USGS
science for a changing world

Prepared in cooperation with the Idaho Department of Water Resources

Seasonal Seepage Investigation on an Urbanized Reach of the Lower Boise River, Southwestern Idaho, Water Year 2010

Scientific Investigations Report 2011–5181

U.S. Department of the Interior
U.S. Geological Survey

Cover: Photograph of the Boise River Diversion Dam, Idaho, looking upstream from inactive streamgage, Boise River below Diversion Dam (U.S. Geological Survey station No. 13203510). Photograph taken from suspended cableway by Alvin A. Sablan, U.S. Geological Survey, May 25, 2010.

Seasonal Seepage Investigation on an Urbanized Reach of the Lower Boise River, Southwestern Idaho, Water Year 2010

By Marshall L. Williams

Prepared in cooperation with the Idaho Department of Water Resources

Scientific Investigations Report 2011–5181

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
KEN SALAZAR, Secretary

U.S. Geological Survey
Marcia K. McNutt, Director

U.S. Geological Survey, Reston, Virginia: 2011

Suggested citation:
Williams, M.L., 2011, Seasonal seepage investigation on an urbanized reach of the lower Boise River, southwestern Idaho, water year 2010: U.S. Geological Survey Scientific Investigations Report 2011-5181, 24 p.

Contents

Figures

Tables

Conversion Factors and Datum

Conversion Factors

Multiply	By	To obtain
	Length	
inch (in)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
cubic foot per second per square mile [(ft^3/s)/mi]	0.0176	cubic meter per second per kilometer [(m^3/s)/km]

Datum

Horizontal coordinate information is referenced to World Geodetic System of 1984 (WGS 84).

Seasonal Seepage Investigation on an Urbanized Reach of the Lower Boise River, Southwestern Idaho, Water Year 2010

By Marshall L. Williams

Abstract

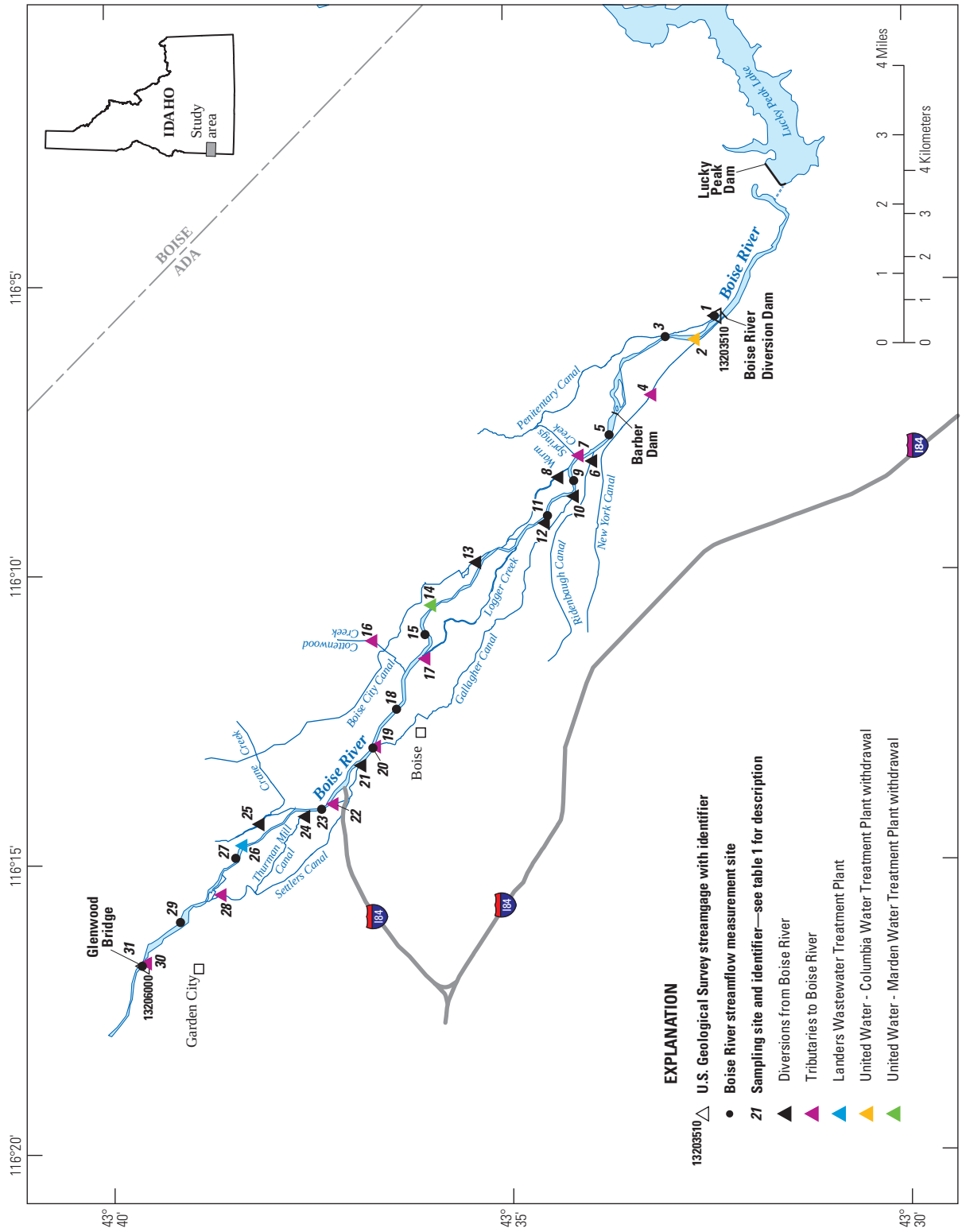
The U.S. Geological Survey in cooperation with the Idaho Department of Water Resources Treasure Valley Comprehensive Aquifer Management Planning effort investigated seasonal groundwater gains and losses on the Boise River, Idaho, starting in November 2009 through August 2010. The investigation was conducted using seepage runs in 11 subreaches over a 14-mile reach from downstream of the inactive streamgage, Boise River below Diversion Dam (U.S. Geological Survey station No. 13203510) to the active Boise River at Glenwood Bridge streamgage (U.S. Geological Survey station No. 13206000). The seepage runs measured mainstem discharge, and significant tributary contributions and diversions along the reach. In addition, an evaluation of the groundwater hydraulic gradient was simultaneously conducted through shallow groundwater mini-piezometers adjacent to the river during February (low stream discharge) and May (high stream discharge) measurement timeframes.

