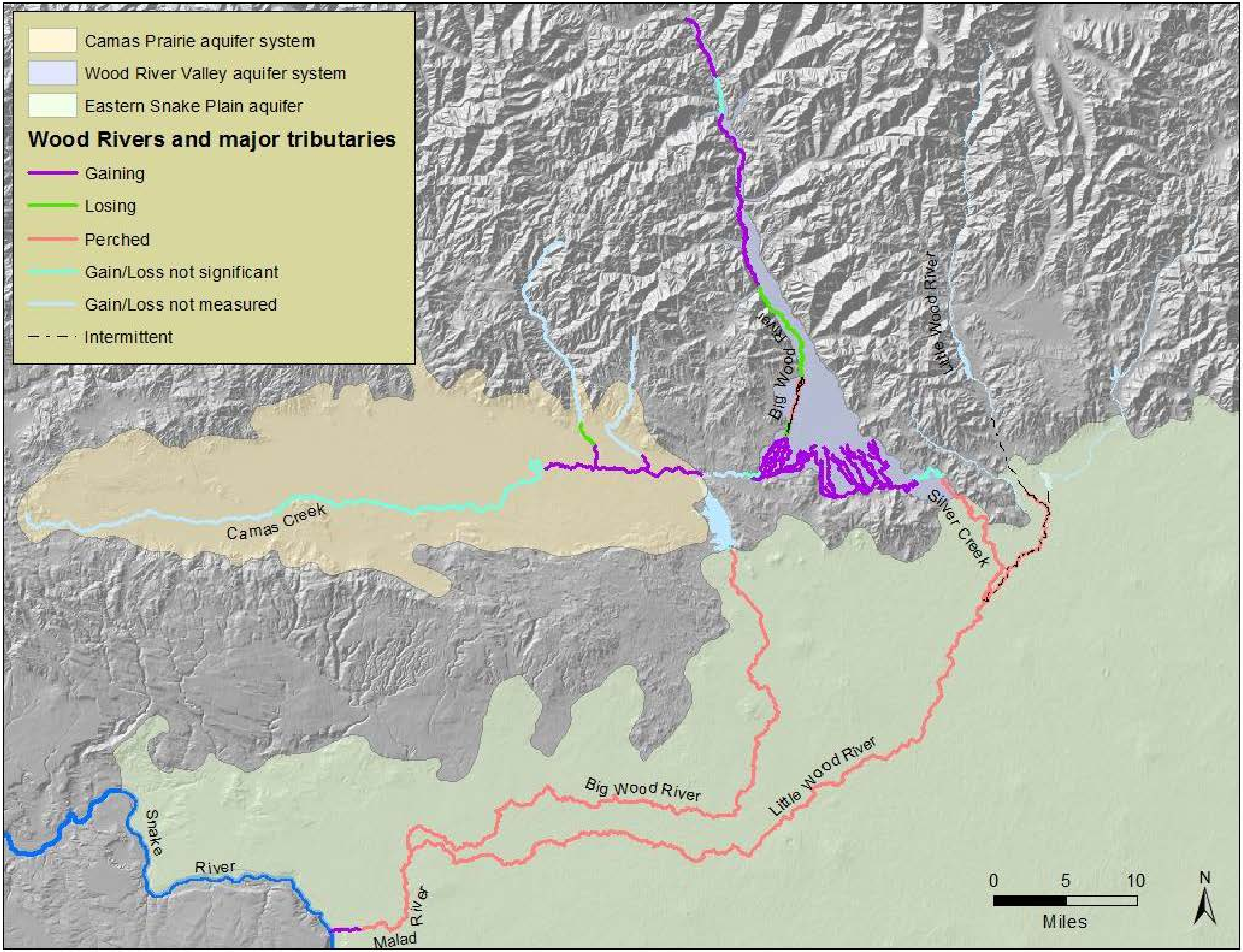

Figure 3. Generalized location of aquifers and interaction with surface water.

Interaction between Camas Prairie aquifer system, Camas Creek, and Magic Reservoir

USGS scientists investigated the hydrogeology of Camas Prairie in 1957 (Walton, 1962) and in 1977 (Young, et al., 1978; Young, 1978). The Camas Creek drainage basin is an eastward trending intermontane basin of approximately 730 square miles. The principal aquifers in the basin are located beneath the Camas Prairie in a structural depression approximately 40 miles long and 8 miles wide. The basin is bounded by mountains and uplands on the north, west, and south. Camas Creek flows eastward through the basin, joining the Big Wood River at Magic Reservoir (Figure 4).

