Lower Wise River Water Resources Investigation

September 26, 2013
Big Hole River Watershed, Montana

Big Hole Watershed Committee

Prepared by:

Jennifer Downing
Big Hole Watershed Committee
PO Box 21, Divide, Montana 59727
406-960-4855
info@bhwc.org
www.bhwc.org

Submitted to:

Montana Department of Environmental Quality
Water Quality Planning Bureau
Contract 211081

Acknowledgements

Most of the sites used in this project were located on private property. Our appreciation is extended to the residents and groups in Wise River that generously provided access to their property and their wells during this project.

Agencies working together made this project possible. They each put in countless hours to create and implement this project. Without their dedication, expertise, materials, and time this project and continue Wise River monitoring would not be possible.

DEQ Water Quality Planning Bureau not only financially supported this project, but also provided expertise in developing the monitoring plan, executing the project, and compiling the results. We send our appreciation for making this project successful.

Table of Contents

Tables

Figures

Abstract

The Lower Wise River Water Resources Investigation inventoried baseline conditions of surface water, groundwater, surface water/groundwater interactions, water temperature, and fisheries. The Wise River is the largest tributary to the Big Hole River and located in southwest Montana. The study begins at the on the Wise River below the confluence of Pattengail Creek and ends at Wise River mouth as it enters the Big Hole River near the Town of Wise River. The Big Hole River is considered to have impaired water quality due to high water temperatures and a number of other issues related to physical habitat. The Wise River is also considered to have impaired water quality, primarily due to high sediment/siltation, metals, and physical habitat alterations. Wise River is a documented important cold water influx for the Big Hole River through surface waters and its many springs. Several irrigation infrastructures are present on the Wise River in each requiring in-stream management, and are without flow measurement. Changes in irrigation infrastructure have occurred in recently.

The following parameters were collected for this investigation: surface flows using TruTrack loggers and synoptic sampling, groundwater levels using a groundwater well network, water quality parameters for ground- and surface waters (pH, specific conductivity, and temperature), and isotope analyses (oxygen -18 and deuterium). Major findings from this investigation are below. Additional findings are provided in the discussion section:

Groundwater:

- Overall the 14 groundwater hydrographs showed similar patterns, where elevations peak near July with spring runoff and the start of irrigation, decline through the rest of the summer, increase for a short period with the onset of fall irrigation, then decline again into the late fall/early winter when they reach base level. Any alterations in this pattern were likely due to local effects such as well pumping or withdrawal in proximity, local groundwater recharge, etc. Annual fluctuation was between 7 and 32 feet.

Surface Water:

- Surface water in the Wise River peaked with snowmelt. Prior to irrigation, Wise River gains water as it moves downstream from the top of the reach to the mouth. During irrigation, the opposite occurs with the top of the reach having higher flows than the bottom of the reach;
- Water temperatures in the mid reach and lower reaches of the study area peaked in late summer. Water temperatures greater than 70°F occurred and may have caused stress to fish.

Groundwater-Surface Water Interaction:

- The isotope data indicate that the sources of groundwater and surface water are the same and that they interchange with one another;
- Groundwater and surface water elevations evaluated near the mouth of Wise River indicate that during the irrigation season groundwater is providing a source of cool flow to Wise River, while during the non-irrigation season Wise River is recharging the groundwater;

Fish:

- The fish population in the Wise River in the lower reached downstream of Adson Creek Bridge is likely limited by the number and quality of slow water habitats and low summer stream flows. Low stream flows in the summer due to irrigation withdrawal likely greatly reduce available habitat in the river.

Acronyms

BCD	Beaverhead Conservation District
BHWC	Big Hole Watershed Committee
CFS	Cubic Feet Per Second, as measured in flow
DEQ	Montana Department of Environmental Quality
DNRC	Montana Department of Natural Resources & Conservation
GWIC	Ground Water Information Center
MFWP	Montana Department of Fish, Wildlife and Parks
MBMG	Montana Bureau of Mines & Geology
NRCS	Natural Resources Conservation Service
PKR	Pete Kamperschroer Ranch
SC	Specific Conductivity
USFS	United States Forest Service

Project Site

Wise River, Montana is located in southwest Montana. This study monitored the lower portion of the Wise River, from the confluence with Pattengail Creek to Wise River's confluence with the Big Hole River. Monitoring included surface water flow and temperature, groundwater, surface water-groundwater interaction, and fisheries. See **Figure 16** for project location map.

A Note on Spelling:

It is common for creeks or locations to have several correct spellings for the same location:

Pattengail versus Pettengill: Pattengail Creek is the spelling used in the TMDL; therefore, “Pattengail” is the spelling used in this document. MFWP and USFS frequently used “Pettengill” and additional spellings are also used on occasion.

Technical Advisory Committee and Contributors

This Lower Wise River Water Resources Investigation was developed and overseen by a Technical Advisory Committee (TAC). The committee is coordinated by the Big Hole Watershed Committee. Members were invited to represent diverse interests and expertise based on monitoring needs. This Technical Advisory Committee was selected to oversee the Lower Wise River Prioritization in 2010. Members provided oversight on monitoring plan development and implementation, offered ideas and resources from their affiliation, and ensured the monitoring plan met its goals. Members have changed, but the interests have continued to be represented through this project. Members and roles are provided below:

Name	Affiliation	
Jen (Titus) Downing	BHWC	Project Coordinator Report Contributor
Kyle Tackett	NRCS	Irrigation
Ginette Abdo	MBMG	Groundwater & Water Chemistry Report Contributor
Todd Myse	MBMG	Groundwater & Water Chemistry Report Contributor
Jim Olsen	MFWP	Fisheries & Habitat Report Contributor
Dan Downing	USFS	USFS Lands
Liz Jones	Private Lands	Private Lands
Pete Kamperschroer	Private Lands	Private Lands
Dave Amman	DNRC	Surface Water Report Contributor
Tom Miller	BCD	Conservation District

Introduction

History and Project Area

The Wise River is the largest tributary to the Big Hole River. Waters from the Wise River drainage are generally cold and the lower Wise River is documented as an important spring system that provides late season flows and cold water to the Big Hole River (Flynn, 2008; Marvin & Voeller, 2000).

In 1901, during the mining and homestead boom of Wise River, a reservoir was built in Pattengail Creek. In 1927, the area was inundated with a large flood. Flood waters rose and the dam failed, sending a powerful torrent of water down Wise River to reach the Big Hole. The entire lower Wise River channel was scoured. The flood dropped large alluvium and erased important aquatic habitat features. The effects of the flood are evident today.

The Lower Wise River section begins on Wise River just below the confluence of Pattengail Creek and ends at the Wise River confluence with the Big Hole River. The section starts in a narrow valley with steep tributaries. As Wise River passes Adson Creek nearly 4 miles from Pattengail Creek, the valley widens and the geology changes from a bedrock canyon to a wide, alluvium valley (**Figure 17** and **Figure 18**). In the wide valley residents and ranches all report a strong connection between groundwater (as seen through residential wells and springs) and surface waters (ditches and Wise River). Residents report wells rising significantly when ditches are full, and wells lowering when ditches turn off, with some reporting wells going dry after an irrigation season or during drought. Ranchers report ditch losses from points of diversion to points of use. Public water supplies require monthly sampling for bacteria. For example, spring 2011 enjoyed abundant water; however, two restaurants reported coliform in their water during that period, again adding evidence to a strong surface water-ground water connection. Conversely, 2012 was a year of extremely low water levels.

Tracking Change

A Wise River water monitoring project was conducted in 2003 (NRCS, DNRC, 2003). The first part of the study assembled basic watershed information including history, hydrology, land use, geology, and fisheries. The second part of the study collected and analyzed macroinvertebrate data, water chemistry, and a qualitative assessment of riparian condition. Data was collected in eight reaches from the headwaters to the mouth, five of which were located in the study area of this project. The habitat assessments found that the impacts of the Pattengail flood remain evident with large cobbles and a lack of diversity in stream habitat. The upper most portion of the study reach (Wise River to Flying Cloud) scored a 90% rating in riparian condition, although the Flying Cloud Bridge was noted as a source of scour and the floodplain was accessible only in extremely high water. Near Adson Creek, the 2003 study pointed to the Company Ditch and Truman Ditch infrastructure as a source of stream degradation and the need for improved channel function. Wise River near Swamp Creek had an 85% riparian condition rating. Active bank erosion was present contributing a significant amount of material to the bed load and the floodplain was accessible. The surface water flow had decreased here by 60% from the previous reach likely due to irrigation diversions and channel aggregation. The last monitoring point, downstream of the Town of Wise River and near its mouth, scored an 80% riparian condition rating, had some bank erosion present, and the stream had access to its floodplain. Stream flow was higher here than in the previous section near Swamp Creek, showing a gain in surface water flow from springs and groundwater.

Impaired Waters in Wise River and the Middle Big Hole River

The Montana Department of Environmental Quality (DEQ) assesses rivers and streams in Montana for water quality in accordance with the Clean Water Act. For the area of study, applicable water quality results were provided in the following documents: 303(d) 2012 listing for waters not meeting beneficial use, the Middle-Lower Big Hole River TMDL produced in 2009 outlining maximum allowable loads for water quality impairment (Montana DEQ, September 2009), and the 2012 listing of Impaired Waters (Montana DEQ, March 2012).

The full length of Wise River (26.7 miles) is considered impaired due to metals, siltation, and physical habitat alterations. The Big Hole River Middle and Lower segments are considered impaired waters to due high water temperatures, siltation, and physical habitat alterations, and metals. Wise River enters the Big Hole River in its middle segment. See **Table 1** for a full listing of water quality impairments that apply to the study reach.

Table 1: DEQ Impaired Water designations for Wise River, tributaries entering Wise River, and the Middle Big Hole River section where the Wise River flows into. Source: Montana DEQ Water Quality Clean Water Information Center.

River Section	2012 Impaired Waters	2012 303(d)
Big Hole River Middle Segment	Alteration in littoral cover Copper, Lead Low flow alterations Physical habitat alterations Sediment/Siltation Temperature	No
Wise River	Copper, Cadmium, Lead Sediment/Siltation Physical habitat alterations Low flow alterations	No
Pattengail Creek	Physical habitat alterations Siltation Alteration in littoral cover	No
Elkhorn Creek	Arsenic, Copper, Cadmium, Lead Sediment/Siltation Zinc	No
Gold Creek	Alteration in littoral cover Siltation Phosphorous	Yes Phosphorous

The TMDL plan for the Middle-Lower Big Hole River was published in 2009 and provides guidance on improving impaired waters based on their inability to meet beneficial uses (Montana DEQ, September 2009). Wise River is also cited as an important coldwater source to the Big Hole River through both surface water and groundwater (Flynn, 2008). Maintaining cold flows is important to help buffer high water temperatures in the Big Hole River.

The BHWC initiated a study to look more closely into the issue of high water temperature in the Big Hole River (BHWC, April 2013). Findings showed that after flows are maintained to a critical level, shading is of next critical importance to maintain low water temperatures as solar radiation can have a direct impact on high water temperatures.

Lower Wise River Irrigation Improvement Prioritization

The Middle-Lower Big Hole River TMDL points to irrigation infrastructure improvements (i.e. flow control structures, permanent diversions, consolidation or retirement of points of diversion, flow measurement, etc.) as a source of improvement for water quality. These improvements can provide flow maintenance through water savings and decrease habitat degradation that leads to sediment inputs. The irrigation infrastructure of the Wise River was inventoried for projects that could improve water quality in 2010 as a result of the findings of the TMDL and ranked those projects in terms of priority (Oasis Environmental, 2010). The top priority project suggested combining five points of diversion into one with an improved functional headgate, permanent diversion, and flow measurement on the PKR Ranch in the Lower Wise River. This project is expected to save water and allow healing of stream banks, therefore reducing sediment, and was completed May 2012. Additional projects are awaiting implementation.

Drought Management

In 1997, the BHWC created a Big Hole River Drought Management Plan (Big Hole Watershed Committee, 1997 - 2010), advocating shared sacrifice to maintain in-stream flows and reduce stress to fish. Water users are notified when flows or temperatures reach a critical trigger point and are asked to voluntarily reduce irrigation withdrawals and take conservation measures. The Wise River irrigators participate in the Big Hole River Drought Management Plan in response to triggers on the Big Hole River. Water users have expressed interest in developing a drought management plan specific to maintaining flows and temperatures in the Wise River. Since Wise River was not monitored for flows and temperatures and water users did not have flow measurement devices, development of a plan was not possible. The information gathered with this study and subsequent flow measurement devices will make a Wise River Drought Management possible.

Watershed Restoration Plan

The Middle-Lower Big Hole River Watershed Restoration Plan was developed by BHWC and approved by DEQ and EPA in September 2013 (BHWC, 2013). This plan identifies a roadmap for water quality improvement in the entire Middle-Lower Big Hole River watershed, of which Wise River is a part of. The top priority is to improve water quality first for water temperature and stream flow and second for reduced sediment and nutrient loading. The results of this study were used to develop watershed priorities in the Wise River.

Groundwater

The study evaluated groundwater in the Lower Wise River. The Lower Wise River includes the Town of Wise River, where homes and businesses utilize wells for drinking water, and a few large ranch operations that utilize flood and sprinkler irrigation for pasture lands that grow hay and graze livestock, and stockwater tanks for watering livestock. Past studies show a link between flood irrigation and groundwater recharge ((G. Abdo, Butler, J., Myse, T., Wheaton, J., Snyder, D., Metesh, J. and G. Shaw, 2013). Increased development in Wise River has increased the number of wells utilizing groundwater, and several pastures that were flood irrigated have been converted to sprinkler irrigation. Because cold groundwater recharge from Wise River is of high importance to the Big Hole River, it is important to understand the source and flow pattern of the groundwater. This study was designed to evaluate the existing groundwater resources for:

- seasonal groundwater fluctuations;
- groundwater elevation;

- groundwater – surface water interaction;
- baseline data to drive future watershed decision making;
- establish a monitoring network or resources than could be used in the future.

The groundwater portion of the study was contributed by Ginette Abdo, Hydrologist and Todd Myse, Montana Bureau of Mines and Geology.

Surface Water

The surface water portion of the study evaluates surface water quantity and water temperatures in the lower Wise River drainage system. Surface waters include Wise River, springs, and ditches. Surface waters were measured by data loggers called TruTracks in Wise River and synoptic measurements throughout the system.

Past Wise River flow data are limited, consisting mainly of 13 years of USGS gage record (1973-1985) at one location near the top of the study reach. After considerable map and field reconnaissance, continuous water level recorders were installed at three sites on the Wise River mainstem (**Figure 1**). One additional gage was installed at the mouth of Smart Creek, which is a spring creek joining the Wise River immediately north of the Town of Wise River. Synoptic measurements were taken in 2011 and 2012 in order to gain an understanding of the entire system including irrigation diversions, tributary and groundwater inflows, and river flows. The surface water information supported:

- groundwater/surface water interaction;
- Existing flow and water temperature regime of Wise River;
- Surface water gain and loss sources by tributaries, springs, groundwater, and irrigation or other withdrawal;
- Future surface water monitoring and decision making.

The surface water portion of this study was contributed by Dave Amman, Hydrologist, Montana Department of Natural Resource and Conservation.

Fish

The Wise River is the largest tributary to the Big Hole River and is an important source of cold water to the Big Hole during warm summer conditions (Montana DEQ, September 2009). However, little is known about the Wise River fishery as it has only been sporadically sampled over the past 40 years and a recent, thorough fisheries investigation of the Wise River has not been conducted. It is unknown if sport fish from the Big Hole River such as brown and rainbow trout use the Wise River for spawning and rearing. The Big Hole River is home to the last remaining fluvial population of Arctic grayling and grayling have been reported in the Wise River. Tributaries to the Big Hole River near the Wise River are important for Arctic grayling; during the summer months as water temperatures in the river increase, fish seek out colder streams like Deep Creek. It is unknown if grayling from the Big Hole River use the Wise River for thermal refuge or as a spawning and rearing stream. Hybridized westslope cutthroat trout are also present in the river and conservation populations of the fish are present in several tributary streams (fishery information from J.Olsen 2011). The Wise River sees approximately 4300 angler days (1 angler fishing for 1 day) per year (MFWP, 2010).

MFWP worked with the BHWC in 2011 and 2012 to sample the Wise River in an effort to determine the current state of the fishery and potentially determine fisheries management opportunities in the watershed. Three sections of Wise River were surveyed beginning at its headwaters at the confluence of Mono and Jacobsen creeks downstream to near the Town of Wise River, as seen in **Figure 22**. In addition to population monitoring sections, MFWP performed a habitat inventory of the lower sections of the river from Adson Creek Bridge to the confluence with the Big Hole River. This section of river is believed to have been significantly impacted from the breaching of Pattengail (Pettengill) Dam and the large-scale flood that occurred downstream. It is believed that this flood resulted in significant scour of the riverbed leaving a channel that is incised, contains degraded fisheries habitat, and less able to access the floodplain.

The BHWC is interested in improving water quality and water quantity, particularly as it applies to improvements based on recommendations in the TMDL Improvement Plan (BHWC, 2013). A second priority is to improve waters to the benefit of fisheries, especially native trout and grayling. The BHWC and its partners through this study conducted a baseline fisheries assessment to determine the quality of the Wise River fishery. Moreover, baseline fisheries data will help to determine the effect of water quality improvements in years to come. Finally, the baseline data will help to evaluate the fishery response due to potential habitat improvements. Habitat improvements may be the result of irrigation infrastructure improvements or other habitat improvements that specifically address water quality issues and habitat in the Wise River.

The fish portion of this study was contributed by Jim Olsen, Big Hole River Fish Biologist, Montana Fish, Wildlife and Parks.

Research Questions

In the Lower Wise River . . .

1. What is the characterization of the groundwater system?
   i.e. water quality, direction of flow, sources, map, depth, etc.
2. What is the groundwater/surface water relationship?
   i.e. Where are the connections? Direction of connections? Seasonal variance?
3. What is the characterization of the surface water system?
   i.e. how much surface water enters the Big Hole River? How does this change seasonally? How does this change longitudinally from the top of the reach to the bottom? What are the sources of input and outflow?
4. Specific to the irrigation infrastructure project, how do recent projects impact surface water flows and groundwater levels?
5. What is the baseline condition of the Wise River fishery?
   i.e. What species are found in the Wise River? What are the baseline population estimates? What is the existing condition of the fishery? What appears to be the limiting factors, if any, for fish?
6. What recommendations for the future can we suggest with the results of this project to address water quality?
   i.e. Drought Management Plan, assessment plan for improvements

The Lower Wise River Monitoring Study includes:

1. Groundwater
   Groundwater levels and water chemistry

   Contributed by Ginette Abdo and Todd Myse, Montana Bureau of Mines & Geology

2. Surface water,
   Surface water flow and water temperature

   The surface water portion for flow and TruTrack installation is contributed by Dave Amman, Montana DNRC Hydrologist

3.Groundwater -Surface Water Interaction

4. Fisheries

   Contributed by Jim Olsen, MFWP Big Hole River Fish Biologist

5. Irrigation Improvement Projects

Methods

1. Groundwater Methods

Well Network and Groundwater Elevations

A well monitoring network was established in the Lower Wise River which included 14 wells. Two wells were used for stockwater, four wells were not in use, and the remaining 9 wells were used for domestic purposes. The sparseness of development and the congregation of wells in the Town of Wise River limited the sample site distribution and the majority of the network wells were near the Wise River mainstem or in the Town of Wise River. **Figure 19** shows the well network locations and **Table 10** lists well information.

Well information used to create the well monitoring network was obtained through the Ground Water Information Center (GWIC), an online statewide database created and maintained by the MBMG. The GWIC contains well drilling logs and provides basic information on location, owner, well specifications, and well use.

Wells were measured manually May 2011 through October 2012. These wells were monitored twice each month during the irrigation season (May – October) and monthly during the non-irrigation season (November-April) (**Figure 16**). Each well was measured for a depth to water using a Solinist Water Level Meter 102. No instrument calibration is required. The Solinst was cleaned with a bleach solution after each well to prevent the potential transfer of contaminants. In addition to manual measurements, a data logger was installed in one well located at the Wise River School. The pressure transducer/data logger measured groundwater levels hourly from April 2012 through present.

The depth to water measurements collected at the wells were used to create the groundwater elevation (water table) information, or Potentiometric map. Elevations of each well ground level and well top level were surveyed using a licensed surveyor for location and elevations.

Water Chemistry

Water parameters can help characterize the aquifer and groundwater/surface water interactions. Water chemistry parameters were collected once during the study in August 2011 for pH, specific conductivity, water temperature and isotopes.

Water chemistry for pH, specific conductivity, and water temperature were collected at 11 well locations. Wells not measured were not equipped to pump water. A well casing volume was measured to determine the pump rate. Each well was pumped approximately three full well casings of water prior to collecting water quality. Field parameters were recorded once they stabilized within 10% on specific conductivity and within 0.1 pH unit. The water quality meter was a WTW Multi Meter provided by MBMG. The meters were calibrated at the start of each sample day. Water chemistry was also measured at select surface water sites including Wise River tributaries, Wise River, ditches, and the Big Hole River.

Isotope analysis for deuterium (D) and oxygen-18 (O-18) of groundwater and surface water can provide insight into groundwater and surface water connections. Isotope samples were collected at 14 well locations, 20 surface water locations including Wise River tributaries, Wise River, ditches, and the Big Hole River, and 1 precipitation sample August 2011 (**Figure 20, Table 10, Table 12**). Analysis was completed by Weatherford Labs.

2. Surface Water Methods

TruTrack Locations and Installation

TruTracks are data loggers that collect information on surface water depth (stage) and water temperature and are used by DNRC on projects throughout Montana. More information is available on the TruTrack website: http://www.trutrack.com/gpapp_pulse.html.

TruTracks were installed in small diameter stilling wells by DNRC staff at four locations on the Wise River in early May 2012 (**Figure 19**). Examination of 2012 USGS gage data in the area (e.g. USGS Gage 06024540 Big Hole River below Mudd Creek) suggests that the 2012 peak flow on area streams (including Wise River) occurred a week before activation of the Wise River gages. Although there was no intention of capturing peak flow data in 2012, the instruments were activated earlier in 2013 in order to do so. According to USGS frequency analysis, there is a 90% chance that a peak flow of 1070 cfs will be exceeded at the discontinued station in any given year.

The water level loggers were calibrated, programmed to log on a half-hour time interval, and placed in the stilling wells. However, due to operator error, the uppermost gage (T3) did not log data until late July. Discharge measurements were taken at the gage sites in order to create stage-discharge rating curves, which relate water height to stream flow at the gage location. Carefully selected cross-sections yielded extremely accurate ratings, with r-squared coefficients ranging from 0.99 to 1.0; near-perfect correlation between water depth and measured stream flow rate.

Figure 19 shows the four locations where TruTracks were deployed. The uppermost mainstem gage, T3, is located at river mile (RM) 10.45, about 500 feet below the Pattengail Creek confluence. It is also located 1.5 river miles upstream from the inactive USGS gage, 06024590 Wise River near Wise River, MT. T3 is a good indicator of Wise River flows above most water diversions in the lower valley, and it allows for data comparison with the USGS gage, which operated from 1973 through 1985.

The next gage, T2, is located downstream at RM 2.85, immediately upstream from the Upper PKR diversion, where extensive headgate improvements were made in late 2011. Streamflow at T2 represents water supply below the Company Ditch (RM 5.88) and the Truman Ditch (RM 5.10), and just above the Upper PKR diversion.