November discharge estimates, representative of autumn, had gains and losses that varied by subreach with an overall net gain of 42 ± 8 cubic feet per second (ft^3/s). This finding compares favorably to a previous U.S. Geological Survey seepage investigation in November 1996 that found a gaining reach with an estimated gain of 52 ft^3/s. This finding also is supported by a U.S. Geological Survey investigation in the study reach in November 1971 that estimated a gain of 74 ft^3/s, which largely came from groundwater. The February discharge estimates, representative of winter conditions, showed variability in the reach with a net gain of 52 ft^3/s with an uncertainty estimate of ±7 ft^3/s, which is consistent with the low stream discharge findings from November 2009. This finding is further supported by the differential hydraulic head measured at transect sites that qualitatively indicated groundwater to surface-water movement with few exceptions. The May discharge estimates, representative of the spring-time conditions, were gaining or potentially gaining in all but one of the upper subreaches between Boise River below Diversion Dam and Boise River near MK Nature Center sites, with seepage run results supported by hydraulic head differentials indicating a groundwater to surface-water movement. The lower end of the study reach between Boise River near MK Nature Center and Boise River at Glenwood Bridge sites showed more variability with observed hydraulic head differentials that partially supported the potential gains or losses in the reach. Overall, the reach had a calculated net gain of 24 ± 51 ft^3/s and, therefore, this estimate may or may not reflect the actual conditions in the reach. The groundwater gains and losses in August, representative of summer conditions, varied in both the upper and lower parts of the reach, with a net loss of -88 ± 69 ft^3/s.

Overall, the reach experienced a net gain from groundwater at low stream discharges (November and February), a net loss to groundwater at moderately high stream discharge (August), and an ambiguous finding at a higher stream discharge (May). The hydraulic head differentials measured between the groundwater and surface water largely supported the calculated gain and loss estimates in the subreaches, with a potential for groundwater to surface-water movement at low stream discharge in February, and variability during high stream discharge conditions in May.

Introduction

The Boise, Idaho metropolitan area has experienced rapid population growth for more than two decades with associated land use changes from traditional agricultural practices to urbanized commercial, residential, and manufacturing environments. Concern for future water resources has spurred research into evaluating the status of current water resources in order to create strategies to meet future needs. The U.S. Geological Survey (USGS) in cooperation with the Idaho Department of Water Resources (IDWR) Treasure Valley Comprehensive Aquifer Management Planning (CAMP) effort investigated seasonal groundwater gains and losses on the Boise River, Idaho (fig. 1), from November 2009 through August 2010. The investigation was conducted using seepage runs and evaluation of the groundwater hydraulic gradient observed at shallow groundwater wells (mini-piezometers) adjacent to the river.



Base from ESRI ArcGIS Online and data partners including USGS and © 2007 National Geographic Society, 1:100,000. Coordinate system: Geographic, datum is World Geodetic System of 1984.

Figure 1. Study reach from downstream of the Boise River Diversion Dam to the Glenwood Bridge, Boise River, Idaho.

Geographically, the lower Boise River begins at the base of the mountains near Lucky Peak Reservoir with stream discharge in the study reach controlled by water releases from Lucky Peak Dam (fig. 1), which is located 2.33 mi upstream of the first measurement site. During the irrigation season (approximately early-April to mid-October), the Boise River Diversion Dam upstream of the first measurement site, also controls a measure of stream discharge as it diverts water from the Boise River to the New York canal network to meet agricultural irrigation needs in the valley. The studied reach includes multiple smaller diversions (irrigation and municipal) and natural tributary inflows. The river flows through the city of Boise, and is bounded on the north by foothills and mountains, and to the south by low rolling hills with relatively flat topography.

The studied reach runs from an inactive streamgage, Boise River below Diversion Dam (USGS station No. 13203510) and ends at the active streamgage, Boise River at Glenwood Bridge (USGS station No. 13206000), a distance of nearly 14 river miles. Data from this seepage investigation supports IDWR's Treasure Valley CAMP goals of providing reliable sources of water into the future, and bridging gaps between future water needs and supplies.

Seepage runs are a series of stream discharge measurements that are conducted to understand spatial variation in stream discharge gain and loss that can be attributed to groundwater in a specified reach (Rosenberry and LaBaugh, 2008). A seepage study conducted in November 1996 by the USGS found a net gain from groundwater in the reach downstream of Lucky Peak Dam to the Glenwood Bridge (Berenbrock, 1999). In discussions with IDWR, it was agreed that the 1996 data should be enhanced by examining the temporal and spatial gains and losses during the ambient conditions typical of the four seasons. The seepage runs were timed to coincide with stable flow conditions and conducted as close to mid-season as possible (fig. 2):

- Autumn—low stream discharge after the end of irrigation season (November)
- Winter—low stream discharge outside of irrigation season (February)
- Spring—high stream discharge after the beginning of irrigation season (May)
- Summer—mid to high stream discharge after mid-irrigation season (August)

The studied reach was divided into 11 subreaches between 12 mainstem measurement sites (table 1). Anomalous stream discharge losses at site 3 (Boise River below Highway 21) lead to the discovery of a side-channel diversion that skirted the measurement site during high

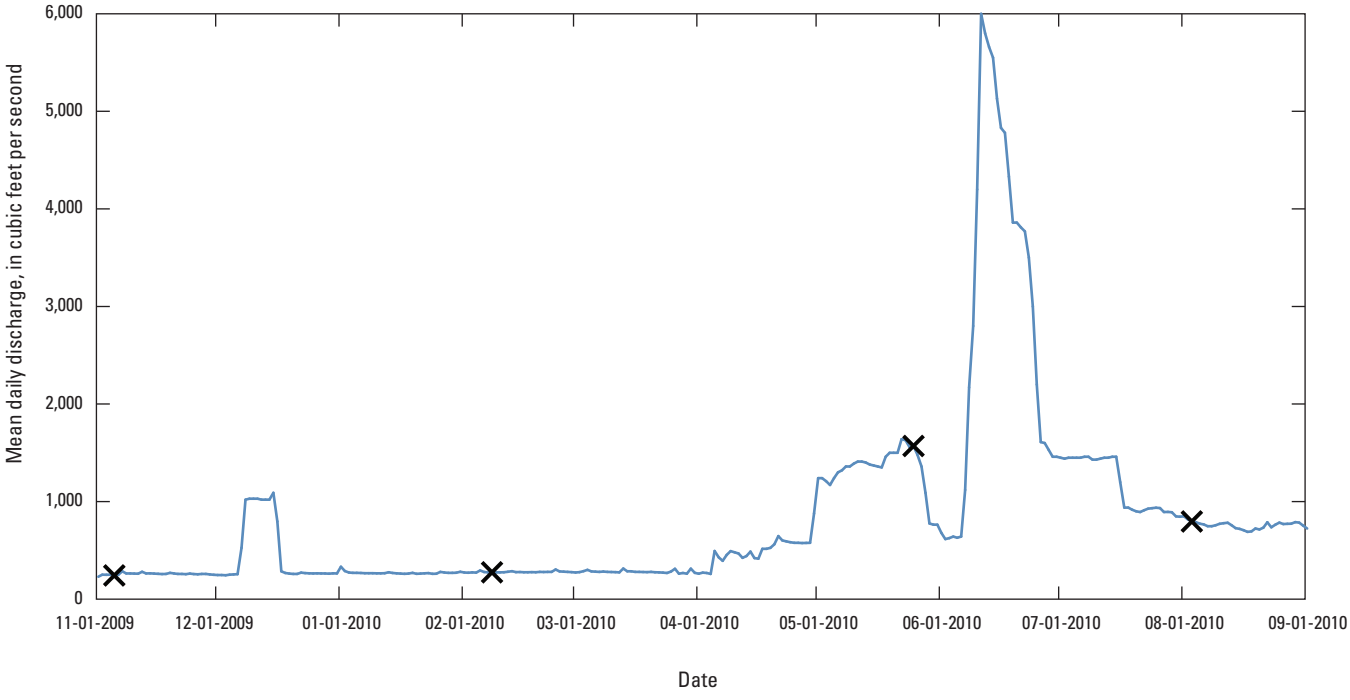


Figure 2. Mean daily discharge, Boise River at Glenwood Bridge (USGS 13206000), Idaho, from November 1, 2009–September 1, 2010, with annotated seepage and groundwater measurements dates.