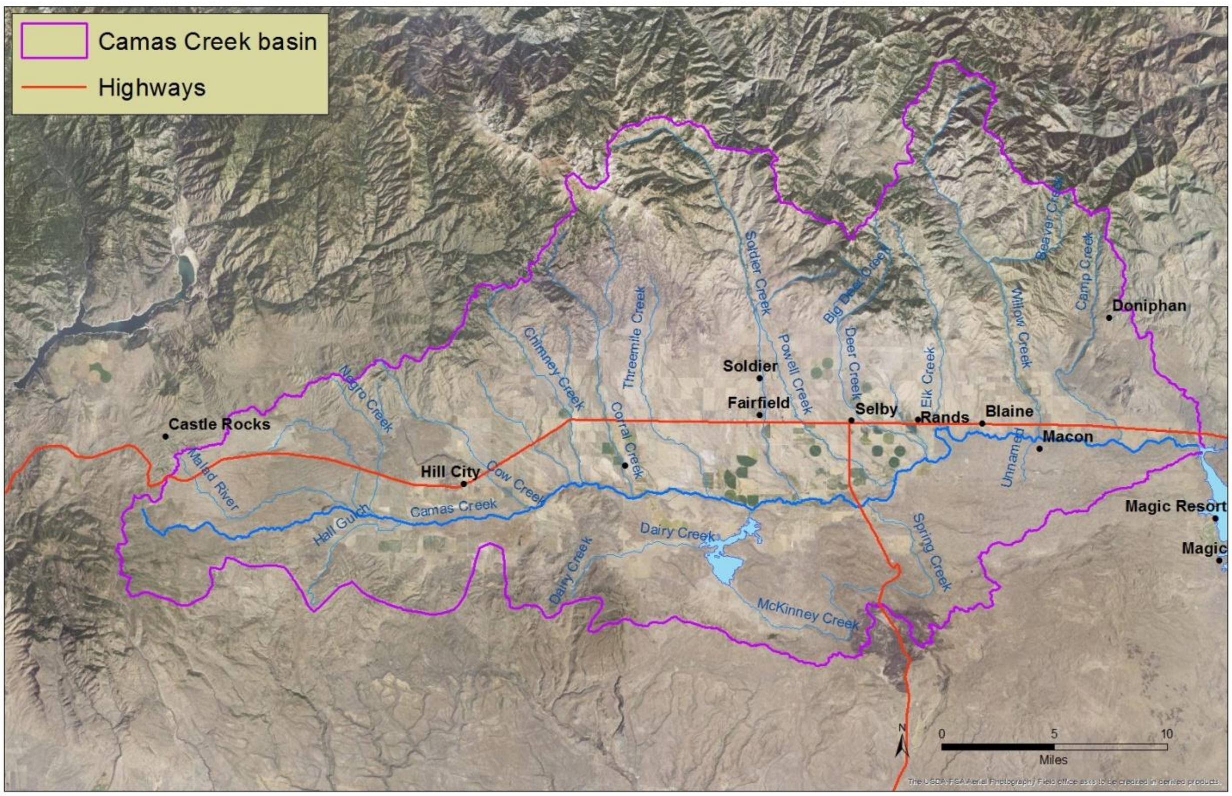

Figure 4. Camas Prairie hydrography

During the Pliocene and Pleistocene periods (between approximately 10,000 and 5 million years ago) lava flows intermittently blocked the basin's outlet to the east, resulting in deposition of valley fill sediments exceeding thicknesses of 500 feet in some locations. The valley fill includes alluvial (stream-deposited) and lacustrine (lake-bed) sediments. The alluvial sediments consist of interbedded clay, silt, sand, and gravel. The lacustrine deposits consist of silt and clay. Snake River Group basalt is exposed along the eastern, western, and southern margins of the

Camas Prairie. The basalt consists of a sequence of separate lava flows, and has permeable zones along contacts between lava flows, joints, and other crevices.

The principal aquifers in the Camas Creek basin are composed of sand and gravel within the valley fill sediments and Quaternary basalt of the Snake River Group. Walton (1962) and Young (1978) describe a moderately permeable shallow unconfined aquifer to depths of about 40 feet. Between depths of approximately 40 and 120 feet, silt and clay lenses within the alluvial valley fill result in locally confined conditions. Between depths of approximately 120 feet and 210 feet, low permeability lake-bed sediments form a significant confining unit with an average thickness of 90 feet. The confining unit is underlain by two zones of permeable sand and gravel. The upper zone, referred to by Walton (1962) as the "upper artesian aquifer" averages approximately 50 feet in thickness. The lower zone, referred to by Walton (1962) as the "lower artesian aquifer" occurs at the base of the valley fill and averages approximately 85 feet in thickness. Walton (1962) also noted confined conditions within the basalt. Most irrigation wells in the Camas Prairie withdraw water from the confined aquifers. In 1957, artesian pressure in confined aquifers beneath much of the Camas Prairie was sufficient to cause wells to flow at ground surface (Walton, 1962). By 1977, Young (1978) noted declines in pressure head in response to increased pumping for irrigation.

The Camas Prairie aquifer system is recharged primarily by direct infiltration of precipitation and seepage from streams. Groundwater beneath the Camas Prairie generally flows from recharge areas along the foot of the Soldier Mountains and Mount Bennett Hills toward Camas Creek, then eastward toward the basin outlet (Walton, 1962; Young, 1978). The confining units are leaky and allow upward flow of water from the deeper confined aquifers to the shallow unconfined aquifer. At the east end of the Camas Prairie, where Willow Creek and Camas Creek are incised into the basalt, groundwater discharges to the creeks and possibly the Camas Creek arm of Magic Reservoir (Figure 5). The elevation of Camas Creek drops from approximately 4,974 feet above mean sea level at the Elk Creek confluence to approximately 4,800 feet at the location of Young's Station 14. Walton (1962) noted, "*Water-level data for wells at Magic show that most of the underflow from the prairie discharges into Camas Creek or Magic Reservoir. Little, if any, of the underflow reaches the Snake River Plain*."