The last main stem gage, T1, is located at RM 0.25 near the mouth. T1 is immediately downstream of the Lower PKR diversion, which was also greatly improved with a new headgate installation in 2012. This site measures the Wise River flow that reaches the Big Hole River.

A fourth gage was installed in Smart Creek (T4). This spring creek appears to originate in the Wise River alluvium south of town, and is about 1.5 miles long. Smart Creek joins the river at RM 0.45, about 1000 feet upstream from the T1 gage site. This spring may also receive flow through the Jolly Ditch diversion during periods of high water. Data collected here may shed light on groundwater-surface water interaction.

Synoptic Study

Synoptic measurements provide an estimate of flows throughout the system at a similar moment in time (the same day). Synoptic runs were conducted fall 2011 and spring/summer 2012. Flows are measured using a

March-McBirney Flow meter and DNRC standard measurement protocols. Synoptic sites are listed in **Table 10** and displayed in **Figure 21.** DNRC conducted the synoptic data.

Figure 1: TruTrack water level recorder installed in Smart Creek

3. Fish Methods

Montana Fish, Wildlife and Parks (MFWP) led the fishery evaluation effort. The effort was under two tasks:

1. Fish Populations

MFWP biologists conducted population estimates in the Wise River. Population estimates are conducted using a mark-recapture methodology. Fish are collected via electrofishing. On the first pass fish are marked with a small fin clip and released. A second pass approximately 7-10 days later is performed to recapture fish. The percentage of marked fish versus unmarked fish collected on the second pass is used to determine the total fish population size. FA+ fisheries analysis software is used to calculate the population estimate and error associated with the estimate. All captured fish are anesthetized, identified to species, weighed (0.01 lb) and measured (0.1 in) then released. Water quality is collected at each site. FWP biologists use a Hanna Waterproof Combo meter to collect water temperature, pH and specific conductivity.

The methods, equipment, animal safety, and analysis occurred according to MFWP protocol and completed by MFWP biologists.

The fisheries population of the Wise River was monitored through electrofishing. A boat mounted mobile anode electrofishing system was used to collect fish in each section. A Leach type rectifying unit was used with a 3500 watt gas powered generator. The population monitoring sections were not selected at random. One of the objectives of the monitoring was to determine if Arctic grayling are present in the Wise River. Upstream sections (Mono Creek and Lacy Creek) were selected in areas with a low gradient stream channel and near tributary streams (Wyman Creek) where Arctic grayling have been captured in the past. All fish species encountered were captured and measured (0.1 inch) and weighed (0.01 lbs) with the exception of mottled sculpin where only a representative sample were measured and weighed. Mark-recapture population estimates were performed on the Lacy Creek and Adson Creek section of the river with a single marking even and a single recapture event. Single pass electrofishing was performed in the Mono Creek section.

2. Fish Habitat:

The habitat survey was performed by walking the stream from the Adson Creek Bridge to the confluence with the Big Hole River. The stream habitat was classified as riffle, run, or pool based (Bain, M.B. and N.J. Stevenson, 1999). GPS points were taken at each habitat section break so the length of each habitat type could be quantified. Notes and photos were also taken of each habitat section and other significant features in the reach such as diversions, side channels, substrate size and micro habitat features.

Results

1. Groundwater Results

Groundwater was examined to determine the direction of flow and seasonal variability. Groundwater levels were measured in wells and water chemistry parameters were used to evaluate groundwater quality and groundwater/surface-water interactions.

Geologic Setting

The wells within the Wise River study area are located within a mix of sands, gravels, and occasionally cobbles and boulders. The surficial geologic map shows that all but two of the wells are completed in Pleistocene-age glacial outwash (**Figure 18**). The glacial outwash (Qo) is described as poorly sorted boulders, gravels, and sand (Ruppel, E.T., J.M. O'Neil, D.A. Lopez, 1993). The well closest to the Big Hole River (PKR Cabin, well W3) is completed in the Holocene-age Big Hole River alluvium (Qa). The floodplain and channel of the Big Hole River consists of alluvium which is primarily composed of sand, silt, and gravel. The well located in the southeast corner of the map (PKR Stockwater South, well W1) is completed in Holocene and Pleistocene-age landslide deposits (Ql). These landslide deposits are composed of angular bedrock fragments mixed with soil or boulders and finer grained materials (Ruppel, E.T., J.M. O'Neil, D.A. Lopez, 1993). From a hydrogeological perspective, these three units (Qo, Qa, and Ql) are composed of similar, unconsolidated sand, gravel and boulder with some finer material. They likely function as a single hydrogeologic unit with some variations in hydraulic conductivity.

Groundwater-Level Trends

For the period of record (late-May 2011 through early-October 2012), groundwater elevations in monitored wells ranged between 5,580 and 6,170 feet above mean sea-level (ft amsl) with an average of 5,730 ft amsl (**Figure 19,**

Table 13). Groundwater trends were similar in all monitoring wells during the period of record. Select hydrographs are shown in **Figure 2** and the rest of the hydrographs are included in **Figure 25**. Annual groundwater-level fluctuations ranged between 7 and 32 feet with an average fluctuation of 16 feet. No spatial trend is apparent in these fluctuations; rather they appear to reflect local responses to seasonal recharge and discharge stresses.

Groundwater levels rose in late spring and early summer and peaked during mid-June to mid-July in 2011 and 2012. The rise in groundwater levels appears to be primarily due to snowmelt in the spring and irrigation water that recharges the groundwater system. Groundwater recharge from irrigation is well documented (G. Abdo, Butler, J., Myse, T., Wheaton, J., Snyder, D., Metesh, J. and G. Shaw, 2013). Groundwater levels declined through the rest of the summer into the late fall/early winter when they reached base level with the exception of short rise in the fall during fall irrigation. Groundwater levels probably declined in response to decreasing irrigation applications, high transpiration, and low precipitation during the late summer and early fall months.

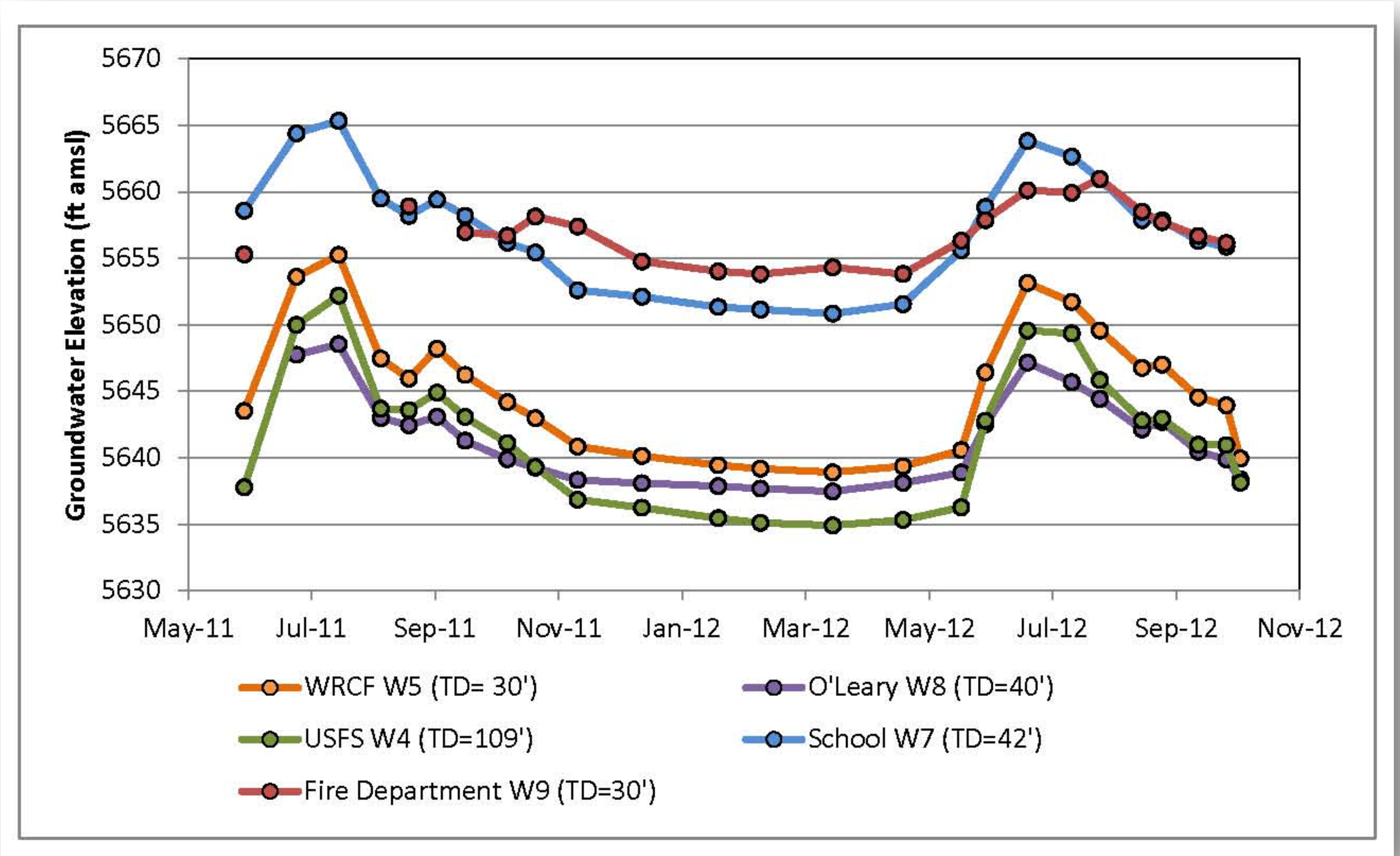

Figure 2: Representative hydrographs show that groundwater elevations typically are higher in the late spring/early fall and then decrease through fall/winter. All displayed wells were located in Pleistocene glacial outwash (Qo).

Groundwater Potentiometric Map

Groundwater elevations from all monitoring wells were used to construct a generalized potentiometric map for the study area. In the Wise River valley the shallow groundwater flows towards the Big Hole River valley. The potentiometric map indicates that groundwater moves down the Wise River valley at a relatively steep gradient to the northeast. At the Wise River/Big Hole River confluence, Wise River valley groundwater joins the relatively low gradient groundwater system of the Big Hole River valley, and turns to the east (**Figure 3**). The configuration of the potentiometric surface is similar to that compiled by Marvin & Voeller (Marvin, R.K., Voeller, T.L., 2000).

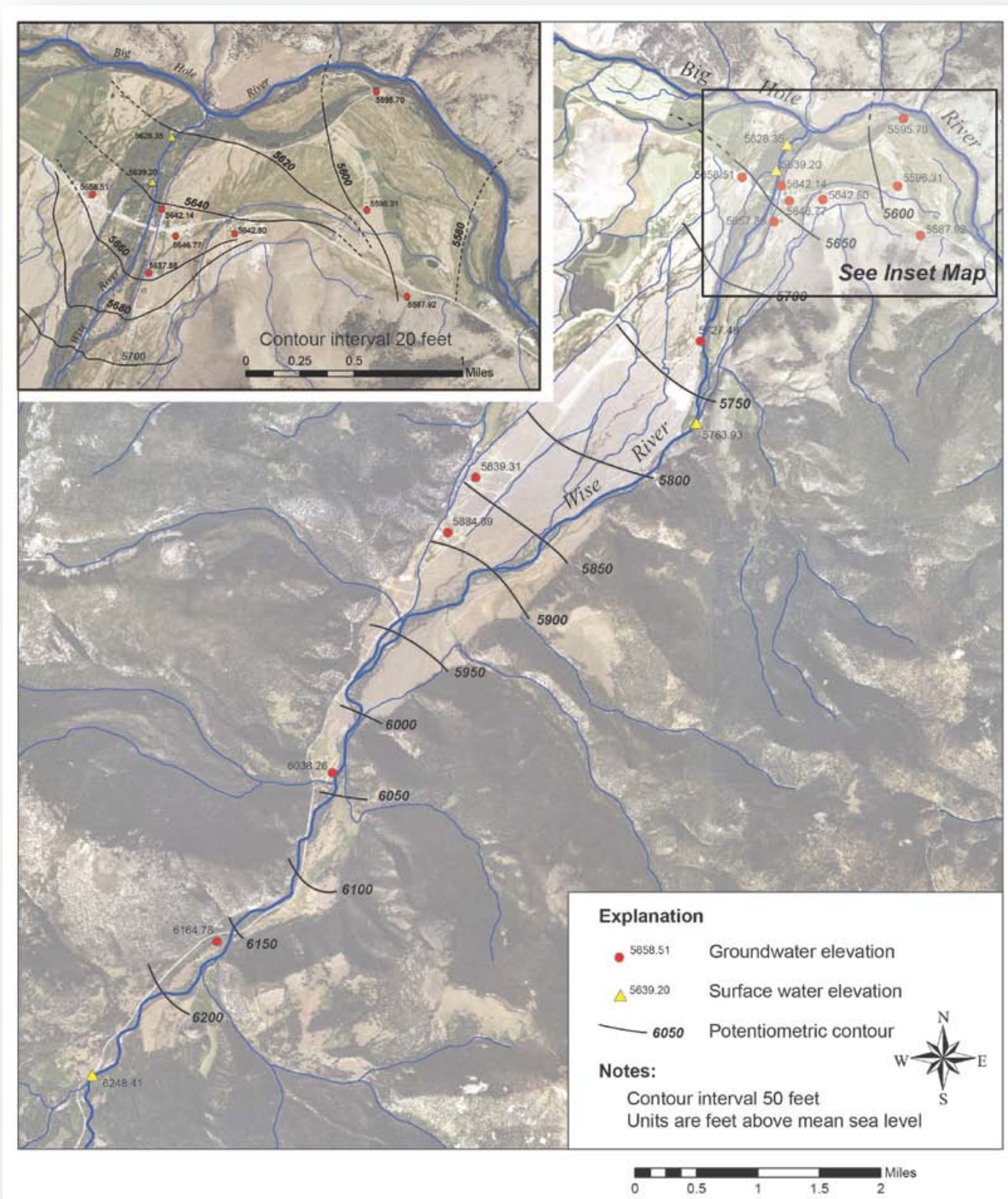

Figure 3: Groundwater potentiometric contour map. (*Map by MBMG 2013)*

Water Chemistry

Field Parameters

Specific conductivity (SC) is the ability of a material (in this case water) to conduct electricity. It is directly correlated to total dissolved solids, thus, as specific conductivity increases the total dissolved solids increase (Hem, J.D., 1985). The SC increases in Wise River from the most upstream site (TruTrack T3 (I6); 66 µs/cm) to the mouth (TruTrack T1 (I23); 109 µs/cm) (**Figure 4**, **Table 2**). Downstream from the confluence of the Big Hole and Wise River (I27), SC was similar to the Wise River at 112 µs/cm. Stine Creek (I14) which flows into Wise River from the west side had the lowest SC (31 µs/cm). Sheep Creek (I16), Adson Creek (I15) and Swamp Creek (I22) flow into Wise River from the east side and had higher SC values (302, 325, and 576 µs/cm, respectively). The presence of higher dissolved solids in the east side creeks may be due to geologic differences and/or mining activity in the upper reaches of these drainages resulting in more dissolution of minerals into the surface water and groundwater.

Specific conductivity in irrigation ditches ranged from 94 to 204 µs/cm, with Company Ditch (I18) and Truman Ditch (I19) having the lowest values. These samples were collected in the upper and mid-reaches of the study area. SC in the ditch sites increased further down gradient. Groundwater SC ranged from 62 to 233 µs/cm. The wells with the two lowest values (Miller, I11 and Brimhall, I10) are located on the west side of the Wise River valley, indicating that not only is SC lower in the surface water but also in groundwater on this side of the valley. The wells with the two highest SC values (Lovell, I4 and USFS, I13) are located on the east side of the valley in the lower reach of Wise River drainage.

Overall, the temperature in Wise River varied less than 5° F from the most upstream site (T3, I16) to the mouth (T1, I23; **Table 2**). From T3 (I16) at the top of the reach to T2 (I25) at the middle of the reach, temperature increased from 55.9 to 60.8° F. Further downstream near Stodden well W10 (I9) the temperature in Wise River was 58.5 and increased to 60.3° F at the mouth (I23). Groundwater temperatures ranged from 43.7 to 50.4° F. There were no discernible trends in ground water temperatures versus well depths. The coolest groundwater temperatures were found in a well near the Big Hole River, PKR Cabin (I1) (43.7° F) and the furthest upgradient well (Fellin, I7, 44.3° F). The warmest groundwater temperature was found in the well at the Wise River Fire Department, I5 at 50.4° F. Tributary temperatures ranged from 47.5 to 55.5° F, higher than the groundwater temperature range. Overall, temperatures were highest in the ditches/slough, and were greater than 58° F. The exception was a slough east of TruTrack T1 (I28) with a temperature of 48.9° F. The sample collected from a shallow irrigation pond east of PKR Stockwater North (I29) had the highest temperature at 73.3° F.

The pH ranges varied less than 2 pH units for each of the groundwater, ditches, tributaries and Wise River categories (**Table 2**). In general, the pH in groundwater increased down gradient. The highest pH values were found in the tributaries that flow into Wise River from the east side of the drainage.

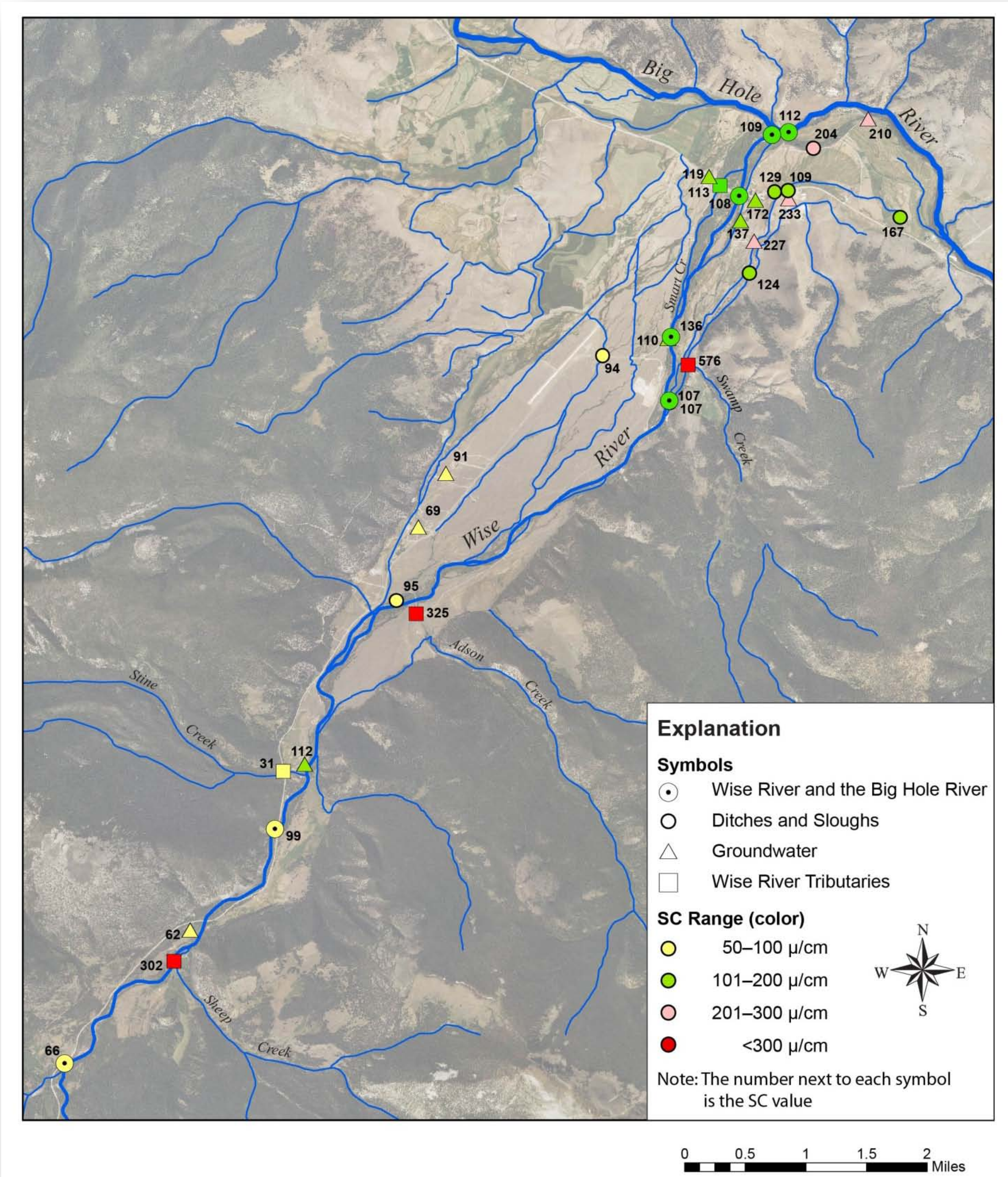

Figure 4: Distribution of specific conductivity in groundwater and surface water samples collected August 2011. *(Map by MBMG 2013)*

Table 2: Field parameters (pH, specific conductivity and water temperature) measured August 19-20, 2011. Isotope samples were collected at the same time.

Location			Field Parameters				Isotopes	
	Site	Name	pH	SC	Temp (°C)	Temp (°F)	Deuterium	Oxygen-18
Groundwater	I1	PKR Cabin	6.94	210	6.5	43.7	-17.62	-138.2
	I2	WRCF	7.21	172	8.0	46.4	-12.85	-122.7
	I3	Wise River School	6.96	137	6.8	44.2	-17.48	-138.9
	I4	Lovell	7.38	230	9.5	49.1	-11.09	-115.4
	I5	Wise River Fire Department	6.63	119	10.2	50.4	-17.28	-138.3
	I7	Fellin	6.17	62	6.9	44.3	-17.29	-138.7
	I8	Stodden	6.79	136	8.6	47.5	-11.58	-118.2
	I10	Brimhall	6.34	91	8.2	46.8	-15.08	-130.4
	I11	Miller	6.37	69	7.5	45.6	-14.72	-129.5
	I12	Ronchetto	6.51	112	8.3	46.9	-10.40	-114.3
	I13	USFS	7.52	233	9.1	48.4	-17.92	-141.2
Ditch/Slough	I18	Carpenter Ditch	8.18	95	14.9	58.8	-15.70	-132.7
	I19	Truman Ditch	8.96	94	20.2	68.4	-14.88	-130.1
	I24	PKR Headgate	8.44	107	16.0	60.8	-13.11	-122.7
	I26	Spring seep	7.42	124	18.7	65.7	-13.16	-124.7
	I28	PKR Slough	8.04	204	9.4	48.9	-15.08	-131.7
	I29	PKR Pond	10.81	167	23.0	73.3	-11.89	-116.3
	I30	PKR ditch at Hwy 43	8.65	109	15.9	60.6	-14.11	-127.3
	I31	PKR ditch at Hwy 43	8.61	129	15.9	60.6	-14.02	-125.7
Tributaries to Wise River	I20	Smart Creek	6.95	113	13.0	55.5	-15.31	-131.1
	I22	Swamp Cr	8.71	576	11.3	52.3	-12.07	-120.4
	I15	Adson Cr	8.63	325	7.6	45.7	-14.30	-129.9
	I14	Stine Cr	7.21	31	8.6	47.5	-16.02	-133.4
	I16	Sheep Cr	8.52	302	8.8	47.8	-12.47	-123.1
Big Hole River	I27	Big Hole River	8.26	112	16.0	60.8	-16.73	-137.6
Wise River	I23	T1 - Bottom of Reach	7.92	109	15.7	60.3	-11.25	-118.2
	I21	Wise River (between T1 and T2)	7.78	108	16.1	61.0	-9.90	-115.1
	I25	Wise River - PKR Headgate	8.52	107	16.0	60.8	-12.85	-124.0
	I9	Wise River (between T3 and T2)	8.01	110	14.7	58.5	-11.12	-118.2
	I17	Wise River above Stine	7.78	99	14.0	57.2	-15.48	-131.9
	I16	T3 - Top of Reach	7.45	66	13.3	55.9	-14.25	-127.8
Precipitation	I32	Rainwater					-69.0	-8.90

Isotopes

Stable isotopes of oxygen and deuterium (^{18}O and D, or ^{2}H) were used to help differentiate sources of groundwater and surface water. Comparisons were made between groundwater and surface water stable isotopes and the local meteoric water line (LMWL). The LMWL was established (Gammons, C., S. Poulson, D. Pellicori, P. Reed, A. Roesler, and E. Petrescu, 2006) using precipitation data for Butte, Montana (**Figure 5**).