Table 1. Seepage run and mini-piezometer measurement site locations, and descriptions on selected reaches of the Boise River, Idaho.

[Measurements taken from U.S. Geological Survey streamflow-gaging stations. Mini-piezometers located on main-stem transect sites only. Latitude and longitude meaurements were obtained with a handheld Global Positioning System (GPS); Horizontal datum-World Geodetic System (WGS) 1984]

Site No.	Station No.	Mainstem site names	Diversion and tributary site names	Latitude	Longitude
1	13203510	Boise River below Diversion Dam		43°32'23"	116°05'37"
2	4332391160601		United Water - Columbia Water Treatment Plant and Surprise Valley / Micron withdrawal	43°32'39"	116°06'01"
3	4333001160558	Boise River below Highway 21		43°33'00"	116°05'58"
4	4333121160658		Seep from New York Canal near East Boise River Lane	43°33'12"	116°06'58"
5	4333431160739	Boise River above Eckert Road		43°33'43"	116°07'39"
6	13203758		Ridenbaugh Canal at head near Boise	43°33'57"	116°08'06"
7	13203900		Warm Springs Creek below Eckert Road	43°34'07.2"	116°08'00.1"
8	13204000		Diversion to Harris Ranch near Eckert Road	43°34'22.6"	116°08'22.6"
9	4334101160826	Boise River above Loggers Creek (Barber Park)		43°34'10"	116°08'26"
10	13204005		Gallegher Canal at head near Boise	43°34'11.1"	116°08'42.3"
11	4334301160902	Boise River above Chatburn diversion		43°34'30"	116°09'02"
12	13204010		Chatburn Canal below East Park Center Bridge	43°34'33.1"	116°09'09.7"
13	13204190		Boise City Canal at Warm Springs Golf Course	43°35'25.1"	116°09'49.8"
14	4335591161033		United Water - Marden Water Treatment Plant	43°35'59.3"	116°10'33.7"
15	4336031161104	Boise River near Morrison-Knudsen (MK) Nature Center		43°36'03"	116°11'04"
16	13205010		Cottonwood Creek at Jefferson Street at Boise	43°36'43.8"	116°11'10.1"
17	4336041161129		Loggers Creek at mouth	43°36'04"	116°11'29"
18	4336251161221	Boise River above Capitol Boulevard		43°36'25"	116°12'21"
19	13205510		Bubb Canal spill at mouth at Ann Morrison Park at Boise	43°36'41.8"	116°12'59.5"
20	4336431161301	Boise River at Ann Morrison Park Foot Bridge		43°36'43"	116°13'01"
21	13205515		Settler's Canal at head at Boise	43°36'53"	116°13'19"
22	13205609		Settler's Canal spill to Boise River below Main Street	43°37'14.2"	116°13'58.7"
23	4337221161404	Boise River below Main Street		43°37'22"	116°14'04"
24	13205622		Thurman Mill Canal at 36th Street at Garden City	43°37'35.6"	116°14'11.5"
25	13205640		Farmers Union Canal at Veterans Park at Boise	43°38'10"	116°14'19"
26	4338231161441		Lander Street Waste Water Treatment Plant	43°38'23"	116°14'41"
27	4338271161454	Boise River near Willow Lane		43°38'27"	116°14'54"
28	13205647		Settler's Canal spill near 49th Street at Garden City	43°38'39.1"	116°15'31.9"
29	4339091161600	Boise River near Remington Lane		43°39'09"	116°16'00"
30	4339361161642		Unnamed inflow to Boise River above Glenwood Bridge	43°39'35.6"	116°16'42.2"
31	13206000	Boise River at Glenwood Bridge		43°39'38"	116°16'45"

stream discharge. The side channel was dry during low stream discharge, and was not readily apparent during initial site selection. To eliminate the influence of unmeasured discharge at this site, gains and losses were calculated between sites 1 and 5, thus eliminating the discharge bypass during high stream discharges. Left and right bank mini-piezometers remained installed at the original site 3 transect. All measurement sites were selected based on USGS suitability criteria for discharge measurements (Rantz and others, 1982; Mueller and Wagner, 2009). Along the studied reach, 9 tributaries (inflows) and 10 diversions (outflows) were quantified to determine significant contributions or withdrawals to the Boise River. In situations where water treatment facilities discharge to, or withdraw from, the Boise River, the values were provided by the utility for the days stream discharge measurements were conducted. To provide ancillary data to the seepage run gain and loss estimates, measurements of hydraulic head differences between the groundwater (mini-piezometers) and the surface water at low (February) and high (May) stream discharges also were conducted to provide a qualitative assessment of potential groundwater and surface water interaction on both the left and right banks at the mainstem transect sites.

Methods

Stream discharge measurements were conducted in accordance with USGS Office of Surface Water protocols, policies, and published guidance (Rantz and others, 1982; Oberg, and others, 2005; Mueller and Wagner, 2009). The instruments used to conduct the measurements were either YSI SonTek FlowTracker handheld acoustic Doppler velocimeters (ADV) or Teledyne RDI StreamPro acoustic Doppler current profilers (ADCP) and were selected based on ambient stream discharge conditions. Hydraulic head differential measurements were conducted in accordance with USGS guidance found in *Field Techniques for Estimating Water Fluxes Between Surface Water and Ground Water* (Rosenberry and LaBaugh, 2008). Geographic coordinates provided for the measurement sites were based on a hand-held Global Positioning System, using the World Geodetic System 1984 horizontal datum.

Seepage Runs

The seepage runs were conducted during a single day; stable flows were requested from the Boise River watermaster through IDWR for each sampling date. Dates selected for sampling within the seasonal timeframes were: November 5, 2009 (autumn); February 8, 2010 (winter); May 25, 2010 (spring); and August 3, 2010 (summer). During the seepage runs, discharge measurements were made at sites along the mainstem of the river, and significant inflows and outflows were measured along the subreaches. The increase or decrease between mainstem measurement sites that could not be attributed to inflows or outflows represents the net seepage interchange between the surface water and the groundwater. The mass balance equation used for determining this estimate is as follows (Simonds and Sinclair, 2002):

$$\text{Net seepage gain or loss} = Od - T - Ou + D, \quad (1)$$

where

Od is the discharge measured at the downstream end of the reach, in cubic feet per second;
Ou is the discharge measured at the upstream end of the reach, in cubic feet per second;
T is the sum of tributary inflows, in cubic feet per second; and
D is the sum of the diversion outflows, in cubic feet per second.

The result is the estimated net volume of water gained or lost from the river. Positive values indicate a gaining reach, and negative values show a loss of water volume.