Geologic mapping in the vicinity of Magic Reservoir (Kauffman and Othberg, 2007; 2008) and the relatively small to negligible underflow from the Wood River Valley aquifer system to Magic Reservoir (Smith, 1959; Brockway and Kahlown, 1994; Bartolino and Adkins, 2012) suggest there is not a significant hydraulic connection between the Camas Prairie and Wood River Valley aquifer systems. While both aquifer systems contribute to the inflow of Magic Reservoir, groundwater levels in the Camas Prairie aquifer system are not expected to affect groundwater levels in the Wood River Valley aquifer system and vice versa.

Figure 5. Camas Creek measurement sites on the east end of Camas Prairie.

Both Walton (1962) and Young (1978) performed seepage studies to evaluate the interaction between groundwater and streamflow in the Camas Prairie. In November 1957, Walton (1962) measured a 1.3 cfs gain from groundwater to Camas Creek between the Soldier Creek confluence and Willow Creek confluence. A gain of 4 cfs from groundwater was measured in the vicinity of lower Willow Creek. Walton (1962) did not attempt to measure gains in Camas Creek between the confluence with Willow Creek and Magic Reservoir.

In May 1977, Young (1978) measured small reach losses to groundwater from Camas Creek between Cow Creek and Elk Creek. Corral Creek, Soldier Creek, Deer Creek, and upper Willow Creek also lost water to the aquifer. Between the confluence with Elk Creek and Magic Reservoir, where Camas Creek is incised into basalt, the creek gained approximately 5 cfs from groundwater. Total groundwater discharge to lower Camas, Willow, and Camp Creeks at the east end of the Camas Prairie was slightly more than 10 cfs. Young (1978) did not measure downstream of Station 14 (Figure 5), which was located near the upper extent of Magic Reservoir backwater. Additional groundwater discharge may occur directly to Magic Reservoir.

The USGS has one active stream gaging station on Camas Creek. Discharge measurements at Station 13141500, Camas Creek near Blaine (Figure 5) began in June of 1912. Between 1912 and 1944, data were not collected during the winter months. Year-round operation of the gaging station began in 1945. The gaging station is located downstream of the confluence with Willow Creek and measured streamflow includes surface runoff and groundwater discharge to lower Willow Creek and part of Camas Creek. Flow may be affected by upstream diversions of surface water during the irrigation season. During periods with little or no surface runoff, discharge from the Camas Prairie aquifers maintains the streamflow at the gage site (Young, 1978). Monthly average discharge measured at the gage site between 1945 and 2014 ranged from 1.3 cfs in June 1992 to 3,300 cfs in April 1952. Between July and February, flow at the gage site is commonly between 2 and 50 cfs. Additional groundwater discharge to Camp Creek and Camas Creek occurs downstream of the gage site. In May 1977, Young, et al. (1978) measured a reach gain of 5 cfs from groundwater to Camas Creek between the gage site and Magic Reservoir, and an inflow of 1 cfs from Camp Creek. Approximately half of the groundwater reach gains measured in May 1977 occurred downstream of the Camas Creek gage. Additional groundwater discharge may occur directly to Magic Reservoir downstream of the location measured by Young et al. (1978).

Water District 37 currently determines inflow from Camas Creek to Magic Reservoir using the flow measured at the Camas Creek gage. Aquifer discharge to the creek or reservoir downstream of the gage is not included in this measurement. In 1922, the watermaster S.H. Chapman reported adding 20 cfs to the calculation of Magic Reservoir inflow to account for "*normal gain in the reservoir section as found from past investigation*." This practice apparently continued for decades (Lakey, 2015), but was abandoned prior to the tenure of the current watermaster (Kevin Lakey, personal communication).

USGS studies performed by Walton (1962), Young (1978), and Young et al. (1978) document the interconnection between the Camas Prairie aquifer system and streamflow in lower Camas Creek. The seepage survey described in Young (1978) and Young et al. (1978) found a significant portion of the aquifer discharge to Camas Creek occurs downstream of the USGS gage on Camas Creek. This portion of the aquifer discharge is not measured and is not included in Water District 37's calculation of inflow to Magic Reservoir.

Interaction between Wood River Valley aquifer system and surface water

The hydrogeologic framework of the Wood River Valley aquifer system is described in detail by Bartolino and Adkins (2012). The primary aquifer system is composed of alluvial sediments and basalt. The aquifer system includes an unconfined aquifer underlying the entire valley and a deeper confined aquifer present only in the southwestern portion of the valley. Sediment thicknesses range from less than a foot at the margins of tributary valleys to about 350 feet in the central Bellevue fan. Bartolino and Vincent (2013) provide a summary of the hydrogeologic framework and observed hydrologic trends.