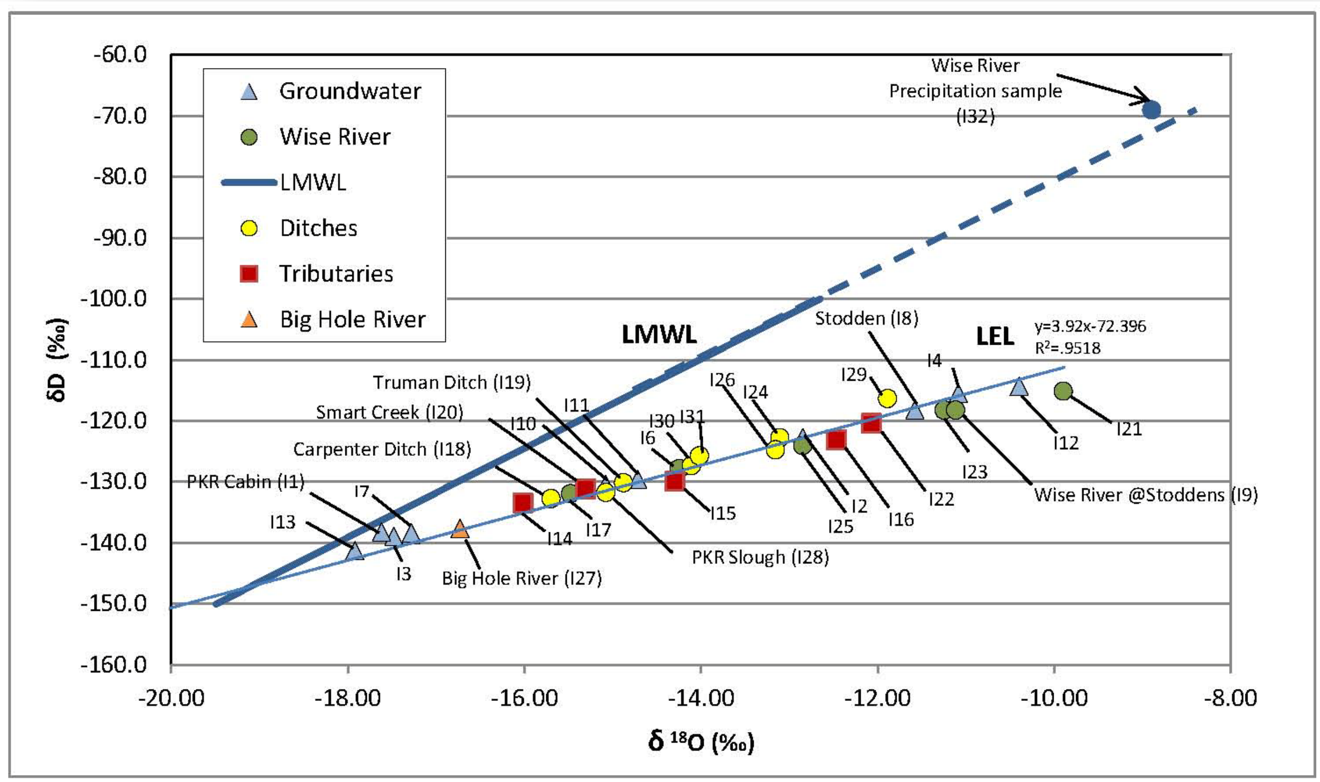

Figure 5: Groundwater and surface water are more isotopically enriched at some locations. All samples plot along the same general trend line indicating that the source for groundwater and surface water is the same. Refer to Figure 20 and Table 10 for information about points. Local Meteoric Water Line (LMWL) (Gammons, C., S. Poulson, D. Pellicori, P. Reed, A. Roesler, and E. Petrescu, 2006).

Evaporation results in partial fractionation of isotopes where the bonds holding the lighter isotopes (^{1}H and ^{16}O) break more easily than the bonds holding the heavier isotopes, resulting in a higher concentration of heavier isotopes in water that has been influenced by evaporation. Evaporation affects D more than ^{18}O, and has the effect of decreasing the slope of a trend line fit to evaporated waters (LEL, **Figure 5**). The greater the departure from the LMWL for a water sample, the more evaporation has influenced that water. The isotopic composition of waters is also affected by temperature, altitude, continental position (distance from the coast), and precipitation rate. For a detailed discussion on these affects the reader is referred to (Cook, P.G. and A.L. Herczeg, 2001) and (Clark, I.D. and Fritz P., 1997).

Groundwater is subjected to little or no evaporation and is therefore expected to plot close to the meteoric line. Surface water, such as the Wise River and Big Hole River, typically experience some but a limited amount of evaporation and so should plot away from the meteoric water line. Water that is applied to irrigated fields is either consumed by evapotranspiration or becomes return flow to the river or recharges the groundwater. This excess irrigation water is the mostly heavily influenced by evaporation and shows the strongest enrichment of heavier isotopes and should plot furthest to the right along the LEL.

All groundwater and surface water values from this study plot away from LMWL along a local evaporation line (LEL) and follow the same general trend line (**Figure 5**). Since the values plot along the same general trend, groundwater and surface water have the same source. This also indicates that groundwater and surface water interact with one another. The Wise River samples show isotopic enrichment from upstream to downstream as more evaporated return flows reach the river (**Figure 5**). The Big Hole River sample is the least evaporated surface water sample.

The lower cluster of groundwater from wells that plot closest to the LMWL indicates that groundwater is less evaporated in these areas. Conversely, the groundwater samples that plot towards the right along the LEL have been subjected to evaporation indicating an irrigation influence. Differences in the isotopic signatures are due to geologic heterogeneities that affect groundwater flow paths and irrigation water influences.

Comparisons of the isotopic composition at several locations that are proximal to each other illustrate the interchange between groundwater and surface water. The PKR Cabin, well W3 (I1) is located close to the Big Hole River. The isotopic composition at both these locations is similar and plot close to the LMWL. This suggests that there is a mixing of Big Hole River water and alluvial groundwater. Similar isotopic composition also occurs at Stodden, well W10 (I8) and on the Wise River mainstem near Stodden well W10 (I9) indicating the interchange of surface water and groundwater in this area. Isotopic samples collected on the Carpenter Ditch near Adson Creek (I18) and the Truman Ditch (I19) as it crosses the Pioneer Mountain Scenic Byway plot near Smart Creek (I20) and these ditches are most likely a source of recharge to the creek. Generally, the data indicate that irrigation is an important source of recharge for groundwater and that alluvial groundwater is highly connected to surface water.

Summary

Groundwater levels peaked at about the same time in 2011 (before the new ditch construction) and in 2012 (after the new ditch construction). Groundwater and surface water elevations evaluated near the mouth of Wise River indicate that during the irrigation season groundwater is providing a source of flow to Wise River, while during the non-irrigation season Wise River is potentially recharging the groundwater. The isotope data plot on a similar trend line indicating that the sources of groundwater and surface water are the same and that they interchange with one another.

2. Surface Water Results

Surface water measurements were led by Montana DNRC. The surface water monitoring locations are displayed for TruTracks in **Figure 19** and synoptic measurements in **Figure 21**. Information about the locations is available in **Table 10**.

TruTrack Water Level Records

The TruTrack surface water level results are perfectly synchronized in response to the snowmelt peaks in May and June as seen in **Figure 6**. Also in May and June there is more water at the mouth of the river (T1) than there is higher in the watershed, and less water at the mouth later in the summer. This pattern makes sense because tributaries, overland flow and shallow groundwater contribute to the river as the snow melts, causing flow to increase downstream. By early July, the situation reverses and the flow at the mouth is substantially less than the flow upstream. By this time, the snowpack has melted and the tributaries and shallow groundwater contributions subside. Irrigation demands further reduce the river flow.

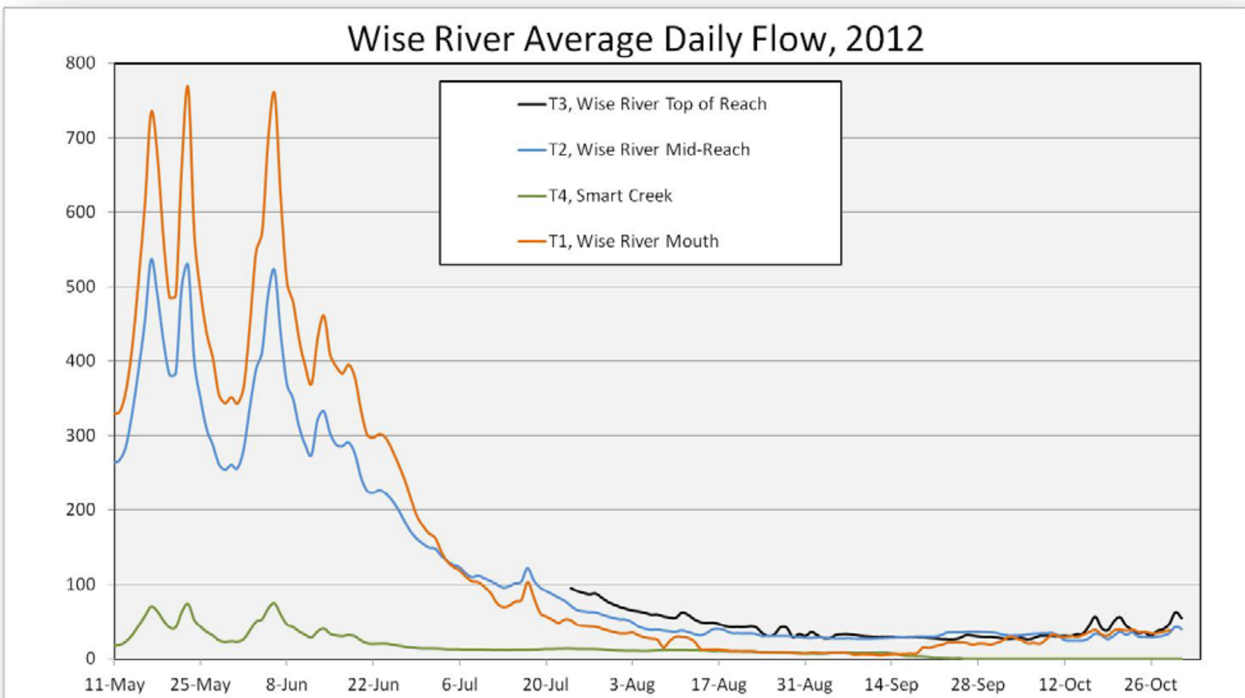

Figure 6: 2012 Hydrograph of four TruTracks in Wise River and Smart Creek

Table 3: Lowest average daily flows of 2012 at each gage as measured by TruTracks.

Location	Discharge	Date
T3: Wise River Top of Reach	27.1 cfs	September 24 and October 6
T2: Wise River Mid-Reach	24.8 cfs	October 13
T1: Wise River Near Mouth	5.0 cfs	September 5

The Smart Creek (a spring creek) hydrograph is also synchronized to the higher early snow melt flows, and is in response to rising groundwater supply in the valley alluvium, or possibly elevated surface flows through irrigation diversions. The Smart Creek flow recedes through the summer and autumn in response to the decreasing shallow groundwater supply. Although the spring did not dry up, flow through the channel cross section fell to less than 1 cfs beginning in late September.

Comparing 2012 Stream Flow to Historic Flow Data

The discontinued USGS gage (06024590 Wise River near Wise River, MT) was operated between October 1972 and October 1985, which is a relatively short period of record. However, it is enough data to make useful comparisons to the uppermost gage, T3. The period 1973 through 1985 was an above normal stream flow period overall. A look at main stem Big Hole River gage data shows that July and August flows were above normal for 8 of the 13 years that the Wise River gage was operated.

A complicating factor in comparing the data is that the USGS gage site is located below the Sheep Creek confluence and therefore includes those inflows; T3 is located above Sheep Creek. However, based on a USGS publication, WRIR 89-4082, which estimates monthly flow characteristics for Sheep Creek, reasonable assumptions can be made to overcome the difference in gage locations.

For comparison purposes, the table below lists the USGS median or 50% exceedance (Q50) monthly flows for the Wise River at the USGS site, and the USGS 90% exceedance (Q90) monthly flows. Statistically the Q50 represents average (i.e. "normal") flows since they are equaled or exceeded in 50 out of 100 years, and the Q90 values indicate very low flows since they are equaled or exceeded in 9 out of 10 years. Also listed are the 2012 average monthly flows at T3; the estimated Sheep Creek Q90 flows; and the result of T3 average flows added to Sheep Creek Q90 flows:

Table 4: Historic flow data compared to measured data. USGS NWIS Water Data for Montana Web page at http://waterdata.usgs.gov/mt/nwis/.

	USGS Q50	USGS Q90	T3 Average	Sheep Cr Q90	T3 plus Sheep Cr Q90
May	508		-	19	
June	858	277	-	13	
July	279	76	-	5	
August	99	49	50	3	**53**
September	79	44	31	2	**33**
October	68	41	38	2	**40**

Combining Sheep Creek Q90 flows to the 2012 T3 average monthly flows yields T3 total flows that closely resemble the historic USGS Q90 flows, as seen in Figure 7. Comparing these flows to the USGS median (Q50) data confirms that 2012 river flows at T3 or the USGS site were very low. The T3 September average flow, and several of the September daily flows, was lower than the lowest flows logged at the USGS gage over its limited period of record. Analysis of the long term USGS gage record for the Big Hole River near Melrose (USGS gage 06025500) reveals that the August and September 2012 monthly flows for the Big Hole River were at about the 80% exceedance level.

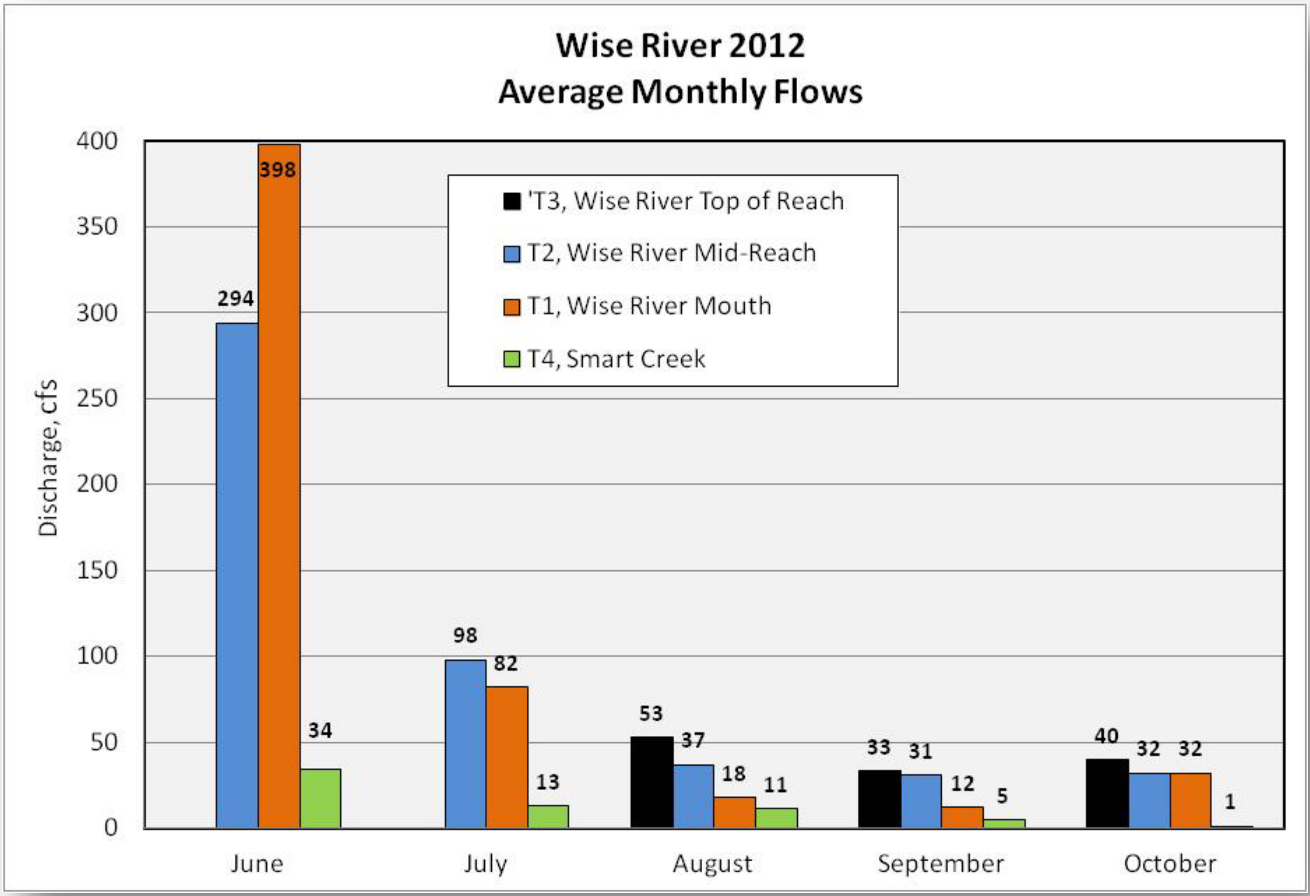

Figure 7: Average monthly flows at three Wise River Gages and Smart Creek. The comparison includes the Wise3 average monthly flows augmented with the estimated Sheep Creek Q90 monthly flows.

2012 Snow Pack and Precipitation

With elevations over 10,000 feet, approximately 70% of the precipitation in the Wise River watershed comes as snow. Early May is typically the time snow water accumulation reaches its peak. However, 2012 was a below average snow year in western Montana. The NRCS snow pack report for early May 2012 showed that the snow water equivalent for the entire Big Hole River Basin was only about 68% of the long term average, and snow course readings local to the Wise River watershed suggested a snow water figure of about 74% of average. Based on these snow pack figures, in early May 2012 the NRCS forecast a seasonal flow volume of 57% of normal for the Big Hole River at Melrose, and only 37% of normal at Wisdom.

According to the National Climatic Data Center, summer precipitation at Wise River was also well below normal in 2012. For May through September, precipitation registered only 3.11 inches. The long-term normal precipitation for that period is 7.18 inches, so summer precipitation was only 43% of normal at the Town of Wise River. The table below shows that less than one-quarter inch of precipitation fell during August, with no measureable precipitation during September.

Table 5: 2012 precipitation by month, Wise River, Montana

	May	June	July	August	Sept	October
2012 Precipitation, inches	0.80	0.89	1.19	0.23	0.00	1.12
Long-term Average	1.66	2.04	1.28	1.16	1.04	0.81

The combination of below-normal snow pack and limited spring and summer rains produced very low flows in the Wise River for much of 2012. Comparing 2012 gage data to the historic USGS data suggests that the Wise River experienced some daily flows as low as the 95% exceedance level during September. Flows would only be less than these rates in 5 out of 100 years.

Synoptic Flow Measurements: Wise River

Analysis of gage data at three locations along the Wise River reveals that it is a naturally gaining system throughout the study reach. This is the typical flow pattern of unregulated, natural river systems and is evident in the Wise River during early spring, when snowmelt and tributary inflows far exceed the effects of irrigation diversions. In the absence of diversions, streamflows would almost certainly increase in a downstream direction throughout the year; however, given the irrigation diversions in place, Wise River flows are directly responding to irrigation withdrawals. Synoptic points are displayed in **Figure 21**.

The previous hydrographs (**Figure 6**) show that May and June flows are greater in the lower reaches of the river (T1) than farther upstream (T2, T3). But this pattern reverses during July, after snow melt cessation, and when irrigation diversions constitute a greater percentage of total river flow. Streamflow at T1 remains less than the streamflow at the upper gages until irrigation diversions are shut down in September or October. The observed hydrographic rebound is typical on diverted streams in western Montana.

Synoptic runs were conducted to gain an understanding of flow characteristics in the lower Wise River system. Three runs occurred in September and October of 2011, before completion of the construction project on the Upper PKR diversion, the Swamp Creek headgate, and placement of various measuring devices. Five additional synoptic runs occurred between July and September of 2012.

Top of Reach (T3) to Mid-Reach (T2)

A September 2011 synoptic run revealed the following flows: T3, 77.9 cfs; the Company Ditch below headgate, 34.2 cfs; Wise River below the Company Ditch, at Adson Creek Road bridge, 42.2 cfs. The flow at T3 minus the Company Ditch diversion almost exactly equaled Wise River flow at the Adson Creek Road bridge; the difference being only 1.5 cfs. This difference of just 2% of the total river flow can likely be attributed to part of the unmeasured diverted flows in the Hjelmstad, Vineyard, Split Diamond and other ditches in the reach. The combined diversion rate of these ditches is much greater than 1.5 cfs, which suggests that this is a gaining reach of the river in which Stine, Sheep and Adson creeks are tributaries.

Given limited synoptic data, it can only be theorized that Wise River again gains flow from the Adson Creek Road bridge downstream to T2. If the Company Ditch consistently diverts 34 cfs from Wise River, 2012 observations suggest that the diversion depletion is offset by unquantified inflows. In July 2012, a measurement at T3 showed 97.4 cfs, and downstream T2 was measured at 73.8 cfs, a difference of only 23.6 cfs. All July and August synoptic runs show flow differences between the stations of only 23.6 cfs to 12 cfs, and not the full 34 cfs of the Company Ditch.

Mammoth Gulch, several unnamed ephemeral tributary drainages, and adjacent upland benches may account for the unconfirmed gains, but more detailed synoptic measurements are necessary to conclusively define the gain or loss character of this river reach.

Mid-Reach (T2) to Mouth (T1)

Prior to the construction projects on the Upper PKR diversion, several small ditches existed below the headgate northward towards Swamp Creek. These ditches were eliminated as part of the project. Their former flows are now combined and diverted through the rebuilt, single PKR ditch. The Town Ditch diversion is also located farther downstream in this reach, but was not part of the project. Town Ditch diverted flow appeared to be between 3 and 4 cfs during 2012 field visits.

The table below (**Table 6**) lists synoptic flow observations in cubic feet per second (cfs). T2 and T1 gage data suggest that there are overall small losses through this reach (0.5-6.8 cfs).These minor losses (2-9% of T2 flow) are within measurement error and are small enough that they could also be influenced by irrigation diversion operations, or perhaps even evapotranspiration.

Table 6: Synoptic flow (cfs) data collected by DNRC in 2012. Readings at T2 added to the (negative) ditch flows and to the (positive) Smart Creek inflow equal the readings in the column entitled, Expected T1. Measured flow at T1 is listed in the column, Actual T1. Identical T1 Expected values and T1 Actual values would indicate no gain or loss between stations. The difference between the two is listed in the final column, and since these are negative values, they are losses.