Estimates of Uncertainty

The estimates of uncertainty for the stream discharge measurements were calculated differently depending on the instrument used to conduct the discharge measurement. The FlowTracker ADV calculates uncertainty internally through a statistical technique developed by the USGS, and outputs a statistical uncertainty value in percent at the completion of the measurement. This value was used to estimate uncertainty for the discharge measurements. For a full discussion on methodology, see *FlowTracker Handheld ADV Technical Manual*, from SonTek (SonTek/YSI, 2009).

The uncertainty in the ADCP measurements was determined by first finding the *t-statistic* for a normal distribution at the 95-percent confidence interval based on the number of transects measured (degrees of freedom, $n-1$). To calculate a margin of error for the confidence interval, this value is multiplied by the coefficient of variation (CV) divided by the square root of the sample number, *n*, and multiplied by 100 to provide an uncertainty value in percent, for the variance around the mean discharge estimate. This value is random uncertainty; bias in the measurements between sites is considered negligible due to the same instrument being used to conduct the mainstem measurements in all but one instance. Table 2 provides a summary of the instruments used to conduct discharge measurements and measurement associated uncertainty statistics.

Table 2. Summary of instruments used to conduct discharge measurements and the measurements' associated uncertainty statistic by date and location on the Boise River, Idaho.

[Measurements taken from U.S. Geological Survey streamflow-gaging stations. **Uncertainty statistic:** SonTek FlowTracker's uncertainty statistic is calculated internally in the instrument. For a full discussion of methodology, see the FlowTracker user's manual. **Coefficient of variation:** RDI StreamPro coefficient of variation (CV) is calculated through RDI WinRiver II software. The CV is the measurement's standard deviation divided by the overall mean. **Abbreviations:** FT, SonTek FlowTracker; SP, RDI StreamPro; –, not applicable or no remarks]

	November 5, 2009		February 8, 2010		May 25, 2010			August 3, 2010		
Site No.	Instrument used	Uncertainty statistic (percentage)	Instrument used	Uncertainty statistic (percentage)	Instrument used	Number of transects	Uncertainty statistic (percentage) or coefficient of variation	Instrument used	Number of transects	Uncertainty statistic (percentage) or coefficient of variation
1	FT	2.3	FT	1.9	SP	12	(0.03)	SP	4	(0.02)
5	FT	2.2	FT	2.3	SP	12	(0.02)	SP	4	(0.01)
6	–	–	–	–	SP	12	(0.01)	SP	4	(0.00)
9	FT	1.7	FT	1.6	SP	12	(0.02)	SP	4	(0.05)
10	–	–	–	–	FT	–	2.7	FT	–	2.5
11	FT	2.2	FT	2.1	SP	12	(0.01)	SP	4	(0.01)
12	–	–	FT	5.3	FT	–	2.3	FT	–	1.8
13	–	–	–	–	FT	–	1.8	FT	–	1.6
15	FT	2.3	FT	3.2	SP	8	(0.03)	SP	4	(0.01)
16	–	–	–	–	FT	–	6.1	–	–	–
17	FT	4.5	FT	3.0	FT	–	1.7	FT	–	2.7
18	FT	2.8	FT	2.6	SP	12	(0.02)	SP	4	(0.01)
20	FT	1.9	FT	1.9	SP	8	(0.02)	SP	4	(0.01)
21	–	–	–	–	SP	4	(0.01)	SP	4	(0.01)
22	FT	22.0	FT	5.9	FT	–	2.9	FT	–	4.6
23	FT	1.8	FT	2.2	SP	8	(0.02)	SP	4	(0.01)
24	–	–	–	–	FT	–	2.7	FT	–	3.1
25	–	–	–	–	FT	–	1.6	FT	–	1.4
27	FT	1.9	FT	1.8	SP	8	(0.03)	SP	4	(0.02)
28	–	–	–	–	FT	–	3.7	FT	–	1.4
29	FT	2.5	FT	3.9	FT	–	1.8	SP	4	(0.02)
30	–	–	–	–	–	–	–	FT	–	7.1
31	FT	1.7	FT	1.5	SP	8	(0.02)	SP	4	(0.02)

As an example, a value for the *t-statistic* appropriate for four transects, with α = 0.025 (two-tailed probability), is 3.182. This factor is multiplied by the measurement CV, in this case 0.03, divided by the square root of the number of transects, then multiply by 100. The result is a 95 percent confidence interval on a 4.8 percent variance around the mean discharge.

- Uncertainty, in percent $= \left(t_a, n-1 * CV / \sqrt{n}\right) * 100$ (2)
- Uncertainty, in percent $= \left(3.182 * 0.03 / \sqrt{4}\right) * 100$
  $= \pm 4.8$ percent

Once uncertainty is determined for each measurement, the propagation of uncertainty was estimated to determine if the net gain or loss estimate exceeds the propagated error. To estimate uncertainty for the groundwater gain or loss within a subreach, apply the following formula (Wheeler and Eddy-Miller, 2005):

$$s = \sqrt{(\pm a)^2 + (\pm b)^2 \ldots + (\pm n)^2}, \quad (3)$$

where

s is the uncertainty for all measurement estimates in the subreach; and

$a, b, \ldots, n$ are the mean estimates of uncertainty for each individual discharge measurement.

As an example, the stream discharge estimates on August 3, 2010, for sites 9 to 11 in table 8, have calculated uncertainty values for each measurement used in the following equation:

$$s = \sqrt{(\pm 82.4)^2 + (\pm 0.119)^2 + (\pm 18.1)^2}$$
$$= \pm 84.4 \text{ cubic feet per second.}$$

The net groundwater gain or loss would have to be greater than ±84.4 ft^3/s to determine the groundwater component in the reach. Because the calculated net gain was 105 ft^3/s, and is greater than the uncertainty estimate, the net gain likely represents actual conditions at the time of the measurement.

Groundwater Wells

Qualitatively, the direction of movement between the river and shallow groundwater was determined by the hydraulic head differential between them. This was accomplished using mini-piezometers installed on both the left and right banks at the mainstem transect sites and using a manometer board to measure the difference in hydraulic head between the river and the shallow groundwater. For the purposes of this report, positive hydraulic head differential values indicate a potential for groundwater-to-surface water movement; negative values indicate a potential for surface water-to-groundwater movement. A detailed description of manometer board usage is presented in Winter and others (1988).

The mini-piezometers were constructed of 1/2-inch galvanized metal pipe with one end of the pipe crimped shut to provide a drive point and 1/8-inch holes drilled around the lower 6 in. of pipe to allow water access, and act as a filter for sediment. Each well was driven to a depth of approximately 7 ft, or to a point where further progress was stopped: a depth range of 3–7 ft.

Results and Analysis

November Seepage Run Results and Analysis

Stream discharge measurements were conducted on November 5, 2009, along the Boise River, from downstream of the Boise River Diversion Dam to the Glenwood Bridge, with significant returns, tributaries, diversions, and withdrawals measured along the reach. A discharge of 218 ft^3/s was measured at site 1, downstream of the Boise River Diversion Dam (fig. 1) at approximately 9:00 a.m. Mountain Standard Time (MST). Irrigation season had ended approximately the second week of October and the National Weather Service (NWS) (2008) reported no measureable precipitation at the Boise Airport within 5 days preceding the measurements. All outflows were zero, with the exception of withdrawals by the United Water (UW) Marden Water Treatment Plant (WTP), the UW Columbia WTP and Surprise Valley/Micron combined withdrawal, and the Chatburn diversion (open year round). Several inflows had measureable discharge and Landers Street Waste Water Treatment Plant (WWTP) was contributing to the river.