The Wood River Valley aquifer system interacts with the Big Wood River, Silver Creek, and tributary streams (Figure 3). Between the confluence with the North Fork of the Big Wood River and Hailey, the Big Wood River generally gains water from the aquifer (Bartolino and Adkins, 2012; Bartolino, 2014). Between Hailey and Black Slough, the Big Wood River loses water to the aquifer. Between Glendale Road and Black Slough, the river is perched above the aquifer and is typically dry part of the summer. Between Black Slough and Willow Creek, the river gains water from the aquifer via seeps and tributary springs. Willow Creek, which enters the Big Wood River below the Stanton Crossing gage station, is fed primarily by the aquifer though seeps and tributary springs. Figure 6 shows the location of springs identified on USGS topographic maps.

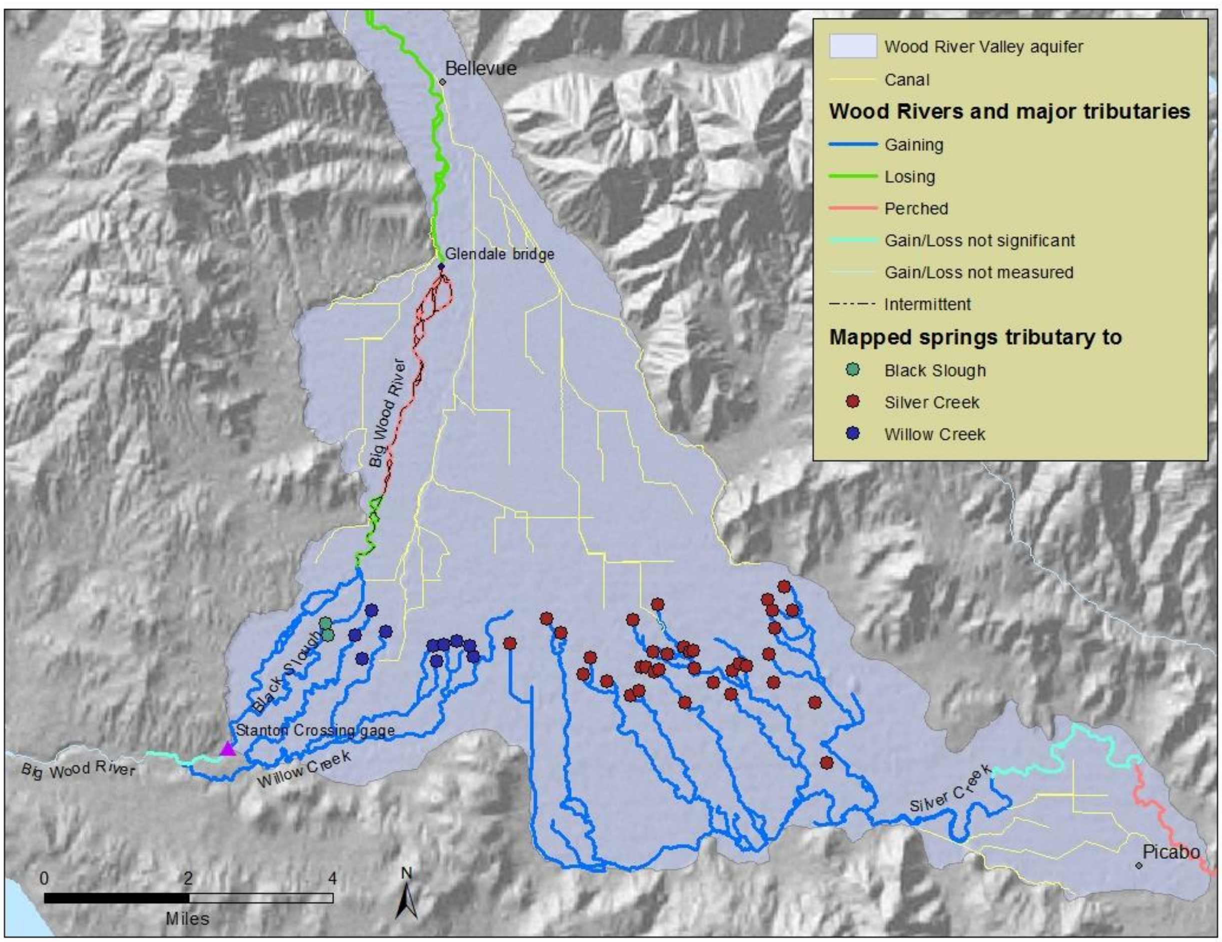

Figure 6. Mapped springs tributary to the Big Wood River and Silver Creek

Underflow beneath the Big Wood River between Stanton Crossing and Magic Reservoir appears to be negligible because of shallow, low-permeability bedrock (Bartolino and Adkins, 2012). Water District 37 determines inflow from the Big Wood River to Magic Reservoir by summing measured streamflow in the Big Wood River at Stanton Crossing and measured streamflow in Willow Creek (Kevin Lakey, personal communication). During high flow periods, both surface water flow and aquifer discharge contribute to the inflow. During low flow periods, Water District 37 diverts the entire flow of the Big Wood River into the Baseline Bypass Canal. While water can be returned from the Baseline Bypass Canal to the Big Wood River, the entire flow is typically diverted by senior water users until October. During low flow periods, aquifer discharge to springs and seeps is the primary source of the inflow from the Big Wood River to Magic Reservoir.