2012 Sample Dates	T2	Upper PKR Ditch	Town Ditch	Smart Creek	Lower PKR Ditch	Actual T1	Expected T1	Loss
July 24	73.8	-12	-4	13	-13	51	57.8	-6.8
August 15	32	-15.8	-4	11.3	-12	11	11.5	-0.5
August 24	32.4	-15.8	-4	9.3	-11	8.6	10.9	-2.3
August 30	28.9	-10.7	-4	6.7	-10.7	7.4	10.2	-2.8
Sept 7	29.5	-10.7	-4	5.9	-11	7.4	9.7	-2.3

Unfortunately, no mainstem flows were collected between stations T2 and T1. It would be of particular interest to obtain Wise River flow characteristics at or near the Highway 43 Bridge, above the confluence of Smart Creek.

Flows at the bridge could actually be lower than flows observed at T1. One area of possible groundwater to surface water inflow was observed just below the bridge. Measurements near the bridge might also assist in further identifying the extent or location of losses or gains in the lower river reaches.

Instream Flow Maintenance

A Wetted Perimeter survey conducted in 1989 (MFWP, June 1989) recommended an upper-inflection point instream flow of 35 cfs for the Wise River. The survey, which was based on channel geometry characteristics measured just downstream of the inactive USGS station, also listed a lower-inflection point flow of 20 cfs. These figures were submitted to the Board of Natural Resources and Conservation as part of the Missouri River Basin Water Reservations process in 1992. The Final Order from the Board granted an instream flow reservation of 20 cfs for the entire length of the Wise River.

In 2012, Wise River flow dropped to 5 cfs at station T1 near the river mouth, but held on relatively well farther upstream. The low flow at T2 was 24.8 cfs, and the low flow at T3 was 27.1 cfs, even under such dry conditions. These figures suggest that the 35 cfs flow target may be attainable in the upper river, even in a severe drought year. However, below the Upper PKR diversion, a 35 cfs target is unlikely. It appears that 20 cfs measured at the Highway 43 Bridge is a reasonable minimum flow target. Data collection during the 2013 low flow season should help in further defining an attainable flow target.

Wise River Water Temperature

Figure 8 shows the average daily water temperatures at each of 4 TruTrack locations (**Figure 19**). TruTracks located on the Wise River mainstem (T1, T2 and T3) mirrored each other, with peak temperatures occurring in August. Smart Creek had an alternate pattern with water temperatures that stayed near 50°F most of the season until waters cooled in late fall to below 50°F.

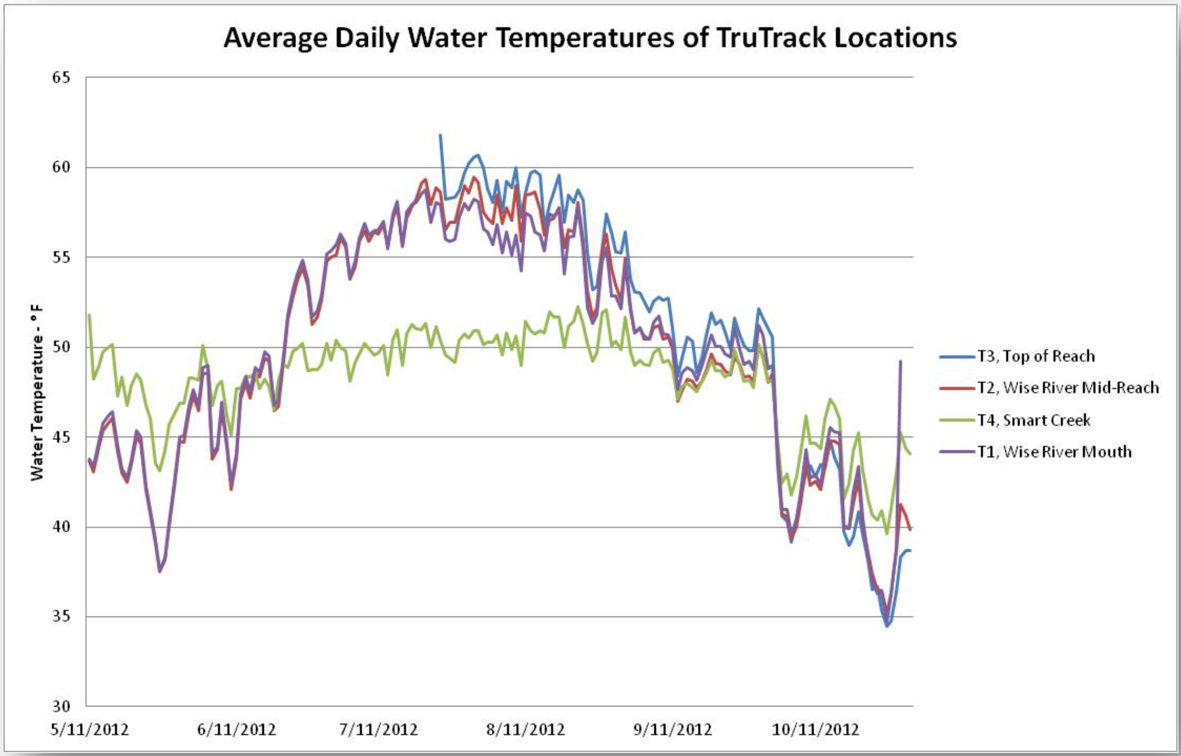

Figure 8: Average daily water temperatures of four TruTrack locations. Average daily water temperature is calculated on a 24 hour period. Note that T3 begins 7/24/12.

A comparison between T1 and T2 water temperatures during the peak temperature period of mid-July to mid-August shows the importance and the capacity of cooler Smart Creek and groundwater waters to buffer the high water temperatures of the mainstem Wise River. As water temperatures increase in early August, T1 is cooler than T2 despite T1 being downstream, likely due to the mixing of cooler waters with the entrance of Smart Creek and groundwater (**Figure 9**). For example, on 8/13/12, the peak water temperature at T2 was 76.8°F and the peak water temperature at T1 was 67.5°F, where T1 is 9.3°F cooler than T2 despite T1 being downstream (**Figure 9**). As summer progressed, the pattern reversed (**Figure 10**). The peak water temperatures in Wise River in 2012 occurred in mid-August. The peak temperature in Wise River occurred at T1 on 8/18/12 at 77.5°F. At this same date and time, T2 water temperature peaked at 75.8°F, a difference of 1.7°F.

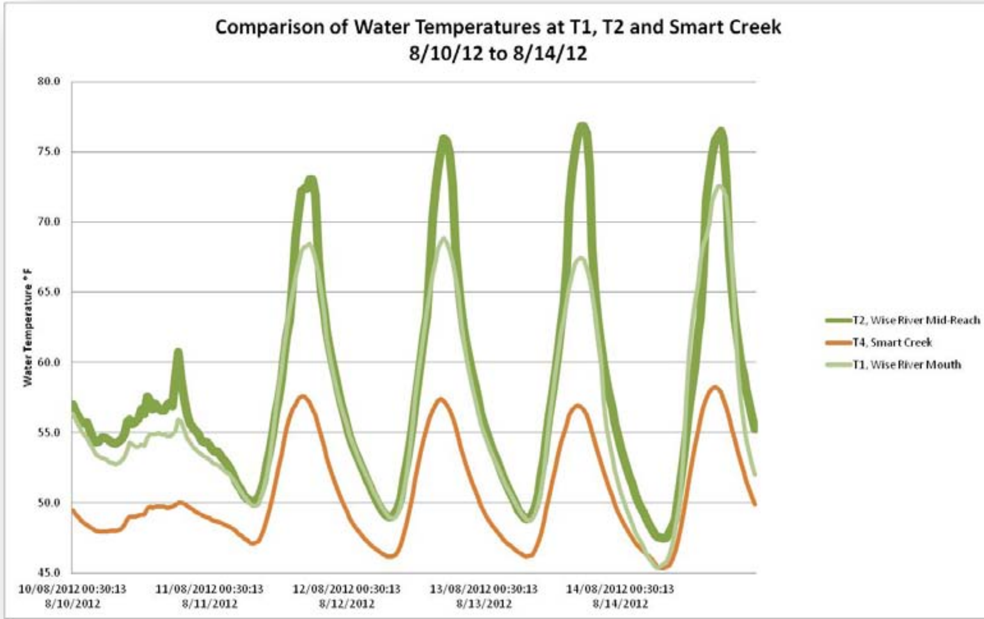

Figure 9: Comparison of water temperatures at T1, T2 and Smart Creek between 8/10/12 and 8/14/12, a period of high water temperatures. Values are the instantaneous water temperature measurements collected every 30 minutes. Note that during high temperatures, T2 peak temperatures is much greater than T1 peak temperatures.

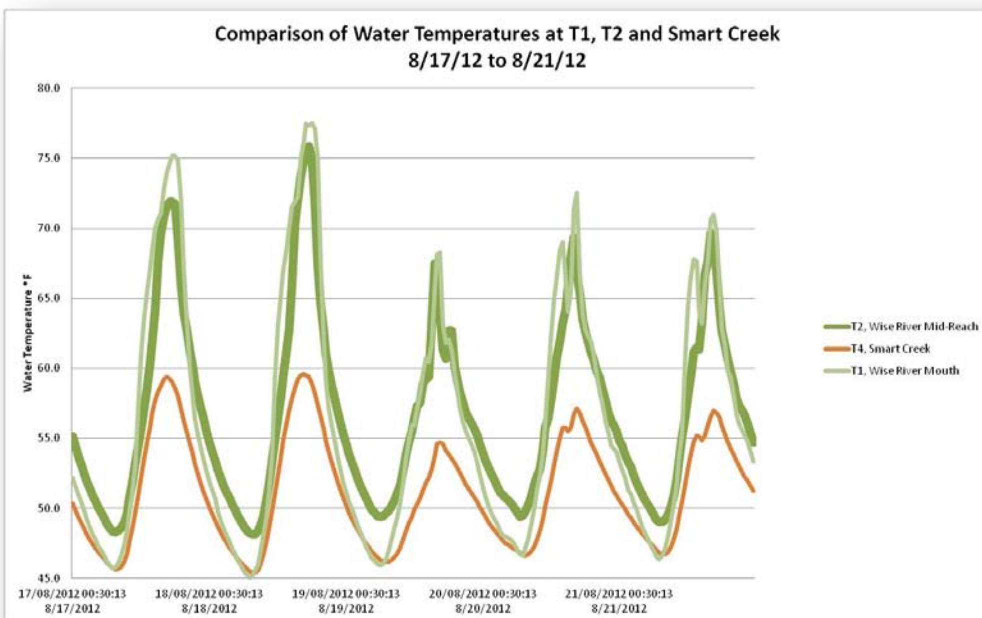

Figure 10: Comparison of water temperatures at T1, T2 and Smart Creek between 8/17/12 and 8/22/12, a period of peak water temperatures. Values are the instantaneous water temperature measurements collected ever 30 minutes. Note that during peak temperatures, T2 peak temperatures are slightly less than T1 peak temperatures.

The average water temperature at each site (average of all instantaneous measurements of 2012 at each site) are similar, ranging from 40°F to 49°F in T1, T2 and Smart Creek May – October 2012. T3 average water temperature was 50.7°F from July – October 2012.

The importance of water temperature in water quality is to fish health. Water temperatures greater than 70°F are considered stressful to fish. MFWP considers 73°F for more than three days as causing fish stress high enough to warrant fishing restrictions. Water temperatures greater than 77°F are considered lethal to trout species. **Table 7** shows the number of days where at least one instantaneous water temperature measurement was equal to or greater than 70°F, 73°F and 77°F. T3 and Smart Creek had 0 days greater than 70°F, showing that these waters remain cool and healthy for trout species. T2 and T1 each have water temperatures greater than 70°F. T2 had the greatest number of days of water temperatures greater than 70°F and 73°F, suggesting that the middle Wise River suffers the most from high water temperatures. T1 had fewer days over 70°F and 73°F due to the cooling effects of mixing with Smart Creek and groundwater inputs. However, T1 had 1 day with water temperatures greater than 77°F, where temperatures are considered lethal to trout species. As T1 peaked to 77.5°F on 8/18/12, T2 peaked at 75.8°F. While the mixing of cool groundwater buffered water temperatures earlier in the summer, by late August the cool waters of Smart Creek warmed to 59.5°F and flows decreased, and therefore offered less cooling capacity.

Table 7: Water temperature summary from TruTracks. The average water temperature is the average of all measurements on all days measured. Number of days over specified degree is measured as at least one instance of that temperature within a 24 hour period. Temperatures were measured between 5/11/12 and 10/31/12 for TruTracks T1, Smart Creek and T2. T3 TruTrack was measured from 7/24/12 to 10/31/12.

Water Temperature Summary Data	T3 Wise River Top of Reach	T2 Wise River Mid-Reach	T4 Smart Creek	T1 Wise River Mouth
Average Water Temperature	50.7°F (7/24 - 10/31/12)	49.7°F	48.0°F	49.9°F
Minimum Temperature Date	33.6°F 10/26/2012	33.5°F 10/26/12	37.5°F 10/26/12	33.2°F 10/26/12
Maximum Temperature Date	68.1°F 8/14/12	76.8°F 8/13/12	59.7°F 8/16/12	77.5°F 8/18/12
Number of days over 70°F	0	15 7/31/12 - 8/23/12	0	8 8/14/12 - 8/23/12
Number of days over 73°F	0	7 8/5/12 - 8/22/12	0	4 8/16/12 - 8/22/12
Number of days over 77°F	0	0	0	1 8/18/12

3. Groundwater-Surface Water Interaction

As stated in previous sections, Wise River has been documented as an important coldwater resource for the Big Hole River due to the influx of flow from springs. These documents and local water users cite a strong connection between surface water and groundwater.

The groundwater and surface water portions of this study were reviewed to look for trends that point to where and when groundwater-surface water interactions are occurring. For example:

- Isotope sampling of both surface water points and groundwater points may point to locations where waters are exchanged.
- Changes in annual stream flow and temperature correlation with changes in groundwater levels and the timing of that correlation lend insight into the timing of surface and groundwater connections, i.e. timing of surface water reduction in flow versus timing of groundwater level reduction.

Surface Water and Groundwater Flows and Elevations

Figure 11 shows surface flow discharge from the four monitoring locations on the Wise River and Smart Creek. Flows peak in early summer with runoff and snowmelt, then decline rapidly as snowmelt ends, precipitation declines, and irrigation reaches peak withdrawals. In mid-September, Smart Creek surface flows almost cease, while flows at T1 near the Wise River Mouth increase, and flows at T2 and T3 remain relatively constant.

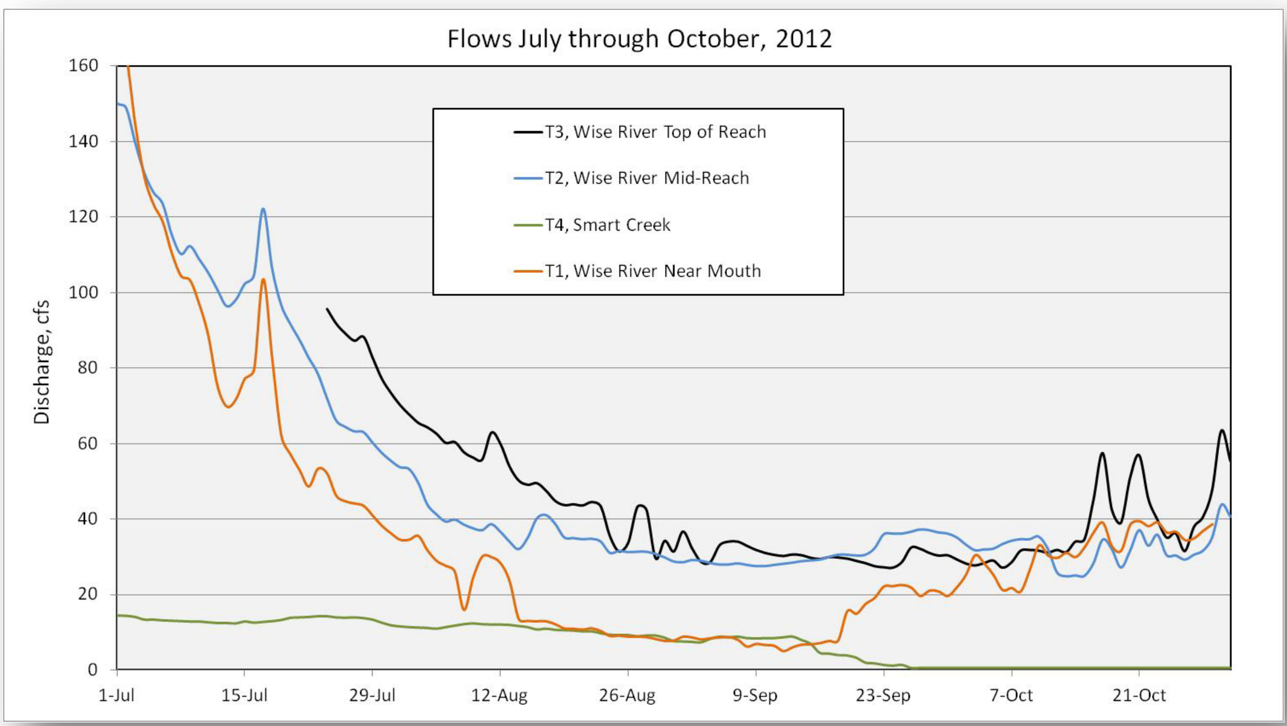

Figure 11: Wise River Flows, July through August 2012 at the TruTrack Locations

The Smart Creek TruTrack (T4) site is located near the O'Leary well, W8 (approximately 680 feet) (**Figure 19**). Groundwater elevations in well W8 were higher than the surface-water elevations in Smart Creek towards the end of the monitoring period (between late-June through late-September 2012) (**Figure 12**). The Smart Creek monitoring station is located near the confluence with Wise River and the stage elevations are likely similar.

The gradient between well W8 and the surface water, and the flow directions determined from the potentiometric map (**Figure 3**) indicate the groundwater was providing flow to Smart Creek and Wise River from mid- to late May through the end of September. During the period of monitoring, surface-water elevations in Smart Creek varied by 1.7 feet while during this same time water levels in well W8 varied by 8.8 feet. Surface water was recharging groundwater prior to the middle of May and after the first of October. Seasonal reversals of flow between groundwater and surface were also observed in a hydrogeologic study of the Beaverhead River (G. Abdo, Butler, J., Myse, T., Wheaton, J., Snyder, D., Metesh, J. and G. Shaw, 2013).

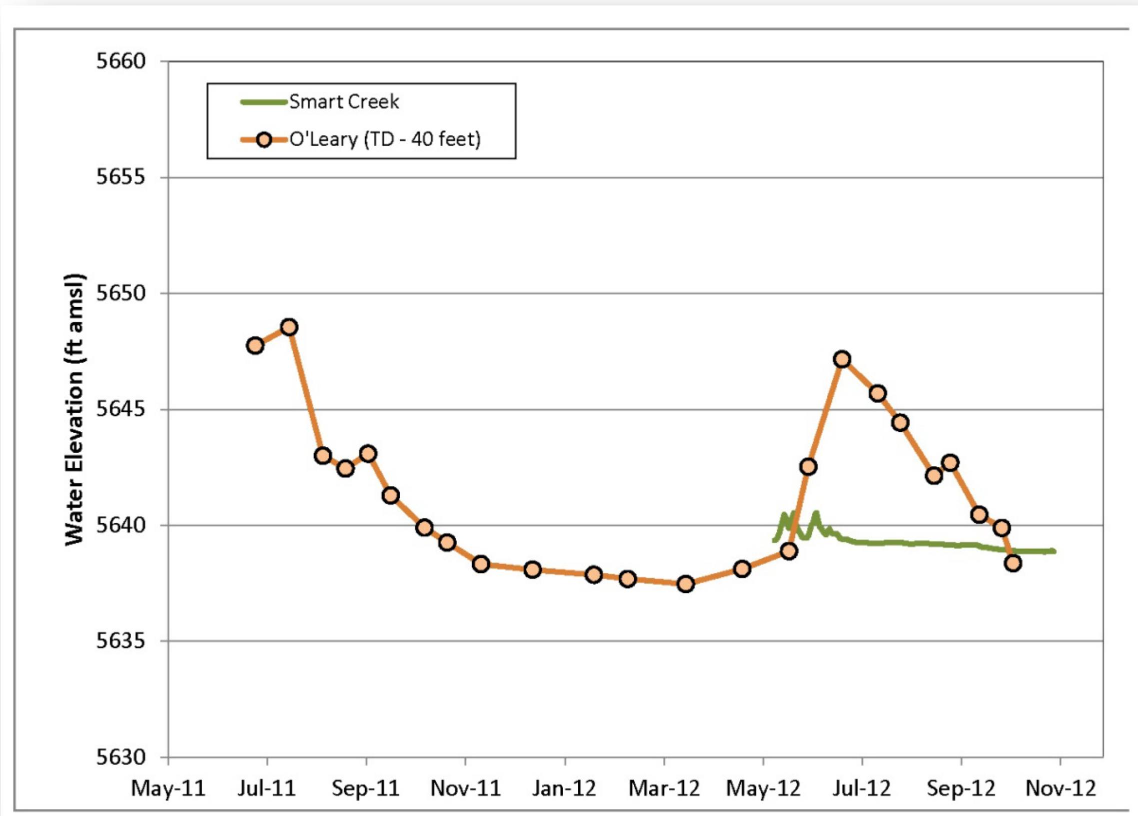

Figure 12: Smart Creek, T4 & O'Leary Well, W8: Groundwater elevations are higher than Smart Creek during the irrigation season indicating that groundwater is recharging Smart Creek and Wise River. The data suggest that there is a reversal during the non-irrigation season and that surface water may be recharging groundwater.

Water Temperatures of Groundwater and Surface Water

The groundwater (measured at the Wise River School, W7) and Smart Creek water temperatures are generally cooler than the Wise River surface waters of T1, T2 and T3 and help to buffer the warming waters in the Wise River **Figure 13**. However, in late fall, the groundwater and Smart Creek are warmer than the surface waters of the Wise River mainstem of T1, T2 and T3, with Smart Creek being cooler than the groundwater.