All subreaches had gains or losses greater than the estimates of uncertainty with the exceptions of subreaches 5–9, 15–18, and 29–31. The greatest net gain was between sites 11 and 15 with 32 ±8 ft^3/s, and the greatest net loss was between sites 23 and 27 with -18.0 ± 6.09 ft^3/s. Overall, there was a net gain in the reach of 42 ± 8 ft^3/s (table 3). This finding reflects the results of the November 1996 USGS seepage study (Berenbrock, 1999) which found this reach to have a calculated net gain of 52 ft^3/s. This also is consistent with an earlier USGS investigation on the Boise River conducted by Thomas and Dion (1974) that found groundwater made up nearly all stream discharge on the Boise River below Lucky Peak Dam, when discharge gates on the dam were completely closed from November 17 to 20, 1971. The USGS used the opportunity to measure discharge from gage equipment on the dam gates, Boise River near Boise (USGS station No.13202000, currently inactive), to the Glenwood Bridge (formerly known as Strawberry Glenn Bridge) from November 18 to 19, 1971. Stream discharge at the dam gates measured 0.99 ft^3/s and increased along the study reach to a stream discharge of 74.8 ft^3/s at the Glenwood Bridge. (See Thomas and Dion, 1974, for additional details.)

Table 3. Summary of discharge measurements, calculated gain and loss estimates, and associated estimates of uncertainty on selected reaches of the Boise River, Idaho, November 5, 2009.

[Measurements taken from U.S. Geological Survey streamflow-gaging stations. **Estimated measurement uncertainty:** Uncertainty calculations for individual measurements are determined by the instrument used for the measurement. A FlowTracker measurement outputs a statistical value in percent that should be divided by 100 and then multiplied by the mean discharge value for an estimate of the the measurement's uncertainty. StreamPro uncertainty calculations are obtained by multiplying an error factor based on the number of transects, by the measurement's coefficient of variation (CV), and then by the mean discharge value. The error factors are 1.6 for 4 transects, 0.8 for 8 transects, and 0.6 for 12 transects. Table 2 summarizes the instruments used for each measurement and the statistical values. **Associated measurement uncertainty:** Propagation of uncertainty for the streamflow gain or loss attributed to groundwater was calculated using the following formula: $s = \sqrt{(\pm a)^2 + (\pm b)_2 + (\pm n)^2}$ Where s is the uncertainty propagated from all estimated individual uncertainties and a, b, ..., n are the estimated uncertainties for the median discharge measurement at each site. **Abbreviations:** ft^3/s, cubic feet per second; $(ft^3/s)/mi$, cubic feet per second per mile; –, not applicable or no remarks; mi, miles; (e), estimate (10 percent uncertainty used in calculation)]

Site No.	Station No.	Mean mainstem discharge (ft^3/s)	Mean discharge from return/tributary (+) or diversion/ withdrawal (-) (ft^3/s)	Estimated measurement uncertainty (ft^3/s)	Estimated streamflow gain (+) or loss (-) attributed to groundwater and associated measurement uncertainty (ft^3/s)	Distance (mi)	Gain or loss (-) per mile [$(ft^3/s)/mi$]	Remarks
1	13203510	218	–	± 5.01	–	0.0		–
2	4332391160601	–	[1](-) 4.07	± 0.04	–			Value provided by IDWR - assessed anuncertainty of 1 percent based on equipment specifications, and calibration standards provided by United Water
4	4333121160658	–	0	–	–			
5	4333431160739	227	–	± 4.99	(+)13.1 ± 7.08	2.64	4.96	Gaining reach
6	13203758	–	0	–	–			–
7	13203900	–	0	–	–			–
8	13204000	–	0	–	–			–
9	4334101160826	228	–	± 3.88	(+)1.00 ± 6.32	3.61	1.03	Difference in measured discharge in subreach is less than the associated measurement uncertainty
10	13204005	–	0	–				–
11	4334301160902	213	–	± 4.69	(-)15.0 ± 6.08	4.35	(-) 20.3	Losing reach
12	13204010	–	[2](-) 43 (e)	± 4.30	–			Estimated discharge value base on information from SBWC watermaster. Consistent with February 8, 2010 discharge measurement estimate. Assessed a 10 percent uncertainty value.
13	13204190	–	0	–				–
14	4335591161033	–	[1]2.04	± 0.02	–			Value provided by IDWR - assessed an uncertainty of 1 percent based on equipment specifications, and calibration standards provided by United Water
15	4336031161104	200	–	± 4.60	(+)32 ± 8	7.08	12	Gaining reach

Table 3. Summary of discharge measurements, calculated gain and loss estimates, and associated estimates of uncertainty on selected reaches of the Boise River, Idaho, November 5, 2009—Continued.

[Measurements taken from U.S. Geological Survey streamflow-gaging stations. **Estimated measurement uncertainty:** Uncertainty calculations for individual measurements are determined by the instrument used for the measurement. A FlowTracker measurement outputs a statistical value in percent that should be divided by 100 and then multiplied by the mean discharge value for an estimate of the the measurement's uncertainty. StreamPro uncertainty calculations are obtained by multiplying an error factor based on the number of transects, by the measurement's coefficient of variation (CV), and then by the mean discharge value. The error factors are 1.6 for 4 transects, 0.8 for 8 transects, and 0.6 for 12 transects. Table 2 summarizes the instruments used for each measurement and the statistical values. **Associated measurement uncertainty:** Propagation of uncertainty for the streamflow gain or loss attributed to groundwater was calculated using the following formula: $s = \sqrt{(\pm a)^2 + (\pm b)_2 + (\pm n)^2}$ Where s is the uncertainty propagated from all estimated individual uncertainties and a, b, ..., n are the estimated uncertainties for the median discharge measurement at each site. **Abbreviations:** ft^3/s, cubic feet per second; $(ft^3/s)/mi$, cubic feet per second per mile; –, not applicable or no remarks; mi, miles; (e), estimate (10 percent uncertainty used in calculation)]

Site No.	Station No.	Mean mainstem discharge (ft^3/s)	Mean discharge from return/tributary (+) or diversion/ withdrawal (-) (ft^3/s)	Estimated measurement uncertainty (ft^3/s)	Estimated streamflow gain (+) or loss (-) attributed to groundwater and associated measurement uncertainty (ft^3/s)	Distance (mi)	Gain or loss (-) per mile [$(ft^3/s)/mi$]	Remarks
16	13205010	–	(+) 2 (e)	± 0.2	–			–
17	4336041161129	–	(+) 13.7	± 0.627	–			–
18	4336251161221	221	–	± 6.19	(+)5 ± 8	8.38	4	Difference in measured discharge in subreach is less than the associated measurement uncertainty
19	13205510	–	0	–	–			–
20	4336431161301	210	–	± 3.99	(-)11.0 ± 7.36	9.05	(-) 16.4	Losing reach
21	13205515	–	0	–	–			–
22	13205609	–	(+) 1.04	± 0.229	–			–
23	4337221161404	231	–	± 4.16	(+)20.0 ± 5.77	10.22	17.1	Gaining reach
24	13205622	–	0	–	–			–
25	13205640	–	0	–	–			–
26	4338231161441	–	[3](+) 17.0	± 0.82	–			Value provided by City of Boise - assessed an uncertainty of 4.8 percent based upon measurement information from treatment facility
27	4338271161454	230	–	± 4.37	(-)18.0 ± 6.09	11.79	(-) 11.5	Losing reach
28	13205647	–	0	–				–
29	4339091161600	246	–	± 6.15	(+)16.0 ± 7.54	13.08	12.4	Gaining reach
30	4339361161642	–	0	–	–			–
31	13206000	245	–	± 4.17	(-)1.00 ± 7.43	13.95	(-) 1.15	Difference in measured discharge in subreach is less than the associated measurement uncertainty
		Overall net gain (+) or loss (-) throughout the reach =			**(+) 42 ± 8**			Gaining reach

[1] Value provided by Idaho Dept. of Water Resources (IDWR).