Discharge from the Wood River Valley aquifer system is the primary source of water for Silver Creek. Direct precipitation and snowmelt provide some additional water seasonally. Figure 6 shows the location of mapped springs emanating from the aquifer to form the tributaries of Silver Creek.

Throughout the year, groundwater elevation in the Wood River Valley aquifer affects discharge to seeps and springs feeding the Big Wood River below Black Slough, Willow Creek, and Silver Creek. Because the impacts of aquifer recharge and withdrawals propagate outward radially from the location of the applied stress, recharge or withdrawal at a single location within the aquifer affects discharge to springs tributary to both the Big Wood River and Silver Creek. Groundwater elevation and corresponding aquifer discharge to seeps and springs is influenced by a number of factors, including, but not limited to:

- volume of seepage from the Big Wood River recharging the aquifer between Hailey and Black Slough,
- volume of irrigation diversions from the Big Wood River and corresponding volume of aquifer recharge via canal seepage and incidental infiltration,
- volume of streamflow in the Big Wood River at Hailey available for riverbed seepage and diversions,
- volume of groundwater consumptively used for irrigation of agricultural fields and landscaping,
- volume of evapotranspiration from wetlands and riparian vegetation.

Groundwater elevation decreases rapidly where the Wood River Valley aquifer system discharges into the ESPA, and Silver Creek is perched above the ESPA (Figure 3). Several researchers have estimated the volume of underflow from the Wood River Valley aquifer system to the ESPA. Estimates range from 4,000 AF/yr (Bartolino and Adkins, 2012) to 53,000 AF/yr

(Garabedian, 1992). The Bartolino and Adkins (2012) estimate is based on more data than was available to prior researchers, and is likely the best estimate of underflow to the ESPA.

Interaction between the ESPA and Big and Little Wood Rivers

The Big and Little Wood Rivers and the upper Malad River are perched above the ESPA (IDWR, 2013). Depth to groundwater in the vicinity of these rivers generally exceeds 50 feet. The Big and Little Wood Rivers and the upper Malad River lose water to the ESPA via riverbed seepage, but the rate of seepage is independent of aquifer water level. The lower Malad River becomes hydraulically connected to the ESPA where the river enters an incised canyon approximately 2 miles before the confluence with the Snake River (Figure 3). The ESPA discharges large volumes of water to the lower Malad River (IDWR, 2013). Changes in water levels and groundwater use within the ESPA will affect flow in the lower Malad River and Snake River, but will not significantly affect streamflow in the Big and Little Wood Rivers.

Interaction between the Little Wood River and small local aquifers in the upper valley

Upstream of the confluence of Silver Creek with the Little Wood River, the Little Wood River is generally dry except during periods of high surface runoff (Water Districts 7 and 11, 1922; Jones, 1952; Claire, 2005; BOR 2010). East Canal and West Canal, below Little Wood River dam divert the entire flow of the Little Wood River during the irrigation season, and most non-irrigation season flow is stored in the reservoir. The entire flow of Fish Creek is similarly diverted or stored (Jones, 1952).

Small local aquifers in the upper Little Wood valley may interact with the upper Little Wood River and tributary creeks, but are not expected to affect streamflow in the Little Wood River downstream of the confluence with Silver Creek when the channel is dry between the East Canal diversion and Silver Creek. Because surface water supply shortages in the Little Wood River are not expected to occur during peak runoff, groundwater use in the upper Little Wood River valley does not appear to be relevant to the Little Wood Water Users Association delivery call. Water levels and groundwater use in upper Little Wood valley aquifers will affect groundwater underflow from the Little Wood basin into the ESPA and discharge from the ESPA to the Snake River and tributary springs, including the lower Malad River.

Section 3. Identification of diversion records for junior ground water pumping available to the Department

Groundwater use in the Wood River Valley

Prior to 2013, most groundwater diversions in the Wood River Valley were not measured or recorded. Water District 37 regulated and recorded a few groundwater diversions north of Bellevue. Water District 37M regulated and recorded exchange well diversions conveyed through Silver Creek. These data are included in the watermaster reports (Water Districts 7 & 11, various years, 1920-1970; Water Districts 37 & 37M, various years, 1971-2013). Larger municipal water providers in the Wood River Valley measure and record their diversions for their own use. Prior to 2013, municipal diversions were not reported to the water district, but municipal providers did submit monthly diversion data to the USGS to assist with development of the Wood River Valley Groundwater Flow Model. These data will be included in the model data sets when the USGS publishes the model.

In 2013, water users began installing flowmeters to comply with a measuring device order, and Water District 37 began recording annual groundwater diversions in the Wood River Valley. Data collected for 2013 and 2014 are stored in IDWR's Water Management Information System (WMIS) (https://www.idwr.idaho.gov/apps/wm/WMIS/). Many groundwater diversions in the Wood River Valley were still unmeasured in 2013 and 2014.