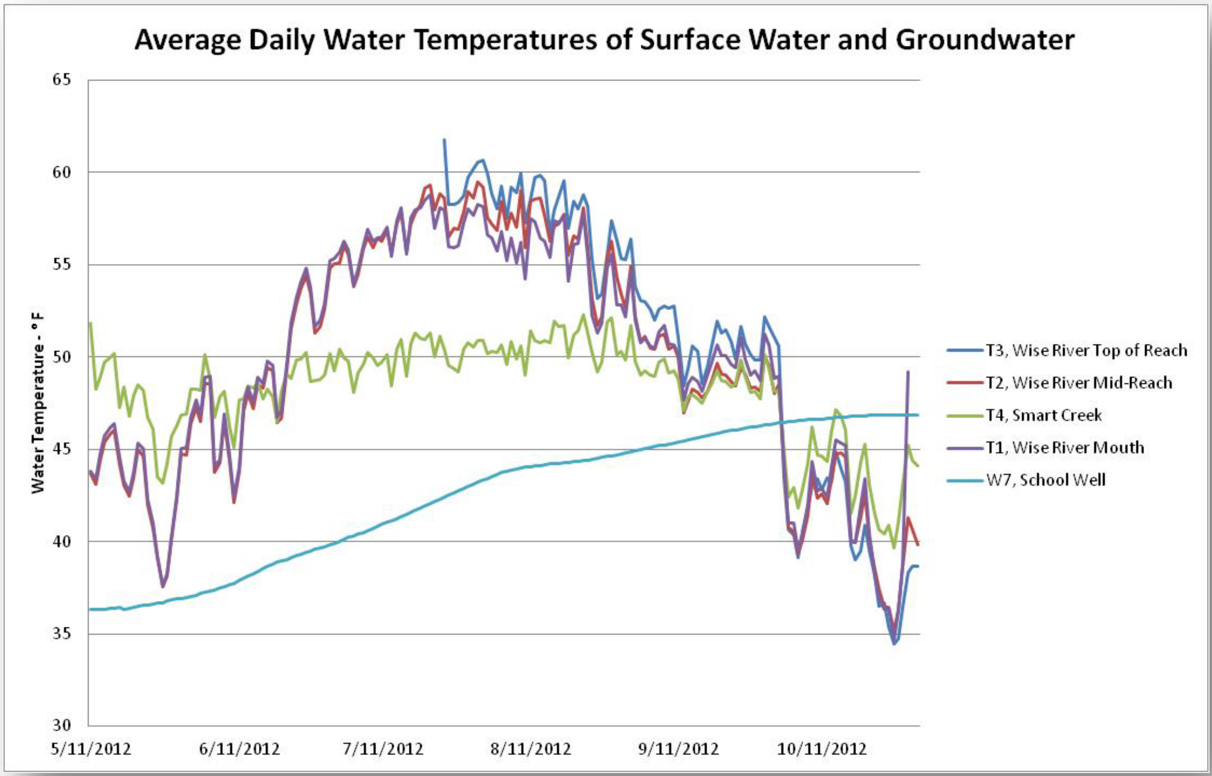

Figure 13: Wise River water temperatures measured at TruTrack locations compared to groundwater temperatures measured at the Wise River School Well, site W7. May – October 2012.

4. Fisheries Results

The fisheries data was collected by MFWP in three sections of Wise River and displayed in **Figure 22**.

Mono Creek Section

The Mono Creek Section of the Wise River began 0.4 miles downstream of the confluence of Jacobsen and Mono creeks (N45.53927, W113.08422) and extended downstream approximately 1.3 miles. The fishery was sampled on 9/21/11. The habitat in this reach consisted of a moderate gradient channel at the beginning of the section with predominantly large boulder substrate and few pools. The stream banks are forested with mostly lodgepole pine trees with few willows and other riparian species. Downstream of the Highway 73 stream crossing the gradient lessens and the stream takes on a more sinuous pattern where high quality pools are frequent. The substrate is primarily gravel and cobble and the riparian vegetation is primarily willows. The fish species encountered in this section included in descending order brook trout, mottled sculpin, rainbow westslope cutthroat trout hybrids, burbot, mountain whitefish, and longnose suckers. No Arctic grayling were captured in this reach. The rainbow trout and westslope cutthroat trout captured ranged in appearance from fish that appeared to be non-hybridized to those that were significantly hybridize; therefore the two species were lumped under a single heading of rainbow-cutthroat hybrids. The fisheries data collected in this section is summarized in **Table 8**. Brook trout were the most common game fish encountered in this section.

Lacey Creek Section

The Lacy Creek Section began at the crossing of Highway 73 upstream of the confluence of Lacy Creek. The habitat in this section consisted of a meandering stream channel and a wide willowed floodplain. The stream substrate for most of the section consisted of gravel and small cobble transitioning to sand near the downstream end of the section. There were several pools in this reach of river that were over 6 ft deep. A mark recapture population estimate was performed in this section (**Table 8**). Fish were marked on 9/22/11 and recaptured on 10/12/11. A significant cold front moved through the area between the mark and the recapture runs leading to either or a combination of fish migrating from the section or poor electrofishing efficiency. A total of 877 fish were marked in the section and only 207 were captured on the recapture run. The poor capture rate on the recapture run may have also been related to seasonal migration of fall spawning fish (brook and brown trout and mountain whitefish) in this reach of river. This difference in capture rate between the marking and recapture run likely led to biased population estimates. Brook trout were still the dominant game species present. Mountain whitefish were also abundant in this reach of river; however, the high number encountered may reflect seasonal habitat use in this reach of river (whitefish spawn in the fall) rather than actual resident numbers of fish. Also present in this reach of river and not encountered farther upstream were brown trout. The large size of some of these brown trout also suggests that they are migratory fish, possibly from the Big Hole River, seasonally using the Wise River for fall spawning. No Arctic grayling were encountered in this section of river. Mottled sculpin were abundant and longnose dace were also present in this section of river.

Adson Creek Section

The Adson Creek section began at the Adson Creek bridge crossing over the Wise River approximately 4.5 miles south of the Town of Wise River and extended downstream 1.01 miles. The habitat in this section can be characterized as moderate gradient with boulder, small boulder and large cobble substrate. Pools are rare in this reach but there is a good amount of micro habitats generally associate with large boulder pocket water within the long riffle reaches. Glide/run habitats were present where riffle grades lessened but rarely were there slow water habitats that were deeper than 3 ft. A mark-recapture population estimate was performed in this section in the fall of 2012 (**Table 8**). The section was marked on 9/20/12 and recaptured on 9/26/12. Of the 3 sections sampled the Adson Creek section contained the highest quality fishery with a relatively abundant population of rainbow and brook trout of catchable size and a high number of individuals greater than 12 inches. There were also greater numbers of brown trout in this section of river than observed farther upstream the year prior. One Arctic grayling was captured in this reach of river.

Habitat Survey

The aquatic habitat in the Wise River was surveyed from Adson Creek Bridge to the confluence with the Big Hole River (5 miles of river) in March of 2013. These data were not yet been entered or analyzed at the time of this report. However, it is clear from the survey that slow water habitats (i.e., pools) with depths greater than 3 feet are extremely limited in this reach of river. Over 80% of the habitat was classified as riffle. The riffle habitat near Adson Creek Bridge has abundant boulders that create microhabitats for fish. Approximately 1.5 miles below the bridge these larger boulders are rare and there is little diversity to the stream channel in the riffle environments. In areas where the stream gradient lessens there is a lack of pool development. The river in these areas is wide and shallow and it appears as though the river is unable to scour and maintain pools due to the large size of the stream substrate. Upon further analysis of these data, habitat recommendation may be made to improve the frequency and quality of slow water habitats.

Summary

The upper Wise River from its headwaters through the meadows downstream of Lacy Creek could represent an area where Arctic grayling could be introduced. The density of brook trout in this reach is relatively low (assuming the population estimate for the Lacy Creek Section was inflated). There is adequate spawning and rearing habitat in the mainstem river as well as high quality adult habitat. Introductions of Arctic grayling in other areas with similar habitat have been successful (i.e, Ruby River drainage).

The fish population in the Wise River in the lower reached downstream of Adson Creek Bridge is likely limited by the number and quality of slow water habitats and low summer stream flows. Low stream flows in the summer due to irrigation withdrawal likely greatly reduce available habitat in the river. As flows recede riffle habitats quickly become too shallow to support larger fish and in very low flows they may be impossible to negotiate for migrating fish. Pool habitats on the other hand retain adequate depth during low flows and provide areas of refuge for fish during low flow times, but pools are rare in the lower Wise River. Improvements in stream flows in the lower Wise River during summer in addition to improvements to the physical habitat in the river could result in significant increases in the quality of the fishery. Arctic grayling have been shown to use cool tributaries farther upstream as summer refuges from warm water temperatures in the Big Hole River. It is possible that improvements in stream flow and physical habitat in this reach could also result in increased use of the Wise River as seasonal habitat for grayling from the Big Hole River.

Table 8: Fisheries data collected from Wise River in the fall of 2011. The fish species sampled were: EB = brook trout, M Cot = mottled sculpin, RB = rainbow trout, WCT = westslope cutthroat trout, RBxWCT = rainbow trout-westslope cutthroat trout hybrids, LL = brown trout, AG = Arctic grayling, BUR = burbot, MWF = mountain whitefish, LND = longnose dace and LSU = longnose sucker (Data from Jim Olsen, MFWP)

Section (Length)	Latitude	Longitude	Survey Type	Species (Number Sampled)	Population Estimate/ mile (Std Dev)	Average Length in Inches (range)	Average Weight in Pounds (range)
Mono Creek	45.53927	113.08422	1 Pass				
(1.3 miles)				EB (206)		6.9 (2.3-13.8)	0.17 (0.01-0.98)
				M Cot (100)			
				RBxWCT (54)		7.0 (3.2-14.4)	0.17 (0.01-0.90)
				BUR (45)		9.4 (4.3-14.9)	0.17 (0.02-0.69)
				MWF (15)		11.5 (5.8-13.3)	0.57 (0.06-1.00)
				LSU (2)		8.0 (7.4-8.5)	0.20 (0.16-0.24)
Lacy Creek	45.59305	113.10219	Mark-Recap				
(1.81 miles)				EB (450)	1,769 (263)	7.2 (2.3-14.8)	0.20 (0.01-1.20)
				MWF (404)	972 (128)	11.7 (2.9-16.0)	0.79 (0.02-1.36)
				RBxWCT (42)	56 (17)	8.3 (4.4-16.6)	0.31 (0.07-1.84)
				BUR (12)	23 (10)	9.4 (6.4-14.0)	0.22 (0.08-0.54)
				LL (9)		11.5 (4.5-22.5)	0.94 (0.05-4.30)
				LSU (6)		6.3 (4.0-8.2)	0.14 (0.04-0.24)
				LND (5)		4.5 (3.7-5.4)	0.05 (0.04-0.10)
				M Cot			
Adson Creek	45.74128	113.00371	Mark-Recap				
(1.01 miles)				RB (470)	861 (40)	8.2 (4.2-15.1)	0.26 (0.03-1.32)
				EB (252)	639 (49)	8.2(3.6-13.2)	0.24 (0.02-0.94)
				LL (78)	169 (29)	12.8 (4.4-18.9)	0.98 (0.03-2.80)
				WCT (2)		9.4 (6.7-12.1)	0.31 (0.09-0.53)
				AG (1)		9.0	0.23
				MWF (1)		4.1	0.03
				BUR (6)		8.7 (7.3-12.6)	0.15 (0.06-0.37)
				M Cot			

Irrigation Improvement Projects on Wise River

Company & Truman Ditch – 2005

The Truman and Company Ditches are located just upstream from Adson Creek on the Wise River. The ditches provide water to the Rafter Ranch and other area ranches located approximately 5 miles downstream. Prior to this project, the diversion included a headgate and gravel diversion structure. The diversion structure required annual in-stream maintenance in order to push water towards the headgate. The completed permanent diversion created a fish passage friendly structure that could provide water to the headgate with minimal instream disturbance.

PKR Ranch – 2012 & 2013

The Lower Wise River Water Management Project is located in Wise River, MT on the Wise River 2.7 miles upstream from the confluence of the Big Hole River. Water served the PKR Ranch and two additional private landowners. The project was identified as a top priority by the BHWC during the 2010 Lower Wise River Project Prioritization study (Oasis Environmental, 2010).

Prior to this project, irrigation diversions did not regulate flow due to deteriorated or absent headgates. No water measurement was installed. “Push up” gravel diversions in the Wise River at each point were created and removed annually with heavy machinery in the river and contribute to sediment load and channel degradation. One deteriorated ditch was at risk of blowout.

The project consolidated five points of diversion into a single point of diversion located just upstream from Swamp Creek. A Technical Advisory Committee, made up of BHWC, landowners, MFWP, DNRC, USFS, and NRCS reviewed the design for maximum natural resource benefit. See **Table 9** and **Figure 23** for a description of recently completed irrigation improvement projects.

Anticipated resource benefits included improved cumulative flow and temperature regimes, improved stream banks, reduced sediment load and improved public safety. The completed project is expected to increase in-stream flow as a result of water savings, improve the stream channel by eliminating need for in-channel alterations by machinery, and improve stream banks with fewer points of diversion allowing stream bank recovery.

Table 9: Recent irrigation improvement projects on the Wise River

Location	Improvement	Expected Resource Benefit
Company Ditch – 2002 *Located just upstream of Adson Creek on the Wise River.*	Installed improved diversion structure in Wise River reduced the need for instream disturbance	Improved Fish Passage Improved habitat Reduced Sediment
PKR Slough – 2002 *Located on PKR Ranch just east of Wise River and north of Highway 43.*	The slough cools water, provides fish and wildlife habitat, and water storage that recharges groundwater and augments late season flows.	Cool Water Flow Augmentation Fish & Wildlife Habitat
Wise River Irrigation Infrastructure Report	This report review irrigation on the Wise River and prioritized potential projects for resource benefit.	Provides potential project and resource benefit description.
Stockwater Tanks - 2011 *Stockwater tanks are wells W1 and W2. See Figure 23 and Table 10.*	Stockwater tanks were installed on the PKR Ranch to provide livestock watering in water tanks rather than ditched water traveling more than 1 mile from Wise River.	Improved Stream Flow and Water Temperature
Wise River Water Management Project - 2012 *Consolidated 5 points of diversion between Wise River just above Swamp Creek to Wise River just upstream of Highway 43.*	**Wise River Portion Added:** Wise River Headgate Permanent Diversion in Wise River made of natural boulders and designed to create a scour pool that also benefits fish. Fish Ladder Water Measurement Flume **Interior Irrigation Portion Added:** 5 new headgates near Swamp Creek Expanded Ditch between Wise River headgate and Highway 43 3 additional interior water measurement flumes	Improved Stream Flow Improved Water Temperature Fish Habitat Fish Passage Reduced Sediment Improved Channel Condition
Town Ditch – 2012 *Located just upstream of Highway 43 on Wise River.*	The PKR waters were moved from the Town Ditch, but a few small water rights continue to be diverted from this point. This point of diversion has a headgate in poor condition.	
New PKR Headgate - 2012 *An additional point of diversion is located on Wise River near the mouth on the PKR Ranch. This site previously did not have flow control, diversion or measurement structures.*	**Project Added:** New headgate Water Measurement Flume Permanent Diversion Structure Interior headgates	Improved Channel Condition Stream Flow
Convert to Sprinkler Irrigation – 2013 *Pastures are located north of Highway 43 and east of Wise River. See Figure 24.*	The PKR Ranch converted approximately 90 acres from flood irrigation to sprinkler irrigation with pivots in 2013. The pastures are used for cattle grazing and hay production.	Improved Stream Flow Improved Water Temperature

Wise River Water Management Project – Hydrology Assessment

The Wise River Water Management Project on the PKR Ditch is located 200 feet downstream of station T2 (**Figure 23**). The synoptic ditch measurements showed very little net loss between the point of diversion and the Swamp Creek inflow, about 2500 feet downstream on this ditch. There is a spot along the ditch where seepage into and out of the ditch is apparent. However, according to the measurements, these components balance each other, resulting in essentially no net gain or loss. For the first run, the PKR ditch measured 12.9 cfs below the Swamp Creek inflow/outflow shuttle. From this location downstream 2.05 miles to Highway 43, there was a measured loss of 2.3 cfs, or 18% of the diverted flow. This is a reasonable loss for an unlined ditch in Montana.

Synoptic runs on October 7, 2011 and September 7, 2012 yielded similar results, with losses of 2.1 cfs and 2.2 cfs respectively. Flow in the ditch below Swamp Creek on these dates was measured as 19.1 cfs and 10.1 cfs. It is interesting that the total seepage loss was essentially the same regardless of ditch flow. This would suggest that the ditch bottom is relatively sound and that seepage rate or volume does not increase as the water level increases within this limited flow range.

The NRCS typically calculates seepage losses by converting cubic feet per second into feet per day, based on the total ditch area and the total volume of water lost in a day. In this example, the daily loss for the Upper PKR Ditch is 2.29 feet per day. This is a relatively low rate of loss. According to the NRCS, seepage may become a concern when the daily loss is above 6 feet per day.

Figure 14: Upper PKR Ditch improvements include a Cutthroat Flume and a screw-gate turnout at Swamp Creek. *(photo by D. Amman)*

Figure 15: Wise River just above Upper PKR headgate. *(photo by D. Amman)*

A major goal of the Wise River Water Management Project was to combine flow from four individual ditches into one larger ditch (the Upper PKR). Synoptic measurement of the individual ditches was not possible before construction was completed. However, it is reasonable to assume that combining the flows into one larger, relatively sound ditch with low seepage rate increases efficiency, reduces the amount of water lost to leakage and evapotranspiration, and limits heating of the water. Estimated water savings as a result of this project are 3-8 cfs, assuming the four other ditches had loss rates similar to that of the Upper PKR ditch (2 cfs or 18% of total ditch flow). Given flows in the lower Wise River (T1) in late July and August 2012 were less than 10 cfs, these instream water savings could constitute a considerable source of water for the lower Wise River.

Discussion

The Study

The Lower Wise River Water Resources Investigation collected information about surface water, groundwater, the surface water/groundwater interaction and fisheries in 2011 and 2012. The study area began on Wise River just below the confluence of Pattengail Dam to the mouth where Wise River enters the Big Hole River in its middle section. The study was conducted because:

1. Wise River is the largest tributary to the Big Hole River;
2. Wise River has been documented to contribute cold water to the Big Hole River through its mainstem and groundwater, which helps alleviate high water temperatures in the Big Hole River;
3. Wise River is considered to have impaired water quality due to high sediment/siltation, metals, and physical habitat alterations. The Lower Wise River habitat is altered with reduced complexity due to the Pattengail Dam failure of 1927;
4. Recent and continued development in the Wise River area, which includes the installation of domestic use wells and changes in historic irrigation practices from primarily flood irrigation and stockwater wells, may alter the groundwater recharge and outflow;
5. Little fish data had been collected on the Wise River prior to this study;
6. Irrigators have expressed interest in participating in the Big Hole River Drought Management Plan using Wise River specific triggers to benefit flow and temperatures for fish;
7. Flow and water temperature were not being collected on the Wise River, therefore changes over time and potential flow and temperature triggers were impossible to determine;
8. In May 2012, a large irrigation improvement project occurred on the Wise River near Swamp Creek which consolidated 5 points of diversion. Several additional irrigation upgrades have also occurred since 2002;
9. The BHWC has identified the Wise River as an important location for improvements in water quality, including recommendations made by a 2010 irrigation infrastructure study and the 2013 Middle-Lower Big Hole River Watershed Restoration Plan. Improvement projects are expected. However, it is important to understand the existing Wise River system prior to additional improvements and to track change over time.

Summary of Findings:

Groundwater:

- Overall groundwater hydrographs of the 14 wells sampled show similar patterns, where elevations peak near July with spring runoff and the start of irrigation, and then declined through the rest of the summer, increased again in fall with the onset of fall irrigation, then declined again into the late fall/early winter when they reached base level. Any alterations in this pattern are likely due to local effects such as well pumping or withdrawal in proximity, local groundwater recharge, etc. Annual fluctuation is between 7 and 32 feet;
- Groundwater levels peaked at about the same time in 2011 (before the new PKR headgate construction) and in 2012 (after the new PKR headgate construction);
- Specific conductivity (SC) of tributaries on the east side of Wise River had high SC values and tributaries on the west side of Wise River had low SC values. The east side of Wise River contains limestone uplands and likely contributing a high amount of dissolved materials to account for the high value.

Surface Water

- Surface water flows in the Wise River peaked with snowmelt. Prior to irrigation, Wise River gains water as it moves downstream from the top of the reach to the mouth. During irrigation, the opposite occurs with the top of the reach having higher flows than the bottom of the reach.
- The top of the reach flow data as compared to historic USGS flow data showed that in 2012 Wise River experience extremely low flows (near 90% exceedance, or the value exceeded in 9 of every 10 years) and the lowest flow on the USGS record. The 2012 snowpack and precipitation were far below average in Wise River and the entire Big Hole watershed.
- Water temperatures in the mid reach and lower reaches of the study area peaked in late summer. Water temperatures greater than 70°F occurred and may have caused stress to fish.
- The Upper PKR Ditch project may contribute 3 to 8 cfs to Wise River due to reduced ditch loss. In addition, this water is not subject to the heating that occurs in the exposed ditch.
- Surface water flow results were similar to those collected in the 2003 Wise River study (NRCS, DNRC, 2003) which found Wise River near Swamp Creek had less water than Wise River near its mouth, indicating water is lost near the middle, but gains water again near its mouth, even though diversions only pull water and do not deposit water. Swamp Creek is the only tributary and pulls 100% of its water to irrigation. Therefore the gain in flows is the result of Smart Creek and groundwater inputs.
- A reasonable flow target that could be used in developing drought management targets in the Wise River near Highway 43 may be 20cfs, based on wetted perimeter and flow data.

Groundwater-Surface Water Interaction

- The isotope data indicate that the sources of groundwater and surface water are the same and that they interchange with one another;
- Groundwater and surface water elevations evaluated near the mouth of Wise River indicate that during the irrigation season groundwater is providing a source of cool flow to Wise River, while during the non-irrigation season Wise River is recharging the groundwater;
- Surface water gains groundwater in the lowest portion of Wise River near the entrance of Smart Creek;
- Cold groundwater and Smart Creek helps to buffer the high water temperatures in Wise River; however, when groundwater becomes depleted and water temperatures are extremely high, these cool inputs are less able to buffer water temperatures in the Wise River.

Fish

- The upper Wise River from its headwaters through the meadows downstream of Lacy Creek could represent an area where Arctic grayling could be introduced.
- The density of brook trout in the Upper Wise River is relatively low.
- The fish population in the Wise River in the lower reaches downstream of Adson Creek Bridge is likely limited by the number and quality of slow water habitats and low summer stream flows. Low stream flows in the summer due to irrigation withdrawal likely greatly reduce available habitat in the river.

Future Recommendations

This study accumulated significant baseline data with an initial investigation of the water resources in the Lower Wise River. This study allowed an opportunity to look for sources of valuable information that could help further answer the questions brought forth in developing this study, continue to seek improvements in water and fish resources in the Wise River, and continue to provide benefit to the Big Hole River. These recommendations include:

Further Study:

1. Activation and maintenance of the TruTrack surface water level and temperature recorders. Collection of annual peak flow and daily flows for May through September at the four gage locations. Maintenance of flow rating curves at these gage sites;
2. Additional synoptic measurements should include the Wise River main stem at Adson Creek Road Bridge, the Company Ditch, the Truman Ditch, Upper PKR ditch, Lower PKR ditch, Town Ditch, and the Wise River flow at the Highway 43 Bridge;
3. Analysis of 2013 data and a report comparing the data to data collected in 2012;
4. Investigate the possibility of installing a real-time, telemetered stream flow and temperature gage, such as a USGS gage, at or near the Highway 43 Bridge, for future use in a Wise River Drought Management ;
5. Collect cation and anion and additional isotope sampling for further water chemistry analysis to further tease out the groundwater/surface water interactions.
6. Collect Big Hole River water temperature data above and below the influence of Wise River to determine the buffering ability of Wise River on Big Hole River high water temperatures;
7. Conduct water quality sampling with a Hydrolab to determine potential influence of metals contributed by Wise River tributaries on reduced fish numbers on the Wise River;
8. The distribution and number of wells in the Wise River are too few to fully investigate the groundwater/surface water elevations. Installation of piezometers near the four TruTracks can quantify the groundwater levels directly to the TruTracks without external influences that occur when wells are far from the TruTracks.
9. The 2003 Wise River study recommended long-term monitoring of the riparian corridor for habitat and channel condition, irrigation improvements, and livestock management.
10. Consider the use of fish tracking mechanisms to determine the use of the Wise River by Big Hole River fish for spawning and/or cool water refuge;
11. Evaluate habitat data collected in 2012 and monitor changes in habitat over time;

Improvement Measures:

12. Seek development of Wise River Drought Management flow and temperature triggers to join with the Big Hole River Drought Management Plan.
13. Continue to seek irrigation improvements as outlined in the 2010 Wise River Irrigation Infrastructure Inventory Study;
14. Seek non-irrigation watershed improvement projects in the entire Wise River watershed that can reduce sediment/siltation, improve fish habitat, and contribute cold waters to the Wise River.