[2] Discharge estimate provided by South Boise Water Co. (SWBC) watermaster.

[3] Value provide by City of Boise.

February Seepage Run and Groundwater Measurement Results and Analysis

Stream discharge measurements were conducted on February 8, 2010, along the Boise River, from downstream of the Boise River Diversion Dam to the Glenwood Bridge, with significant returns, tributaries, diversions, and withdrawals measured along the reach. A discharge of 240 ft^3/s was measured at site 1, downstream of the Diversion Dam at approximately 9:00 a.m. MST. No irrigation flows were present and the National Weather Service (2008) reported 0.27 in. of measureable precipitation at the Boise Airport within 5 days preceding the measurements. All outflows were zero, with the exception of withdrawals by the UW Marden WTP, the UW Columbia WTP and Surprise Valley/Micron combined withdrawal, and the Chatburn diversion (open year round). Several inflows had measureable discharge and Landers Street WWTP was contributing to the river.

All subreaches had gains or losses greater than the estimates of uncertainty with the exceptions of subreaches 15–18, 18–20, and 27–29. The greatest net gain was between sites 11 and 15 with 30.2 ± 8.95 ft^3/s, and the greatest net loss was between sites 23 and 27 with -20.0 ± 7.49 ft^3/s. Overall, there was a net gain in the reach of 52 ± 7 ft^3/s (table 4), which is consistent with the low stream discharge findings in November 2009, and USGS studies conducted in November 1996 (Berenbrock, 1999) and November 1971 (Thomas and Dion, 1974).

Differential hydraulic head measurements were conducted at mini-piezometers installed along the main reach. The results indicate that there is a potential for groundwater to surface-water movement throughout the reach, with some exceptions (table 5). Specifically, there is the potential for groundwater to surface-water movement on the right bank at sites 9 and 15, and the following four sites were found dry: right bank at site 23, and left bank at sites, 5, 15, and 23.

The majority of hydraulic head differentials indicate a potential groundwater to surface-water movement with the left bank at site 1 having the largest positive hydraulic head differential of 0.38 ft. The results qualitatively support the seepage run findings with one notable exception. The hydraulic head differential at site 15 had the largest negative differential of all well measurements at -0.47 ft and indicated the greatest potential for groundwater to surface-water movement in the reach. United Water operates a Ranney collector approximately 0.4 mi upstream of the observation well, between sites 11 and 15, but there was no withdrawal on the day the measurement was conducted and it is unlikely the collector was a significant factor with regard to groundwater movement on February 8, 2010.

May Seepage Run and Groundwater Measurement Results and Analysis

Stream discharge measurements were conducted on May 25, 2010, along the Boise River, from downstream of the Boise River Diversion Dam to the Glenwood Bridge, with significant returns, tributaries, diversions, and withdrawals measured along the reach. A discharge of 2,410 ft^3/s was measured at site 1, downstream of the Diversion Dam at approximately 8:30 a.m. MST. Irrigation season had started approximately the first week of April, and the National Weather Service (2008) reported 1.42 in. of measureable precipitation at the Boise Airport within 5 days preceding the measurements. The irrigation season, and spring rains, produced significant tributary contribution and diversions along the reach.

Only subreaches 1–5, 9–11, and 11–15 had calculated gains or losses that exceeded the estimates of uncertainty. The greatest gain in the reach was between sites 11and 15 with 80.0 ± 46.8 ft^3/s, and the greatest loss was between sites 1 and 5 with -72 ± 52 ft^3/s. Overall, there was a calculated net gain of 24 ± 51 ft^3/s (table 6). Because the net gain was less than the estimate of uncertainty, the gain may or may not reflect real conditions in the reach. However, individual gains and losses in the subreaches, when compared to the differential hydraulic head measurements, provide a qualitative assessment of groundwater movement at the mainstem transect sites. In many cases (13 of 22 measurements), the direction for potential groundwater movement agreed with the findings of the seepage runs and qualitatively supported the results within the subreaches, but in some cases it did not. Hyporheic flow often varies along a reach due to the heterogeneity of fluvial sediments (Rosenberry and LaBaugh, 2008), which may explain why some hydraulic head differentials did not agree with seepage run results. In addition, hydraulic head differential measurements are single points along the reach and are representative of groundwater interchange at that particular point, not along an entire subreach.

Table 4. Summary of discharge measurements, calculated gain and loss estimates, and associated estimates of uncertainty on selected reaches of the Boise River, Idaho, February 8, 2010.

[Measurements taken from U.S. Geological Survey streamflow-gaging stations. Estimated measurement uncertainty: Uncertainty calculations for individual measurements are determined by the instrument used for the measurement. A FlowTracker measurement outputs a statistical value in percent that should be divided by 100 and then multiplied by the mean discharge value for an estimate of the the measurement's uncertainty. StreamPro uncertainty calculations are obtained by multiplying an error factor based on the number of transects, by the measurement's coefficient of variation (CV), and then by the mean discharge value. The error factors are 1.6 for 4 transects, 0.8 for 8 transects, and 0.6 for 12 transects. Table 2 summarizes the instruments used for each measurement and the statistical values. **Associated measurement uncertainty:** Propagation of uncertainty for the streamflow gain or loss attributed to groundwater was calculated using the following formula: $s = \sqrt{(\pm a)^2 + (\pm b)_2 + (\pm n)^2}$ Where s is the uncertainty propagated from all estimated individual uncertainties and a, b, ..., n are the estimated uncertainties for the median discharge measurement at each site. **Abbreviations:** ft^3/s, cubic feet per second; $(ft^3/s)/mi$, cubic feet per second per mile; –, not applicable or no remarks; mi, miles; (e), estimate (10 percent uncertainty used in calculation)]