Unmeasured groundwater diversions from the Wood River Valley from 1995 through 2010 are being estimated for development of the Wood River Valley Groundwater Flow Model. Estimated monthly groundwater diversions are calculated using evapotranspiration (ET), precipitation, surface water diversion data, and estimated irrigation efficiency. ET and precipitation data are used to calculate irrigation water demand within subareas of the model boundary. In areas served only by groundwater, consumptive use of groundwater is assumed to be equal to the irrigation water demand and groundwater diversions are assumed to be equal to the irrigation water demand divided by irrigation efficiency. In areas served by both surface water and groundwater, the portion of the irrigation demand met by surface water is estimated by deducting canal seepage and irrigation inefficiency from recorded surface water diversions. The remaining irrigation demand not met by surface water is assumed to be met by groundwater. Because the irrigation efficiency is unknown, it is an adjustable parameter during calibration of the groundwater flow model. Estimated groundwater diversions used to calibrate the groundwater flow model will be included in the model data sets when the USGS publishes the model.

Groundwater use on the Camas Prairie

Prior to 1923, groundwater use on the Camas Prairie was limited to a few wells used for stockwater and domestic water supply. Early agriculture on the Camas Prairie consisted primarily of non-irrigated wheat (Piper, 1925; Walton, 1962). Between 1923 and 1924, about 50 deep wells were drilled into the upper artesian aquifer (Walton, 1962). Flowing wells developed during this time period yielded between 2 and 100 gallons per minute (gpm). Total groundwater diversions in 1924 were estimated to be approximately 600 acre-feet (AF). Groundwater development increased in the early 1950s. In 1957, Walton (1962) estimated groundwater withdrawals for irrigation and municipal use were approximately 1,350 AF. Walton (1962) also performed an inventory of flowing wells, and estimated the total discharge from flowing wells and springs was about 200 AF.

Another significant increase in groundwater withdrawals for irrigation occurred between 1974 and 1977 (Young, 1978). In 1977, Young (1978) quantified groundwater use using totalizing flowmeters, discharge measurements, power records, and estimates of municipal use. Groundwater withdrawals for irrigation and municipal use were approximately 9,500 AF in 1977, approximately seven times the estimated 1957 withdrawals.

In 2014, groundwater withdrawals reported in the Water District 37B Watermaster's Report (Kramer, 2015) total approximately 13,800 AF, an increase of approximately 45% over the 1977 withdrawals. In 2014, most of the wells were measured using totalizing flow meters. Some withdrawals were determined using power consumption coefficients. A few small diversions were estimated. The watermaster did not report the number of acres irrigated by groundwater in 2014.

Water right priority dates and cumulative maximum diversion rates shown in Figure 7 are generally consistent with the periods of groundwater development described by Walton (1962) and Young (1978). Water right records[2] suggest much of the groundwater development in the Camas Creek basin occurred between 1968 and 1979.

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[2] Water right priority dates and diversion rates were extracted from IDWR's database on April 21, 2015. Data are provided in supplemental files accompanying this memorandum.