Works Cited

Bain, M.B. and N.J. Stevenson. (1999). *Aquatic Habitat Assessment: Common Methods.* Bethesda, Maryland: American Fisheries Society.

BHWC. (2013). *Middle-Lower Big Hole River Watershed Restoration Plan.* Divide, Montana: Big Hole Watershed Committee.

BHWC. (April 2013). *Trend Analysis of Water Temperatures Relative to Air Temperatures in the Big Hole River.* Divide, Montana: Big Hole Watershed Committee.

Big Hole Watershed Committee. (1997 - 2010). *Big Hole River Drought Management Plan.* Big Hole Watershed Committee.

Clark, I.D. and Fritz P. (1997). *Environmental isotopes in hydrogeology.* New York: Lewis Publishers, page 185.

Cook, P.G. and A.L. Herczeg. (2001). *Environmental Tracers in Subsurface Hydrogeology.* Norwell, Massachusetts, Page 529: Kluwer Academic Publishers.

DEQ, M. (2009). *Upper and North Fork Big Hole River Planning Area TMDLs and Framework Water Quality Restoration Approach. M03-TMDL-01A.* Helena, Montana: Montana Department of Environmental Quality.

Flynn, K. D. (2008). *Modeling Streamflow and Water Temperature in the Big Hole River, Montana - 2006. TMDL Technical Report DMS-2008-03.* Helena, Montana: Montana Department of Environmental Quality.

G. Abdo, Butler, J., Myse, T., Wheaton, J., Snyder, D., Metesh, J. and G. Shaw. (2013). *Hydrogeologic Investigation of the Beaverhead River Study Area, Beaverhead County.* Montana Bureau of Mines and Geology, Groundwater Investigations Program, Open File No. 637.

Gammons, C., S. Poulson, D. Pellicori, P. Reed, A. Roesler, and E. Petrescu. (2006). *The hydrogen and oxygen isotopic composition of precipitation, evaporated mine water, and river water in Montana.* page 319-330: Journal of Hydrology, 328.

Hem, J.D. (1985). *Study and interpretation of chemical charecteristics of natural water.* page 263: U.S. Geological Survey Water-Supply Paper 2254.

Lohr, S., Byorth, P., Kay, C., & Dwyer, W. (1996). *High temperature tolerances of Fluvial Arctic Grayling and comparison with summer river temperatures of the Big Hole River, Montana.* Transactions of the American Fisheries Society 125:933-939. Magee and Lamothe (2003-2004).

Marvin, R., & Voeller, T. (2000). *Hydrology of the Big Hole Basin and Assessment of the Effects of Irrigation on the Hydrologic Budget. MBMG Open-file Report 417.* Butte: Montana Bureau of Mines and Geology & MT DNRC.

Marvin, R.K., Voeller, T.L. (2000). *Hydrogeology of the Big Hole Basin and assessment of the effect of irrigation on the hydrologic budget.* Montana Bureau of Mines and Geology: Open File Report No. 417.

MFWP. (June 1989). *Application for Reservations of Water in the Missouri River Basin Above Fort Peck Dam, Volume 2.* Helena, Montana: Montana Fish, Wildlife and Parks.

MFWP. (2010). *Montana Statewide Angling Pressure 2009.* Bozeman, MT: Montana Fish, Wildlife and Parks.

Montana DEQ. (September 2009). *Middle and Lower Big Hole Planning Area TMDLs and Water Quality Improvement Plan. M03-TMDL-02A.* Helena: Montana Department of Environmental Quality.

Montana DEQ. (March 2012). *Montana 2012 Final Water Quality Intergrated Report.* Helena, Montana: Montana Department of Environmetal Quality.

NRCS, DNRC. (2003). *Lower Wise River Stream Corridor Assessment Final Report.* USDA Natural Resources Conservation Service, Montana Department of Natural Resources and Conservation.

Oasis Environmental. (2010). *Lower Wise River Assessment Survey and Prioritization.* Livingston, Montana: Oasis Environmental for Big Hole Watershed Committee.

Ruppel, E.T., J.M. O'Neil, D.A. Lopez. (1993). *Map of Dillon 1x2 quadrangle, Idaho and Montana.* US Geological Survey Numbered Series Map 18030H, Scale 1:250,000.

Appendix

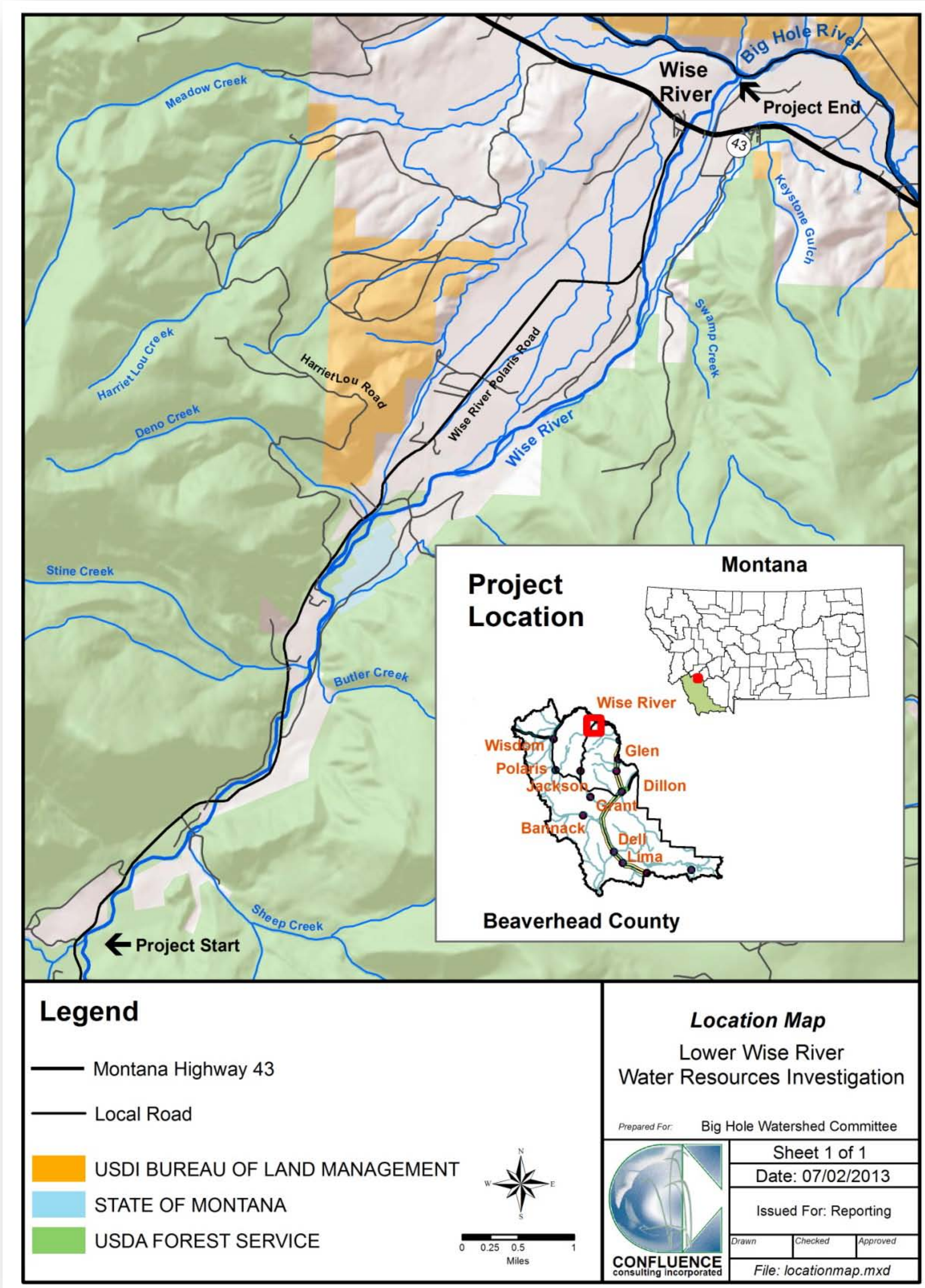

Figure 16: Lower Wise River Water Resources Investigation project location and property ownership map.

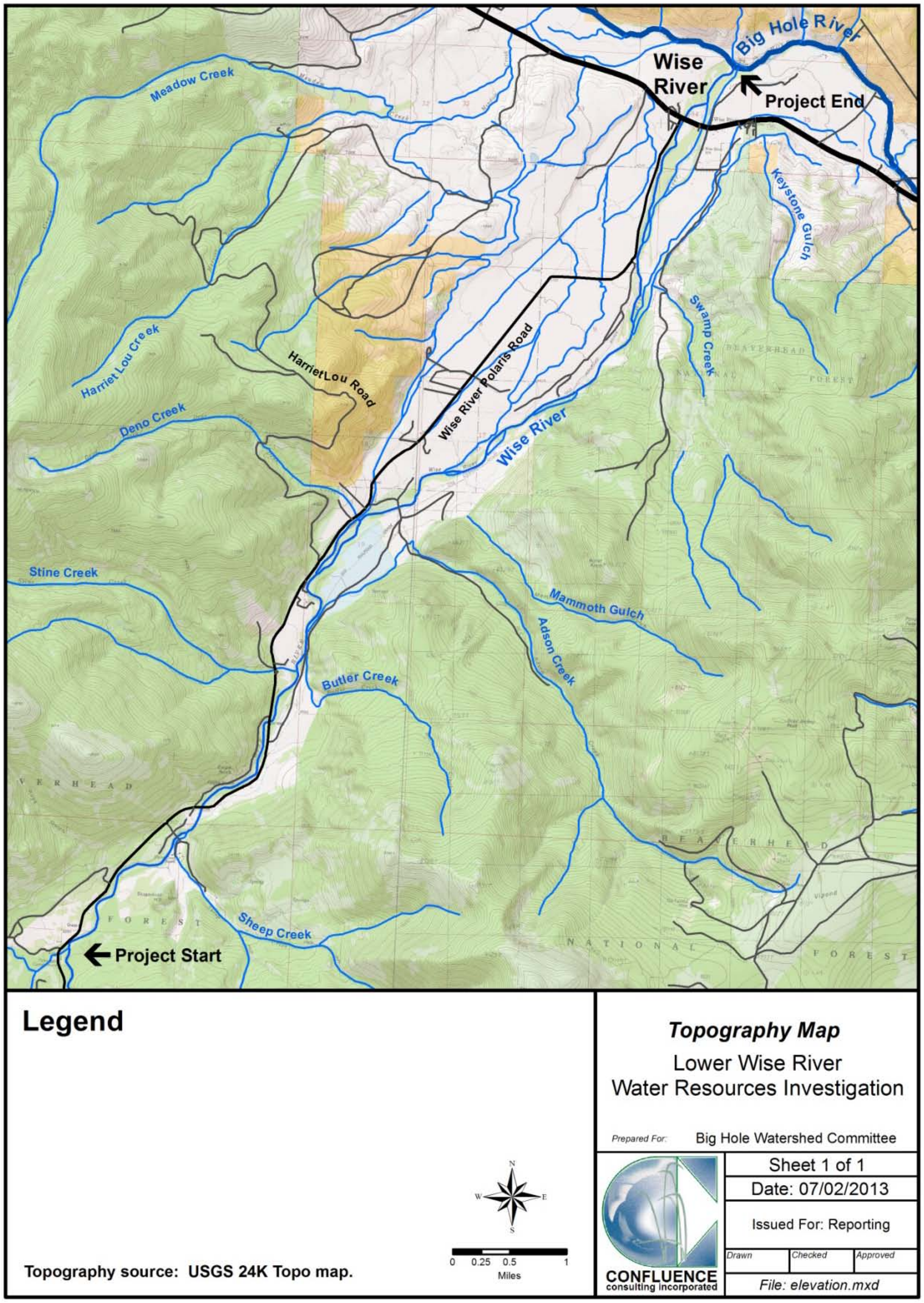

Figure 17: Lower Wise River topography.

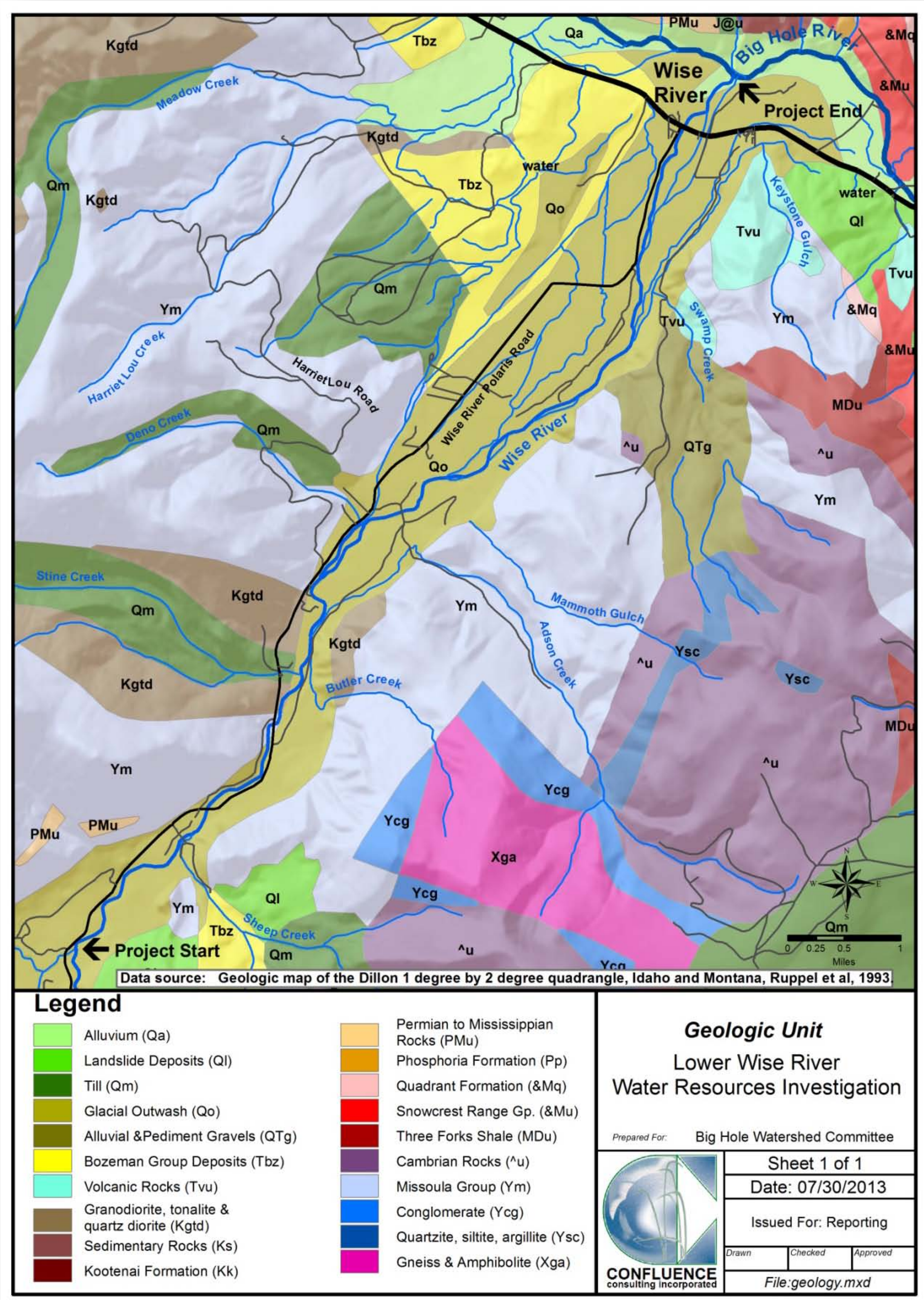

Figure 18: Lower Wise River geology

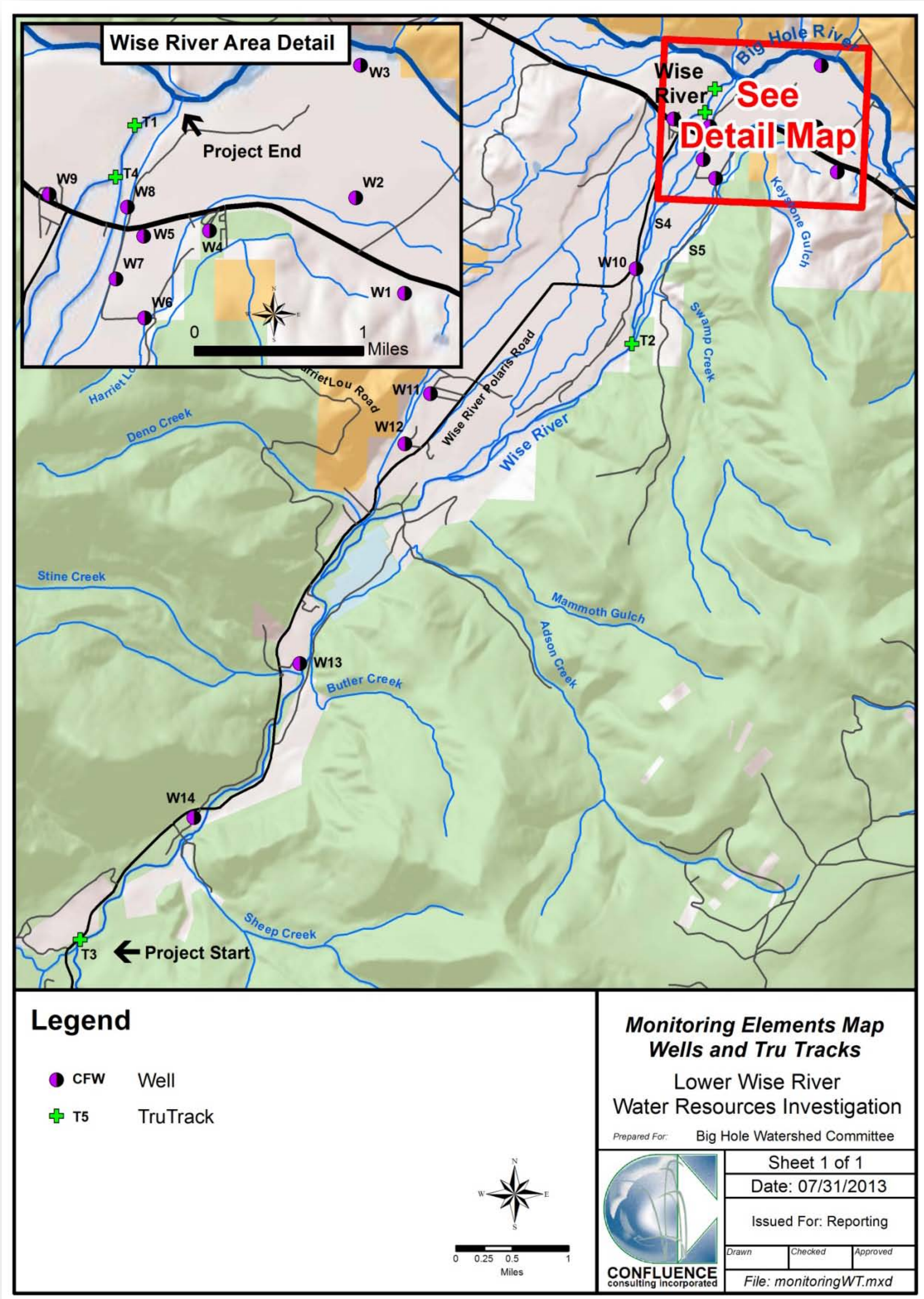

Figure 19: Wise River Wells and TruTrack locations used for monitoring.

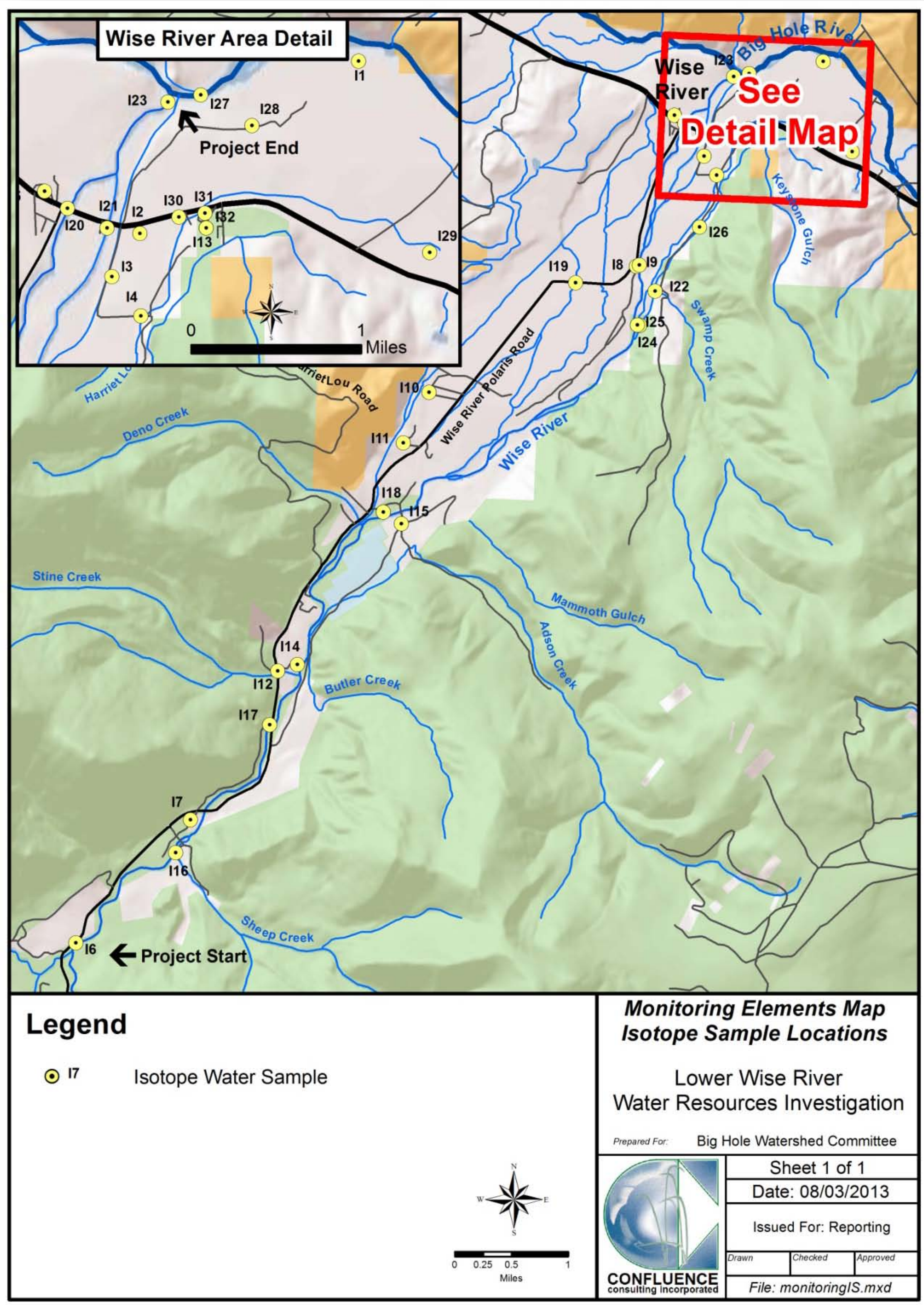

Figure 20: Lower Wise River Water Resources Investigation monitoring locations for isotopes and water chemistry.