Site No.	Station No.	Mean mainstem discharge (ft^3/s)	Mean discharge from return/tributary (+) or diversion/ withdrawal (-) (ft^3/s)	Estimated measurement uncertainty (ft^3/s)	Estimated streamflow gain (+) or loss (-) attributed to groundwater and associated measurement uncertainty (ft^3/s)	Distance (mi)	Gain or loss (-) per mile [$(ft^3/s)/mi$]	Remarks
1	13203510	240	–	± 4.56	–	0.00		–
2	4332391160601	–	[1](-) 5.50	± 0.06	–			Value provided by IDWR - assessed an uncertainty of 1 percent based on equipment specifications, and calibration standards provided by United Water
4	4333121160658	–	0		–			–
5	4333431160739	242	–	± 5.57	(+) 7.50 ± 7.20	2.64	2.84	Gaining reach
6	13203758	–	0	–	–			–
7	13203900	–	0	–	–			–
8	13204000	–	0	–	–			–
9	4334101160826	258	–	± 4.13	(+) 16.0 ± 6.93	3.61	16.5	Gaining reach
10	13204005	–	0	–	–			–
11	4334301160902	235	–	±4.94	(-) 23.0 ± 6.43	4.35	(-) 31.1	Losing reach
12	13204010	–	(-) 43.2	± 2.29	–			–
13	13204190	–	0	–	–			–
14	4335591161033	–	[1]0	–	–			Value provided by IDWR - assessed an uncertainty of 1 percent based on equipment specifications, and calibration standards provided by United Water
15	4336031161104	222	–	± 7.10	(+) 30.2 ± 8.95	7.08	11.1	Gaining reach
16	13205010	–	(+) 2 (e)	± 0.2	–			–
17	4336041161129	–	(+) 17.9	± 0.537	–			–
18	4336251161221	245	–	± 6.37	(+) 3 ± 10	8.38	2	Difference in measured discharge in subreach is less than the associated measurement uncertainty

Table 4. Summary of discharge measurements, calculated gain and loss estimates, and associated estimates of uncertainty on selected reaches of the Boise River, Idaho, February 8, 2010—Continued.

[Measurements taken from U.S. Geological Survey streamflow-gaging stations. Estimated measurement uncertainty: Uncertainty calculations for individual measurements are determined by the instrument used for the measurement. A FlowTracker measurement outputs a statistical value in percent that should be divided by 100 and then multiplied by the mean discharge value for an estimate of the the measurement's uncertainty. StreamPro uncertainty calculations are obtained by multiplying an error factor based on the number of transects, by the measurement's coefficient of variation (CV), and then by the mean discharge value. The error factors are 1.6 for 4 transects, 0.8 for 8 transects, and 0.6 for 12 transects. Table 2 summarizes the instruments used for each measurement and the statistical values. **Associated measurement uncertainty:** Propagation of uncertainty for the streamflow gain or loss attributed to groundwater was calculated using the following formula: $s = \sqrt{(\pm a)^2 + (\pm b)_2 + (\pm n)^2}$ Where s is the uncertainty propagated from all estimated individual uncertainties and a, b, ..., n are the estimated uncertainties for the median discharge measurement at each site. **Abbreviations:** ft^3/s, cubic feet per second; $(ft^3/s)/mi$, cubic feet per second per mile; –, not applicable or no remarks; mi, miles; (e), estimate (10 percent uncertainty used in calculation)]

Site No.	Station No.	Mean mainstem discharge (ft^3/s)	Mean discharge from return/tributary (+) or diversion/ withdrawal (-) (ft^3/s)	Estimated measurement uncertainty (ft^3/s)	Estimated streamflow gain (+) or loss (-) attributed to groundwater and associated measurement uncertainty (ft^3/s)	Distance (mi)	Gain or loss (-) per mile [$(ft^3/s)/mi$]	Remarks
19	13205510	–	0	–	–			–
20	4336431161301	243	–	± 4.62	(-) 2.00 ± 7.87	9.05	(-) 2.99	Difference in measured discharge in subreach is less than the associated measurement uncertainty
21	13205515	–	0		–			–
22	13205609	–	(+) 0.949	± 0.056	–			–
23	4337221161404	263	–	± 5.79	(+) 19.1 ± 7.40	10.22	16.3	Gaining reach
24	13205622	–	0	–	–			–
25	13205640	–	0	–	–			–
26	4338231161441	–	[2](+)17.0	± 0.816	–			Value provided by City of Boise - assessed an uncertainty of 4.8 percent based upon measurement information from treatment facility
27	4338271161454	260	–	± 4.68	(-) 20.0 ± 7.49	11.79	(-) 12.7	Losing reach
28	13205647	–	0	–	–			–
29	4339091161600	264	–	± 10.3	(+) 4.00 ± 11.3	13.08	3.10	Difference in measured discharge in subreach is less than the associated measurement uncertainty
30	4339361161642	–	0	–	–			–
31	13206000	281	–	± 4.22	(+) 17.0 ± 11.1	13.95	19.5	Gaining reach
		Overall net gain (+) or loss (-) throughout the reach =			**(+) 52 ± 7**			Gaining reach

[1] Value provided by Idaho Department of Water Resources (IDWR).

[2] Value provide by City of Boise.

Table 5. Summary of left and right bank, surface water and groundwater hydraulic head measurements, and their difference, at selected locations along the Boise River, Idaho, February 8, 2010.

[Measurements taken from U.S. Geological Survey streamflow-gaging stations. **Hydraulic difference:** Positive values indicate a potential for groundwater to surface-water movement; negative values indicate a potential for surface-water to-groundwater movement. **Abbreviations:** –, not applicable or no remarks; ft, feet; bls, below surface; LB, left bank; RB, right bank; LBSW, left bank – surface water; RBSW, left bank – surface water; LBGW, left bank – groundwater; RBGW, right bank–groundwater]

Site No.	Station No.	Boise river sites	Mini-piezometer depth below surface (ft)		Potentiomanometer readings (ft)					
			LB	RB	LBGW	LBSW	Hydraulic difference (LB)	RBGW	RBSW	Hydraulic difference (RB)
1	13203510	Boise River below Diversion Dam	5.0	5.0	2.48	2.10	0.380	2.88	2.78	0.100
3	4333001160558	Boise River below Highway 21	4.5	7.0	2.72	2.62	0.100	2.48	2.45	0.030
5	4333431160739	Boise River above Eckert Road	6.0	5.0	dry	–	–	2.55	2.46	0.090
9	4334101160826	Boise River above Loggers Creek diversion (Barber Park)	7.0	4.5	2.61	2.57	0.040	2.56	2.68	-0.120
11	4334301160902	Boise River above Chatburn Diversion	7.0	4.5	3.04	2.97	0.070	2.97	2.96	0.010
15	4336031161104	Boise River near MK Nature Center	3.5	4.0	dry	–	–	0.87	1.34	-0.470
18	4336251161221	Boise River above Capitol Blvd	6.0	4.0	2.47	2.41	0.060	2.65	2.61	0.040
20	4336431161301	Boise River at Ann Morrison Park Foot Bridge	4.5	4.5	2.27	2.24	0.030	1.60	1.59	0.010
23	4337221161404	Boise River below Main Street	4.5	3.0	dry	–	–	dry	–	–
27	4338271161454	Boise River near Willow Lane	5.0	5.0	2.61	2.59	0.020	2.96	2.90	0.060
29	4339091161600	Boise River near Remington Lane	3.5	–	2.28	2.25	0.030	–	–	–
31	13206000	Boise River at Glenwood Bridge	6.0	3.0	2.63	2.60	0.030	2.75	2.65	0.100

Table 6. Summary of discharge measurements, calculated gain and loss estimates, and associated estimates of uncertainty on selected reaches of the Boise River, Idaho, May 25, 2010.