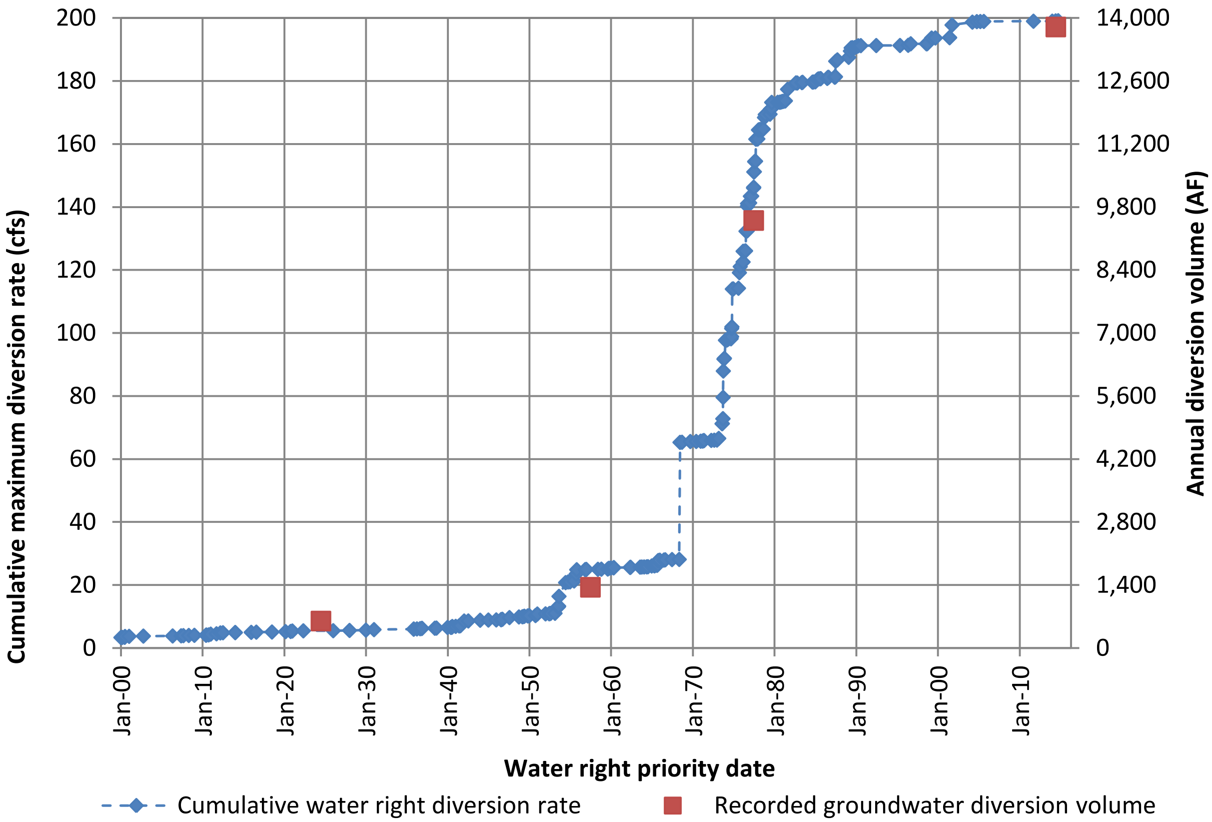

Figure 7. Cumulative maximum groundwater right diversion rate and recorded groundwater pumping in the Camas Creek basin.

<u>Section 4. Identification of methods and data available for analyzing consumptive use associated with junior groundwater pumping</u>

<u>*Wood River Valley*</u>

As discussed in the previous section, consumptive use associated with groundwater pumping in the Wood River Valley is being estimated for development of the Wood River Valley Groundwater Flow Model. Consumptive use is being calculated monthly for 1995 through 2010 using ET, precipitation, and surface water diversion data, and modeled irrigation efficiency. The data sets, programming code used to calculate groundwater demand, and estimated groundwater diversions will be included with the model when it is published by the USGS.

<u>*Camas Prairie*</u>

Consumptive use associated with groundwater pumping from the Camas Prairie aquifer system can be estimated from ET, precipitation, and water right place of use. ET rasters generated using

Mapping EvapoTranspiration at High Resolution and Internalized Calibration (METRIC) are available for the irrigation seasons of 1996, 2000, 2002, 2006, 2008, 2009, 2010, and 2011. Raster files are available at http://idwr.idaho.gov/ftp/gisdata/Spatial/Projects/METRIC/. Because METRIC ET does not assume ideal growing conditions nor require knowledge of crop type and management, use of METRIC ET to quantify irrigation season ET is generally preferable to use of other ET data sources such as ET Idaho. Winter ET varies less with crop type. Winter ET data are available from ET Idaho for the Fairfield Agrimet station, Fairfield National Weather Service (NWS) station, and Hill City NWS station (http://data.kimberly.uidaho.edu/ETIdaho/). Annual and monthly precipitation rasters are available from the PRISM Climate Group at Oregon State University (http://www.prism.oregonstate.edu/). Precipitation data for the Fairfield Agrimet station, Fairfield NWS station, and Hill City NWS station are available from ET Idaho (http://data.kimberly.uidaho.edu/ETIdaho/). Water right place of use data are available from IDWR at http://idwr.idaho.gov/GeographicInfo/GISdata/water_rights.htm.

Consumptive use associated with groundwater pumping from the Camas Prairie aquifer system in 2014 can also be estimated from groundwater pumping records (Kramer, 2015) by assuming a reasonable value for irrigation efficiency. Some information on surface water availability for mixed source lands is also provided in the 2014 Watermaster's Report.

Section 5. Identification of any hydrologic or hydrogeologic methods or modeling tools that may be employed in analyzing the impacts of junior ground water pumping on calling senior-priority surface water right holders

Wood River Valley

IDWR staff anticipates the impact of changes in groundwater use in the Wood River Valley can be simulated with the Wood River Valley Groundwater Flow Model after the model is published by the USGS. The Wood River Valley Groundwater Flow Model is a mathematical approximation of the aquifer developed using the numerical model program MODFLOW-USG (Panday et al., 2013), which is freely available to the public at http://water.usgs.gov/ogw/mfusg/. Numerical models are recognized by the USGS as the most robust approach for analyzing the effects of groundwater pumping on streamflow (Barlow and Leake, 2012). The model is expected to predict impacts of changes in consumptive groundwater use on aquifer discharge to the Big Wood River, Willow Creek, Silver Creek, and the ESPA.

Camas Prairie

Because the recognized outlets for net groundwater discharge from the Camas Prairie are limited to ET and discharge to Camas Creek and Magic Reservoir, the impacts of changes in groundwater use on inflow to Magic Reservoir are equal to the change in consumptive use at steady state. Analytical or numerical modeling is not needed to quantify the impacts of consumptive groundwater use at steady state.

Analytical methods could be employed to estimate the seasonal timing of the impacts, but will require several simplifying assumptions regarding aquifer properties and geometry. Predictions of timing are highly dependent on hydraulic conductivity and the coefficient of storage. A wide range of predictions can be generated using the range of reasonable assumptions for hydraulic conductivity and coefficients of storage applicable to the Camas Prairie aquifer system.