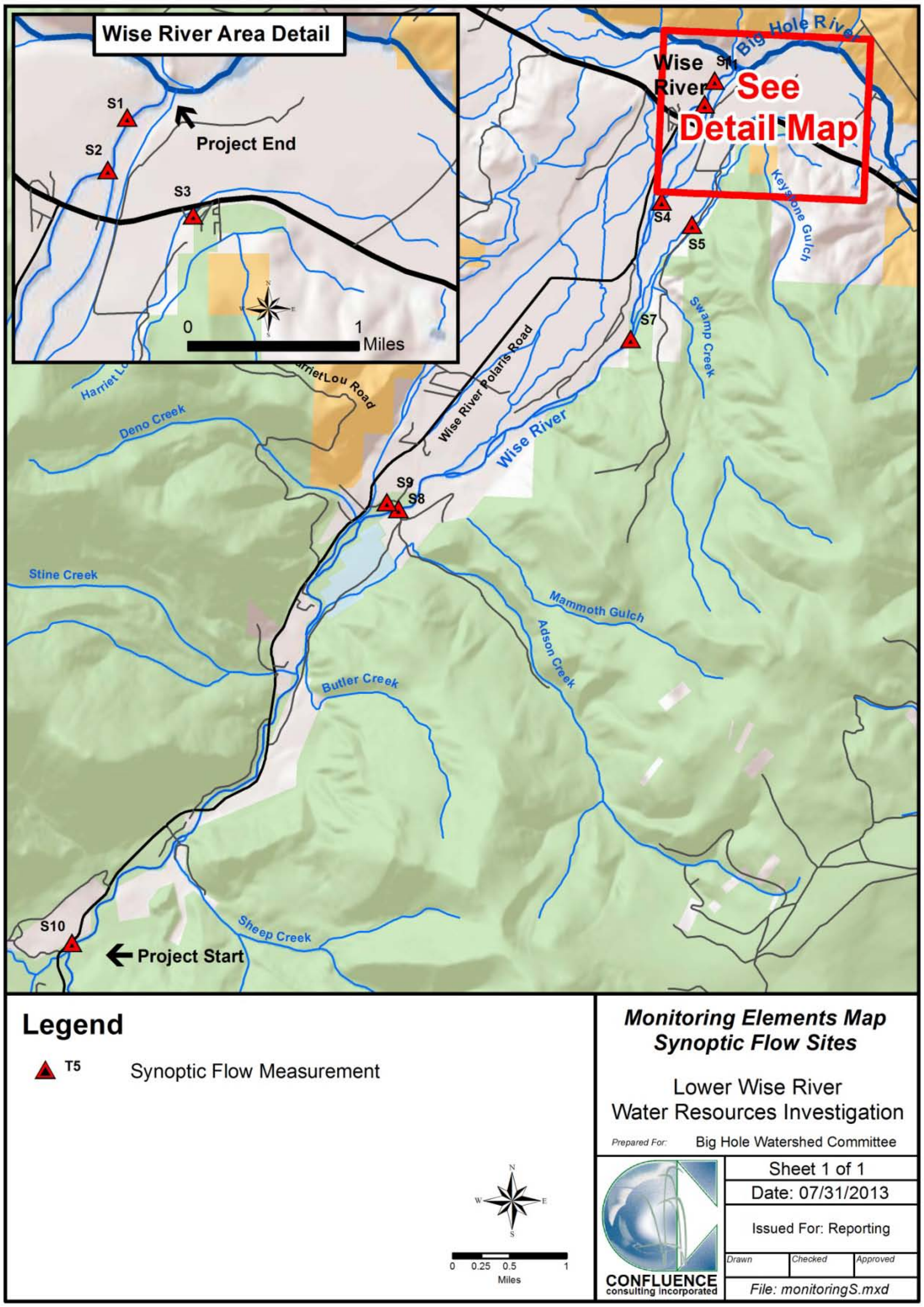

Figure 21: Wise River Synoptic sites used in study.

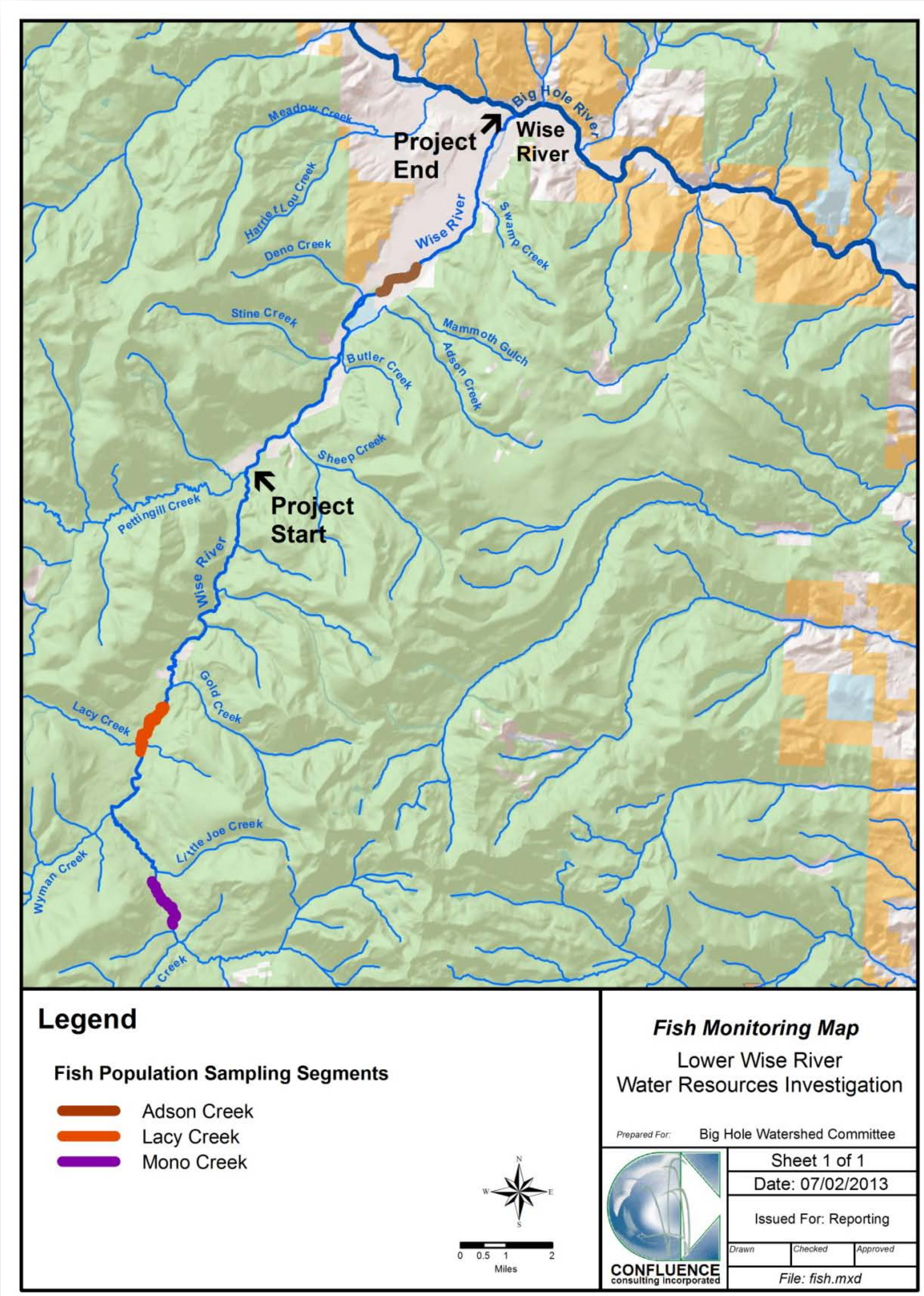

Figure 22: Wise River fish sampling segments. Populations were sampled on the Wise River mainstem near Mono Creek, Lacey Creek and Adson Creek by MFWP in 2012.

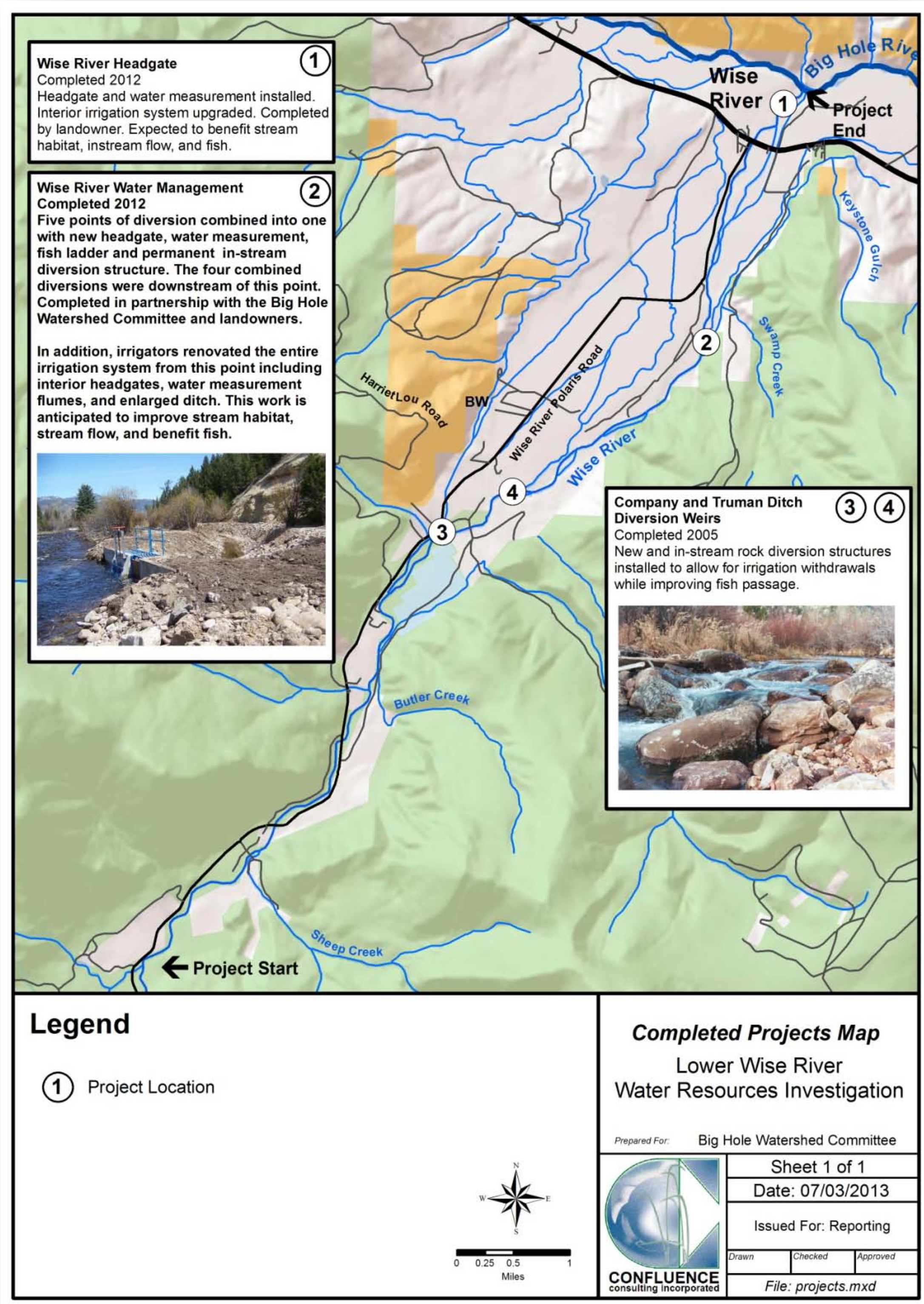

Figure 23: Lower Wise River recently completed projects.

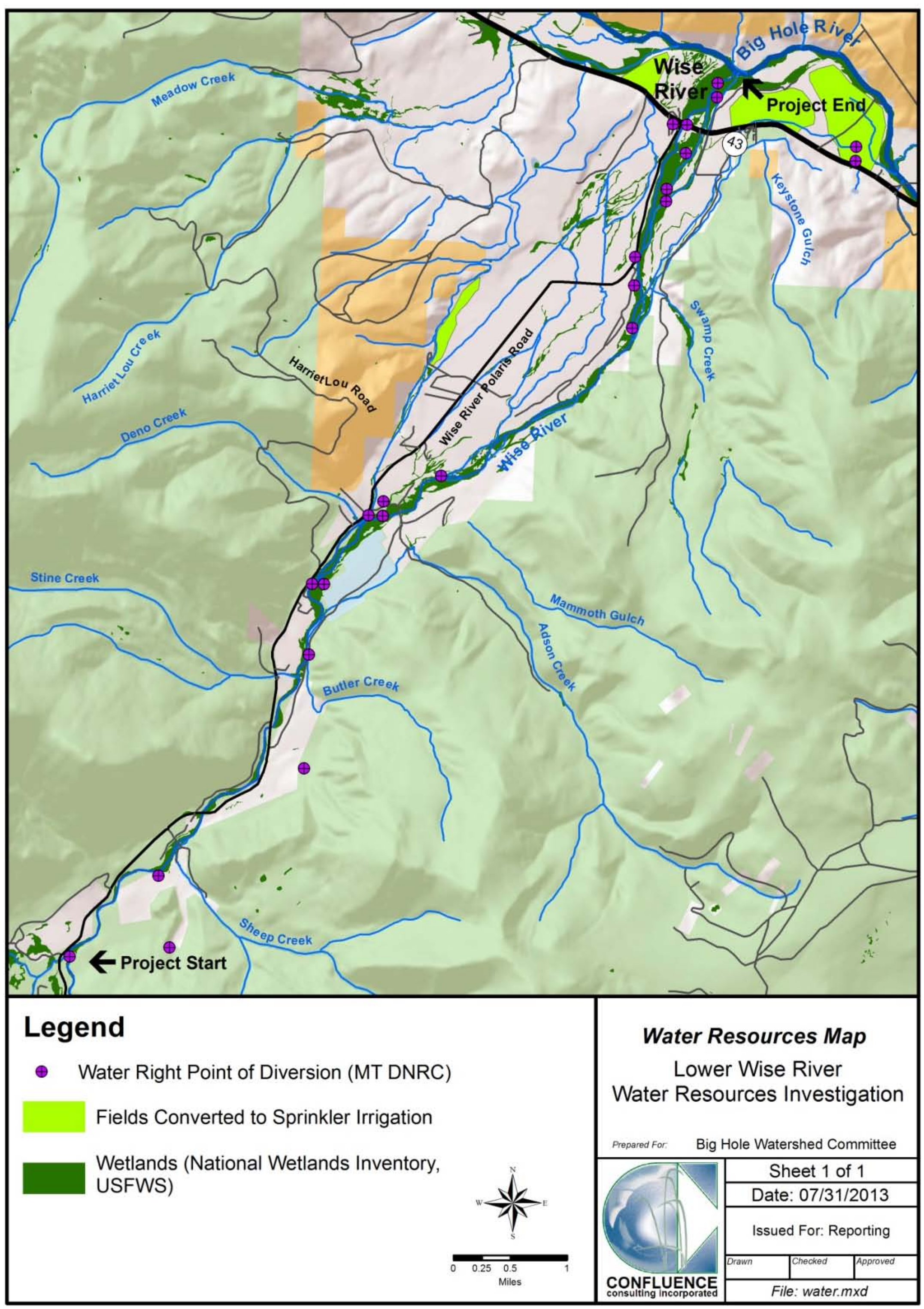

Figure 24: Lower Wise River points of diversion, pastures with sprinkler irrigation, and wetlands.

Table 10: Project monitoring locations including name, location and elevation.

Wise River Monitoring Locations					
Fish Segments					
Site	*Short Name*	*Description*	*Latitude*	*Longitude*	*Elevation (feet)*
Mono Creek	F1	The Mono Creek Section began 0.4 miles downstream of the confluence of Jacobsen and Mono creeks and extended downstream approx. 1.3 miles	45° 32.356'N	113° 5.053'W	6859[1]
Lacey Creek	F2	Lacey Creek fish section is 1.81 miles	45° 35.583'N	113° 6.131'W	6595[1]
Adson Creek	F3	Adson Creek fish section is 1.01 miles	45° 44.477'N	113° 0.223'W	5927[1]
TruTracks					
Site Name	*Short Name*	*Description*	*Latitude*	*Longitude*	*Elevation (feet)*
TruTrack - Wise River 3	T3	Located just below the confluence of Pattengail Creek with Wise River, river left, downstream of a vehicle turnout on the Pioneer Mtn Scenic Byway.	45°41'03.36068"N	113°03'34.17750"W	6248
TruTrack - Wise River 2	T2	Located just upstream of the PKR 2013 headgate replacement project, river right.	45°45'50.85851"N	112°57'46.66692"W	5763
TruTrack - Wise River 1	T1	Located near the mouth of the Wise River, just downstream of the last headgate on the river, river right.	45°47'50.74685"N	112°56'59.13515"W	5631
TruTrack - Smart Creek	T4	Located near the mouth of Smart Creek, which enters the Wise River upstream of the last headgate on the Wise River.	45°47'39.65725"N	112°57'05.00620"W	5638
Synoptic Sites					
Site Name	*Short Name*	*Description*	*Latitude*	*Longitude*	*Elevation (feet)*
W1	S1	Flow measured at TruTrack - Wise River 1 (T1)	45°47'50.74685"N	112°56'59.13515"W	5631
Smart Creek	S2	Flow measured at the TruTrack Smart Creek (T4)	45°47'39.65725"N	112°57'05.00620"W	5638
Highway 43	S3	Flow measured on the PKR ditch just upstream of its crossing under Highway 43	45°47'29.99"N	112°56'39.06"W	5666[1]
Town Ditch	S4	Flow measured in the Town Ditch near the point of diversion.	45°46'54.39"N	112°57'30.43"W	5706[1]
Little Ditch	S5	Flow measured in a small ditch the pulls water from the main PKR ditch.	45°46'44.40"N	112°57'9.72"W	5729[1]
Below Swamp Creek	S6	Flow measured on the PKR ditch just downstream of the enterance of Swamp Creek	45°46'16.22"N	45°46'16.22"N	5764[1]
W2	S7	Flow measured at TruTrack -Wise River 2 (T2)	45°45'50.85851"N	112°57'46.66692"W	5763
Adson Creek Bridge	S8	Flow measured on Wise River at the Adson Creek Road bridge	45°44'28.52"N	113° 0'13.59"W	59271[1]
Carpenter Ditch	S9	Flow measured in the Carpenter Ditch crossing the Adson Creek Road	45°44'31.38"N	113° 0'21.34"W	5933[1]
TruTrack -Wise 3	S10	Flow measured at TruTrack - Wise River 3 (T3)	45°41'03.36068"N	113°03'34.17750"W	6248

Wise River Monitoring Locations (cont'd)

Wells

Name	*Short Name*	*Description*	*Latitude*	*Longitude*	*Elevation (feet)*
PKR Stockwater South	W1	Well is used for a stockwater tank located south of Highway 43.	45°47'14.64926"N	112°55'35.80112"W	5632.53
PKR Stockwater North	W2	Well is used for a stockwater tank located east of the School House Road and at the roads most west end.	45°47'35.14975"N	112°55'50.95725"W	5632.53
PKR Cabin	W3	Well is located in front of the first small cabin, located east of the main residence and near the Big Hole River.	45°48'03.70119"N	112°55'49.40440"W	5600.68
USFS Wise River Ranger District	W4	Well is located south of rangers quarters in an open field	45°47'28.10173"N	112°56'36.04671"W	5700.65
WRCF	W5	Well located east of community building	45°47'26.90475"N	112°56'56.33975"W	5669.27
Lovell	W6	Well is located south of the residence	45°47'09.31873"N	112°56'56.07012"W	5632.72
Wise River School (small)	W7	Well is located in school yard, south of main school building. There are two wells side by side. This well is the smaller of the two.	45°47'17.74199"N	112°57'04.91193"W	5681.84
note: Wise River School Well (W7) also housed the data logger.					
O'Leary	W8	Well is located near north end of the property and near the school house road.	45°47'33.16539"N	112°57'01.43241"W	5658.56
Wise River Fire Department	W9	Well located at north-west corner of fire hall	45°47'35.91319"N	112°57'25.53098"W	5673.93
Stodden	W10	Well is located on the north side of residence.	45°46'25.78408"N	112°57'46.16098"W	5753.73
Brimhall	W11	Well is located near residence. There are two wells on the property. This well is the newer of the two and has a silver cap.	45°45'23.67565"N	112°59'58.54850"W	5897.26
Miller	W12	Well located east of house	45°44'59.90459"N	113°00'14.10013"W	5928.36
Ronchetto	W13	Well located west of house	45°43'15.88709"N	113°01'17.14106"W	6058.67
Fellin/Big Hole Outfitters	W14	Large culvert well located west of the cabins in an above ground wood box.	45°42'02.33401"N	113°02'22.62247"W	6169.47

Wise River Monitoring Locations (cont'd)

Isotope Samples - August 2011

Site	*Short Name*	*Description*	*Latitude*	*Longitude*	*Elevation (feet)*
PKR Cabin	I1	PKR Cabin well (W3)	45°48'03.70119"N	112°55'49.40440"W	5600.68
WRCF	I2	Wise River Community Building well (W5)	45°47'26.90475"N	112°56'56.33975"W	5669.27
Wise River School	I3	Wise River School small well (W7)	45°47'17.74199"N	112°57'04.91193"W	5681.84
Lovell	I4	Lovell well (W6)	45°47'09.31873"N	112°56'56.07012"W	5632.72
Wise River Fire Dept.	I5	Wise River Fire Department well (W9)	45°47'35.91319"N	112°57'25.53098"W	5673.93
Wise River below Pettengill Confluence	I6	Wise River downstream of Pattengail Creek confluence (see TruTrack Wise River 3 (T3))	45°41'03.36068"N	113°03'34.17750"W	6248
Fellin	I7	Craig Fellin well (W14)	45°42'02.33401"N	113°02'22.62247"W	6169.47
Stodden	I8	Stodden well (W10)	45°46'25.78408"N	112°57'46.16098"W	5753.73
Wise River @ Stodden	I9	Wise River @ Stoddens	45°46'26.36"N	112°57'44.21"W	5731[1]
Brimhall	I10	Brimhall well (W11)	45°45'23.67565"N	112°59'58.54850"W	5897.26
Miller	I11	Charlie Miller well (W12)	45°44'59.90459"N	113°00'14.10013"W	5928.36
Ronchetto	I12	Ronchetto well (W13)	45°43'15.88709"N	113°01'17.14106"W	6058.67
USFS	I13	USFS Well - Water collected from faucet at ranger house (W4)	45°47'28.10173"N	112°56'36.04671"W	5700.65
Stine Creek	I14	Stine Creek water - tributary to Wise River	45°43'12.46"N	113° 1'29.87"W	6110[1]
Adson Creek	I15	Adson Creek water - tributary to Wise River	45°44'22.74"N	113° 0'12.88"W	5938[1]
Sheep Creek	I16	Sheep Creek water - tributary to Wise River	45°41'46.99"N	113° 2'31.34"W	6197[1]
Wise River above Stine	I17	Wise River Bridge Upstream of Stine Creek	45°42'47.60"N	113° 1'33.41"W	6093[1]
Top of Carpenter Ditch	I18	Carpenter Ditch (upstream of Adson Creek)	45°44'27.72"N	113° 0'25.20"W	5937[1]
Truman Ditch	I19	Truman Ditch crossing Pioneer Mountain Scenic Byway - 1st crossing north of airport	45°46'16.93"N	112°58'25.60"W	5783[1]
Smart Creek @ Highway 43 Bridge	I20	Spring Creek @ Highway 43 bridge (west of Wise River Club)	45°47'32.27"N	112°57'18.53"W	5660[1]
Wise River @ Highway 43 Bridge	I21	Wise River @ Highway 43 bridge (west of Post Office)	45°47'28.13"N	112°57'6.40"W	5659[1]
Swamp Creek	I22	Swamp Creek Water - tributary to Wise River	45°46'14.74"N	112°57'33.21"W	5768[1]
Wise River Mouth	I23	Wise River mouth	45°47'54.96"N	112°56'47.81"W	5615[1]
PKR Headgate	I24	PKR Upper Headgate/2012 construction site	45°45'58.79"N	112°57'42.40"W	5767[1]
Wise River below PKR Headgate	I25	Wise River below PKR Upper Headgate	45°45'58.82"N	112°57'43.76"W	5767[1]
Spring Seep	I26	Spring Seep on Swamp Creek Road	45°46'45.10"N	112°57'5.93"W	5730[1]
Big Hole River Downstream of Wise	I27	Big Hole River downstream of Wise River confluence	45°47'56.49"N	112°56'37.77"W	5612[1]
PKR Slough	I28	PKR Slough west of Kamperschroer house	45°47'49.96"N	112°56'22.03"W	5624[1]
PKR Pond	I29	Pond north of PKR South Well	45°47'22.87"N	112°55'27.68"W	5600[1]
PKR Ditch crossing	I30	PKR Ditch crossing Highway 43 - west ditch	45°47'30.43"N	112°56'44.44"W	5669[1]
PKR Ditch crossing	I31	PKR Ditch crossing Hwy 43 - east ditch	45°47'31.24"N	112°56'36.46"W	5681[1]
Rainwater	I32	Rainwater collected at USFS well (W4)	45°47'28.10173"N	112°56'36.04671"W	5700.65

Table 11: Survey data collected for wells and TruTracks used in the study.