Because seasonal measurements of aquifer discharge to lower Camas Creek and Magic Reservoir are not available to correlate changes in aquifer discharge with changes in groundwater use, there are not sufficient data available to calibrate a numerical model to predict the timing of impacts.

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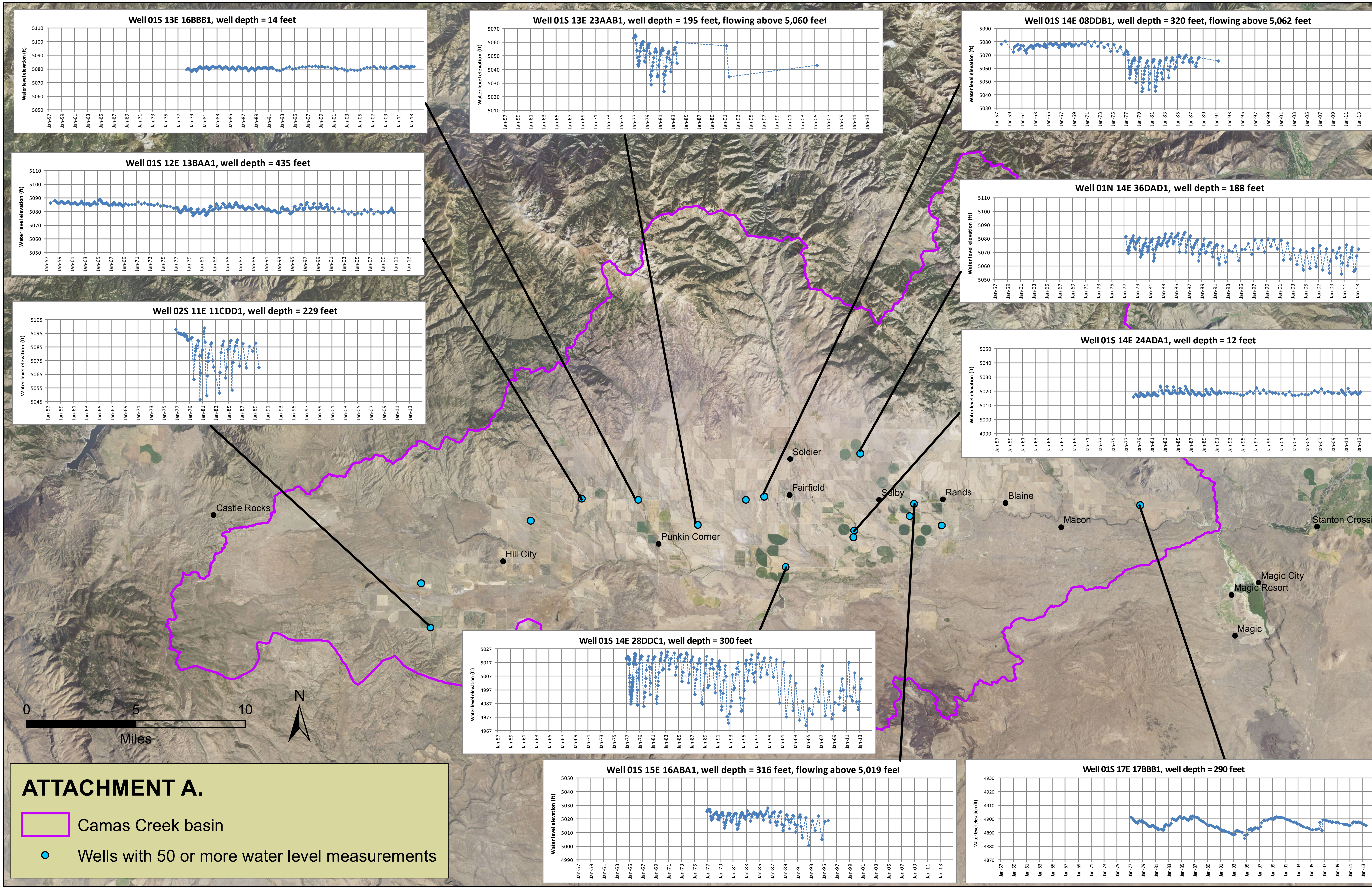
Well 01S 13E 16BBB1, well depth = 14 feet
Well 01S 13E 23AAB1, well depth = 195 feet, flowing above 5,060 feet
Well 01S 14E 08DDB1, well depth = 320 feet, flowing above 5,062 feet
Well 01S 12E 13BAA1, well depth = 435 feet
Well 01N 14E 36DAD1, well depth = 188 feet
Well 02S 11E 11CDD1, well depth = 229 feet
Well 01S 14E 24ADA1, well depth = 12 feet
Well 01S 14E 28DDC1, well depth = 300 feet
Well 01S 15E 16ABA1, well depth = 316 feet, flowing above 5,019 feet
Well 01S 17E 17BBB1, well depth = 290 feet
Water level elevation (ft)
Soldier
Fairfield
Selby
Rands
Blaine
Macon
Stanton Crossing
Castle Rocks
Punkin Corner
Hill City
Magic City
Magic Resort
Magic
0
5
10
Miles
N
ATTACHMENT A.
Camas Creek basin
Wells with 50 or more water level measurements