Wise River Water Resources Investigation

Survey Locations

RPA Survey Point	*WGS 84 Latitude*	*WGS 84 Longitude*	*Northing (MSPC IFT)*	*Easting (MSPC IFT)*	*Elevation (NAVD88)*	*Site Type*	*Site Name*	*Survey Description*
1	45°46'15.20442"N	112°58'42.22562"W	574237.691	1081471.186	5799.01			Set RPA RPC at Wise River Airport, +/- 84' NW of entrance gate in field, +/- 200' SE of runway cl
2	45°43'13.94068"N	113°01'23.59931"W	556413.212	1069222.362	6077.86			Set RPA RPC at Ronchetto Residence, East of Highway 38' NE of first "Y" in driveway, S25 T1S R12W, +/-190' N of Stine Ck
1000	45°47'39.65967"N	112°57'05.00921"W	582476.255	1088729.893	5641.73	Surface Water - Flow & Temp	TruTrack - Smart Creek (T4)	TruTrak Spring Elevation to 6.65 mark on gage, Elevation of 0.00 = 5635.08'
1001	45°47'39.65725"N	112°57'05.00620"W	582476.000	1088730.095	5638.22			Ground shot at TruTrack Smart Creek - T4
1002	45°47'50.74685"N	112°56'59.13515"W	583579.471	1089194.975	5631.53	Surface Water - Flow & Temp	TruTrack - Wise River 1 (T1)	Elevation to 3.33 mark on gage, Elevation of 0.00 = 5628.20' - T1
1004	45°48'03.70119"N	112°55'49.40440"W	584673.059	1094186.367	5599.30	Well	PKR Cabin well (W3)	Ground at PKR Cabin Well
1005	45°48'03.70019"N	112°55'49.40099"W	584672.947	1094186.604	5600.68			MP PKR Cabin Well
1006	45°47'35.15360"N	112°55'50.95728"W	581790.074	1093949.924	5633.40	Well	PKR Stockwater well North (W2)	MP PKR Stockwater Well
1094	45°47'35.14975"N	112°55'50.95725"W	581789.684	1093949.909	5632.53			Ground at PKR Stockwater Well
1007	45°47'14.64850"N	112°55'35.79385"W	579668.822	1094932.137	5635.34	Well	PKR Stockwater well South (W1)	MP PKR Stockwater South Well
1008	45°47'14.64926"N	112°55'35.80112"W	579668.921	1094931.626	5632.72			Ground at PKR Stockwater South Well
1009	45°47'28.10827"N	112°56'36.04710"W	581217.494	1090727.879	5703.29	Well	USFS well (W4)	MP USFS Well
1010	45°47'28.10173"N	112°56'36.04671"W	581216.831	1090727.878	5700.65			Ground at USFS Well
1011	45°47'26.90540"N	112°56'56.34228"W	581159.046	1089286.325	5670.67	Well	WRCF well (W5)	MP WRCF Well
1013	45°47'26.90475"N	112°56'56.33975"W	581158.972	1089286.501	5669.27			Ground at WRCF Well
1014	45°47'17.74341"N	112°57'04.91241"W	580258.983	1088638.990	5684.70	Well and Data Logger	Wise River School well	MP Wise River School Well
1015	45°47'17.74199"N	112°57'04.91193"W	580258.838	1088639.018	5681.84			Ground at Wise River School Well
1017	45°47'33.16145"N	112°57'01.43721"W	581807.775	1088953.675	5660.06	Well	O'Leary well (W8)	MP Oleary Well
1018	45°47'33.16539"N	112°57'01.43241"W	581808.159	1088954.032	5658.56			Ground at Oleary Well
1020	45°47'35.91585"N	112°57'25.54156"W	582161.660	1087260.282	5676.22	Well	Wise River Fire Department well	MP Wise River Fire Department Well
1021	45°47'35.91319"N	112°57'25.53098"W	582161.358	1087261.019	5673.93			Ground at Fire Hall Well
1022	45°47'09.31215"N	112°56'56.06664"W	579378.514	1089227.416	5694.09	Well	Lovell well (W6)	MP Lovell Well
1023	45°47'09.31873"N	112°56'56.07012"W	579379.190	1089227.199	5692.51			Ground at Lovell Well
1025	45°45'50.85948"N	112°57'46.66808"W	571600.665	1085295.177	5766.62	Surface Water - Flow & Temp	TruTrack - Wise River 2 (T2)	T3 Elevation to 6.65 mark on gage, Elevation of 0.00 = 5759.95'
1026	45°45'50.85851"N	112°57'46.66692"W	571600.563	1085295.255	5763.70			Ground at Staff Gage - T2
1028	45°44'59.90140"N	113°00'14.09147"W	566910.543	1074627.058	5930.81	Well	Miller well (W12)	MP Miller Well
1029	45°44'59.90459"N	113°00'14.10013"W	566910.893	1074626.459	5928.36			Ground at Miller Well
1030	45°45'23.67311"N	112°59'58.53949"W	569265.885	1075835.899	5898.77	Well	Brimhall well (W11)	MP Brimhall Well
1031	45°45'23.67565"N	112°59'58.54850"W	569266.170	1075835.272	5897.26			Ground at Brimhall Well
1032	45°43'15.88917"N	113°01'17.13805"W	556589.707	1069689.031	6057.17	Well	Ronchetto well (W13)	Ground at Ronchetto Well
1033	45°43'15.88709"N	113°01'17.14106"W	556589.507	1069688.808	6058.67			MP Ronchetto Well
1034	45°46'25.78238"N	112°57'46.16302"W	575131.749	1085487.217	5755.36	Well	Stodden well (W10)	MP Stodden Well
1035	45°46'25.78408"N	112°57'46.16098"W	575131.915	1085487.369	5753.73			Ground at Stodden Well
1037	45°42'02.34336"N	113°02'22.62488"W	549359.617	1064712.717	6171.66	Well	Fellin well (W14)	MP Fellin Well
1038	45°42'02.33401"N	113°02'22.62247"W	549358.663	1064712.845	6169.47			Ground at Fellin Well
1039	45°41'03.36270"N	113°03'34.18225"W	543623.597	1059369.569	6251.40	Surface Water - Flow & Temp	TruTrack - Wise River 3 (T3)	T1 Elevation to 3.33 mark on gage, Elevation of 0.00 = 6248.07'
1041	45°41'03.36068"N	113°03'34.17750"W	543623.377	1059369.897	6248.21			Ground at Staff Gage - T3

Survey performed by Robert Peccia and Associates in August 2012 — Trimble R8 GNSS GPS system

Coordinates are NAD83(2011)(Epoch:2010.000) Montana State Plane Zone 2500 International Foot Values

Survey Origin is National Geodetic Survey (NGS) Online Positional User Service (OPUS) calculated coordinates for CP 1 and CP 2

Elevations are NAVD88 based upon OPUS solution, no benchmarks were found to verfiy.

Combined Scale Factor (CSF): 0.99934981 at CP1 — Ø=-2°32'40" at CP1

CP - Control Point - 5/8"x24" rebar with Red Plastic Cap marked "RPA CONTROL" — TBM- Temporary Benchmark

RPA Proj#: 12911.000 - Wise River Well Survey for Big Hole Watershed Committee — MP- Measure Point

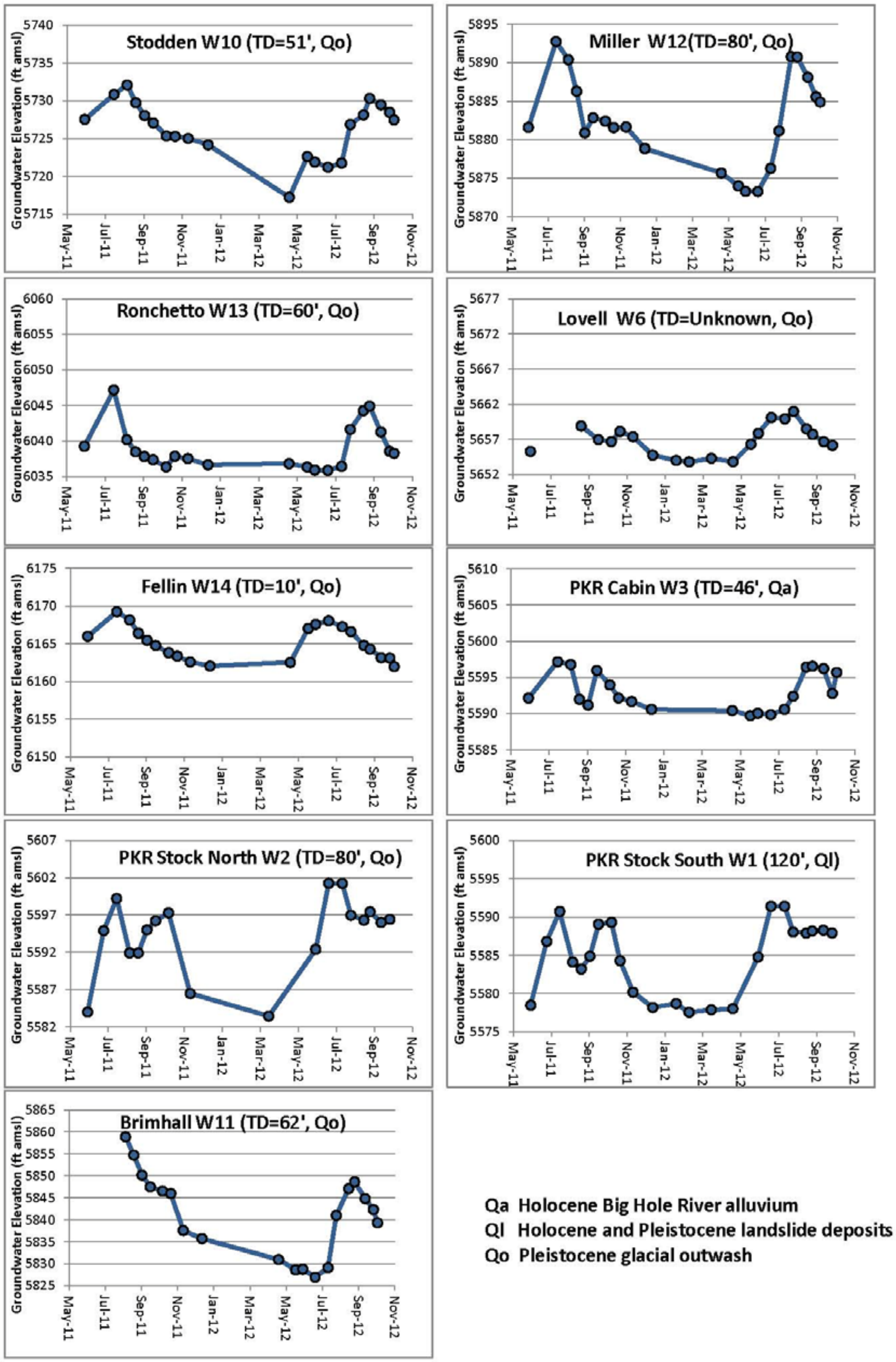

Figure 25: Wise River Hydrogrpahs

Table 12: Isotope Results for water samples.

Isotope Analysis Results						
Site Name	Short Name	Isotech Lab No.	Sample Time	dD H_2O ‰	$d^{18}O$ H_2O ‰	Site Type
PKR Cabin	I1	336989	10:20	-138.2	-17.62	Well
WRCF	I2	336990	10:50	-122.7	-12.85	Well
Wise River School	I3	336991	11:34	-138.9	-17.48	Well
Lovell	I4	336992	12:05	-115.4	-11.09	Well
Wise River Fire Dept.	I5	336993	13:20	-138.3	-17.28	Well
Wise River below Pettengill Confluence	I6	336994	13:53	-127.8	-14.25	Surface Water TruTrack
Fellin	I7	336995	14:25	-138.7	-17.29	Well
Stodden	I8	336996	15:52	-118.2	-11.58	Well
Wise River @ Stodden	I9	336997	16:02	-118.2	-11.12	Surface Water Wise River
Brimhall	I10	336998	16:39	-130.4	-15.08	Well
Miller	I11	336999	17:19	-129.5	-14.72	Well
Ronchetto	I12	337000	17:57	-114.3	-10.40	Well
USFS	I13	337001	18:55	-141.2	-17.92	Well
Stine Creek	I14	337002	19:08	-133.4	-16.02	Surface Water Tributary
Adson Creek	I15	337003	20:28	-129.9	-14.30	Surface Water Tributary
Sheep Creek	I16	337004	14:57	-123.1	-12.47	Surface Water Tributary
Wise River above Stine Creek	I17	337005	14:29	-131.9	-15.48	Surface Water Wise River
Top of Carpenter Ditch	I18	337006	15:42	-132.7	-15.70	Surface Water Irrigation
Truman Ditch	I19	337007	16:08	-130.1	-14.88	Surface Water Irrigation
Smart Creek @ Highway 43 Bridge	I20	337008	16:42	-131.1	-15.31	Surface Water Smart Creek
Wise River @ Highway 43 Bridge	I21	337009	16:30	-115.1	-9.90	Surface Water Wise River
Swamp Creek	I22	337010	17:00	-120.4	-12.07	Surface Water Tributary
Wise River Mouth	I23	337011	16:34	-118.2	-11.25	Surface Water Wise River
PKR Headgate	I24	337012	17:24	-122.7	-13.11	Surface Water Irrigation
Wise River below PKR Headgate	I25	337013	17:31	-124.0	-12.85	Surface Water Wise River
Spring Seap	I26	337014	18:04	-124.7	-13.16	Surface Water Spring
Big Hole River Downstream of Wise River	I27	337015	18:54	-137.6	-16.73	Surface Water Big Hole
PKR Slough	I28	337016	19:13	-131.7	-15.08	Surface Water Irrigation
PKR Pond	I29	337017	19:33	-116.3	-11.89	Surface Water Irrigation
PKR Ditch crossing Highway 43	I30	337018	19:33	-127.3	-14.11	Surface Water Irrigation
PKR Ditch crossing Highway 43	I31	337019	20:01	-125.7	-14.02	Surface Water Irrigation
Rainwater	I32	337020	13:00	-69.0	-8.90	Rain
Isotope water data, analyzed by Isotech						
Job #20745 - "Lower Wise River Sampling"						
Samples collected 8/20/2011						
Samples analyzed 2/25/2013						

Table 13: Wise River well information and groundwater elevation manual measurements 2011 - 2012

Well Attributes							Groundwater Elevations: Elevation-(Depth to Water-Height Above Land)																										Summery Data			
Name	**Use**	**GWIC ID**	**Short Name**	**Total Well Depth (feet)**	**Stick-up from Survey Data (feet)**	**Elevation (feet) from Survey Data**	**5/29/11**	**6/24/11**	**7/15/11**	**8/5/11**	**8/19/11**	**9/2/11**	**9/16/11**	**10/7/11**	**10/21/11**	**11/11/11**	**12/13/11**	**1/20/12**	**2/10/12**	**3/17/2012**	**4/21/12**	5/20/2012	6/1/2012	6/22/2012	7/14/2012	7/28/2012	8/18/2012	8/28/2012	9/15/2012	9/29/2012	10/6/2012	Min. Elevation	Max. Elevation	**Difference**	Average
PKR Stockwater South	Stockwater	259363	W1	120	**2.62**	**5632.72**	5578.50	5586.84	5590.74	5584.14	5583.23	5584.90	5589.08	5589.32	5584.32	5580.22	5578.21	5578.72	5577.58	5577.91	5578.05		5584.81	5591.42	5591.42	5588.06	5587.92	5588.19	5588.29	5587.94		5577.58	5591.42	**13.84**	5584.77
PKR Stockwater North	Stockwater	185698	W2	80	**0.88**	**5632.53**	5584.00	5594.91	5599.21	5591.91	5591.91	5595.00	5596.23	5597.29		5586.49				5583.45			5592.40	5601.25	5601.23	5596.95	5596.31	5597.41	5595.99	5596.42		5583.45	5601.25	**17.80**	5594.35
PKR Cabin	Seasonal Residence	163952	W3	46	**1.38**	**5599.30**	5592.15	5597.18	5596.78	5591.98	5591.18	5595.96	5593.96	5592.16	5591.67	5590.59	5590.42	5589.72	5590.05	5589.86	5590.59	5592.39	5596.43	5596.55	5596.21	5592.80	5595.70	5596.05	5596.18	5596.00		5589.72	5597.18	**7.46**	5593.44
USFS Wise River Ranger District	USFS Residences and Office	164859	W4	109	**2.64**	**5700.65**	5637.78	5649.99	5652.19	5643.69	5643.59	5644.90	5643.07	5641.11	5639.31	5636.85	5636.25	5635.46	5635.11	5634.91	5635.33	5636.27	5642.79	5649.57	5649.35	5645.84	5642.80	5642.94	5640.98	5640.96	5638.13	5634.91	5652.19	**17.28**	5641.57
WRCF	Community Building	178008	W5	50	**1.40**	**5669.27**	5643.53	5653.62	5655.27	5647.47	5645.97	5648.21	5646.24	5644.19	5642.99	5640.85	5640.15	5639.45	5639.19	5638.91	5639.37	5640.58	5646.43	5653.16	5651.73	5649.58	5646.77	5647.02	5644.55	5643.95	5639.96	5638.91	5655.27	**16.36**	5645.16
Lovell	Seasonal Residence	NA	W6	?	**1.58**	**5692.51**		5670.09	5671.79	5663.44	5661.79	5664.47	5663.55	5659.39	5655.76	5653.46	5652.01	5650.75	5650.30	5649.84	5650.49	5652.84	5661.27	5669.80	5668.15	5666.63	5662.76	5662.42	5659.03	5657.23	5652.15	5649.84	5671.79	**21.95**	5659.56
Wise River School (small)	School	161777	W7	42	**2.86**	**5681.84**	5658.59	5664.40	5665.35	5659.50	5658.20	5659.42	5658.20	5656.19	5655.44	5652.61	5652.12	5651.35	5651.15	5650.85	5651.56	5655.61	5658.86	5663.82	5662.65	5660.96	5657.88	5657.87	5656.31	5655.88		5650.85	5665.35	**14.50**	5657.28
O'Leary	Vacant	122672	W8	40	**1.49**	**5658.56**		5647.75	5648.55	5643.00	5642.45	5643.09	5641.29	5639.90	5639.26	5638.33	5638.09	5637.87	5637.69	5637.47	5638.12	5638.89	5642.53	5647.16	5645.69	5644.43	5642.14	5642.70	5640.46	5639.89	5638.37	5637.47	5648.55	**11.08**	5641.47
Wise River Fire Department	Fire Hall	161778	W9	30	**2.29**	**5673.93**	5655.30				5658.92		5656.97	5656.70	5658.15	5657.40	5654.77	5654.02	5653.81	5654.32	5653.83	5656.33	5657.88	5660.12	5659.93	5660.98	5658.51	5657.72	5656.69	5656.15		5653.81	5660.98	**7.17**	5656.93
Stodden	Residence	140949	W10	51	**1.63**	**5753.73**	5727.56	5730.86	5732.11	5729.76	5728.07	5727.09	5725.37	5725.31	5725.03	5724.18	5717.24	5722.64	5721.91	5721.22	5721.78	5726.89	5728.14	5730.34	5729.48	5728.48	5727.49	5727.55	5726.30	5726.64		5717.24	5732.11	**14.87**	5726.31
Brimhall	Seasonal Residence	NA	W11	62	**1.52**	**5897.26**			5858.88	5854.73	5850.18	5847.50	5846.56	5845.96	5837.59	5835.74	5830.95	5828.63	5828.77	5826.96	5829.12	5841.02	5847.09	5848.65	5844.86	5842.32	5839.32	5837.86	5837.76	5836.60		5826.96	5858.88	**31.92**	5840.77
Miller	Residence	147958	W12	80	**2.45**	**5928.36**	5881.61	5892.76	5890.41	5886.31	5880.90	5882.85	5882.42	5881.59	5881.67	5878.86	5875.69	5874.00	5873.29	5873.27	5876.29	5881.15	5890.80	5890.76	5888.12	5885.60	5884.89	5883.63	5882.24	5881.79		5873.27	5892.76	**19.49**	5882.54
Ronchetto	Residence	159484	W13	60	**1.50**	**6057.17**	6039.25	6047.17	6040.17	6038.47	6037.82	6037.36	6036.35	6037.85	6037.52	6036.65	6036.81	6036.33	6035.91	6035.87	6036.43	6041.63	6044.25	6044.91	6041.26	6038.56	6038.26	6038.09	6037.66	6037.79	6036.95	6035.87	6047.17	**11.30**	6038.77
Fellin/Big Hole Outfitters	Commercial Fishing Lodge	NA	W14	10.5	**2.19**	**6169.47**	6165.99		6169.26	6168.16	6166.41	6165.47	6164.77	6163.83	6163.37	6162.61	6162.05				6162.54	6167.04	6167.59	6168.06	6167.27	6166.61	6164.78	6164.29	6163.16	6163.11	6161.97	6161.97	6169.26	**7.29**	6165.16