[Measurements taken from U.S. Geological Survey streamflow-gaging stations. **Estimated measurement uncertainty:** Uncertainty calculations for individual measurements are determined by the instrument used for the measurement. A FlowTracker measurement outputs a statistical value in percent that should be divided by 100 and then multiplied by the mean discharge value for an estimate of the the measurement's uncertainty. StreamPro uncertainty calculations are obtained by multiplying an error factor based on the number of transects, by the measurement's coefficient of variation (CV), and then by the mean discharge value. The error factors are 1.6 for 4 transects, 0.8 for 8 transects, and 0.6 for 12 transects. Table 2 summarizes the instruments used for each measurement and the statistical values. **Associated measurement uncertainty:** Propagation of uncertainty for the streamflow gain or loss attributed to groundwater was calculated using the following formula: $s = \sqrt{(\pm a)^2 + (\pm b)_2 + (\pm n)^2}$ Where s is the uncertainty propagated from all estimated individual uncertainties and a, b, ..., n are the estimated uncertainties for the median discharge measurement at each site. **Abbreviations:** ft^3/s, cubic feet per second; $(ft^3/s)/mi$, cubic feet per second per mile; –, not applicable or no remarks; mi, miles; (e), estimate (10 percent uncertainty used in calculation)]

Site No.	Station No.	Mean mainstem discharge (ft^3/s)	Mean discharge from return/tributary (+) or diversion/ withdrawal (-) (ft^3/s)	Estimated measurement uncertainty (ft^3/s)	Estimated streamflow gain (+) or loss (-) attributed to groundwater and associated measurement uncertainty (ft^3/s)	Distance (mi)	Gain or loss (-) per mile [$(ft^3/s)/mi$]	Remarks
1	13203510	2,410	–	± 43.4	–	0.0		–
2	4332391160601	–	[1](-) 9.00	± 0.090	–			Value provided by IDWR - assessed an uncertainty of 1 percent based on equipment specifications, and calibration standards provided by United Water
4	4333121160658	–	(+) 1 (e)	± 0.1	–			–
5	4333431160739	2,330	–	± 28.0	(-) 72 ± 52	2.64	(-) 27	Losing reach
6	13203758	–	(-) 483	± 2.90	–			–
7	13203900	–	(+) 1 (e)	± 0.1	–			–
8	13204000	–	0	–	–			–
9	4334101160826	1,880	–	± 22.6	(+) 32 ± 36	3.61	33	Difference in measured discharge in subreach is less than the associated measurement uncertainty
10	13204005	–	(-) 4.02	± 0.109	–			–
11	4334301160902	1,910	–	± 11.5	(+) 34.0 ± 25.3	4.35	46.0	Gaining reach
12	13204010	–	(-) 82.4	± 1.90	–			–
13	13204190	–	(-) 12.4	± 0.223	–			–
14	4335591161033	–	[1](-) 5.21	± 0.052	–			Value provided by IDWR - assessed an uncertainty of 1 percent based on equipment specifications, and calibration standards provided by United Water
15	4336031161104	1,890	–	± 45.4	(+) 80.0 ± 46.8	7.08	29.3	Gaining reach
16	13205010	–	(+) 6.57	± 0.401	–			–
17	4336041161129	–	(+) 55.6	± 0.945	–			–
18	4336251161221	1,920	–	± 23.0	(-) 32.2 ± 50.9	8.38	(-) 24.7	Difference in measured discharge in subreach is less than the associated measurement uncertainty
19	13205510	–	(+) 1.5 (e)	± 0.2	–			–
20	4336431161301	1,900	–	± 30.4	(-) 21.5 ± 38.1	9.05	(-) 32.1	Difference in measured discharge in subreach is less than the associated measurement uncertainty

Table 6. Summary of discharge measurements, calculated gain and loss estimates, and associated estimates of uncertainty on selected reaches of the Boise River, Idaho, May 25, 2010—Continued.

[Measurements taken from U.S. Geological Survey streamflow-gaging stations. **Estimated measurement uncertainty:** Uncertainty calculations for individual measurements are determined by the instrument used for the measurement. A FlowTracker measurement outputs a statistical value in percent that should be divided by 100 and then multiplied by the mean discharge value for an estimate of the the measurement's uncertainty. StreamPro uncertainty calculations are obtained by multiplying an error factor based on the number of transects, by the measurement's coefficient of variation (CV), and then by the mean discharge value. The error factors are 1.6 for 4 transects, 0.8 for 8 transects, and 0.6 for 12 transects. Table 2 summarizes the instruments used for each measurement and the statistical values. **Associated measurement uncertainty:** Propagation of uncertainty for the streamflow gain or loss attributed to groundwater was calculated using the following formula: $s = \sqrt{(\pm a)^2 + (\pm b)_2 + (\pm n)^2}$ Where s is the uncertainty propagated from all estimated individual uncertainties and a, b, ..., n are the estimated uncertainties for the median discharge measurement at each site. **Abbreviations:** ft^3/s, cubic feet per second; $(ft^3/s)/mi$, cubic feet per second per mile; –, not applicable or no remarks; mi, miles; (e), estimate (10 percent uncertainty used in calculation)]

Site No.	Station No.	Mean mainstem discharge (ft^3/s)	Mean discharge from return/tributary (+) or diversion/ withdrawal (-) (ft^3/s)	Estimated measurement uncertainty (ft^3/s)	Estimated streamflow gain (+) or loss (-) attributed to groundwater and associated measurement uncertainty (ft^3/s)	Distance (mi)	Gain or loss (-) per mile [$(ft^3/s)/mi$]	Remarks
21	13205515	–	(-) 233	±3.73	–			–
22	13205609	–	(+) 89.1	±2.58	–			–
23	4337221161404	1,750	–	±28.0	(-) 6.10 ±41.6	10.22	(-) 5.21	Difference in measured discharge in subreach is less than the associated measurement uncertainty
24	13205622	–	(-) 15.5	±0.419	–			–
25	13205640	–	(-) 186	±2.98	–			–
26	4338231161441	–	[2](+) 17.0	±0.816	–			Value provided by City of Boise - assessed an uncertainty of 4.8 percent based upon measurement information from treatment facility
27	4338271161454	1,590	–	±38.2	(+) 24.5 ±47.4	11.79	15.6	Difference in measured discharge in subreach is less than the associated measurement uncertainty
28	13205647	–	(+) 3.86	±0.143	–			–
29	4339091161600	1,560	–	±28.1	(-) 33.9 ±47.4	13.08	(-) 26.2	Difference in measured discharge in subreach is less than the associated measurement uncertainty
30	4339361161642	–	(+) 1 (e)	±0.1	–			–
31	13206000	1,580	–	±25.3	(+) 19 ± 38	13.95	22	Difference in measured discharge in subreach is less than the associated measurement uncertainty
		Overall net gain (+) or loss (-) throughout the reach =			**(+) 24 ± 51**			Difference in measured discharge in subreach is less than the associated measurement uncertainty

[1] Value provided by Idaho Dept. of Water Resources (IDWR).

[2] Value provide by City of Boise.

Differential hydraulic head measurements were conducted at mini-piezometers installed along the main reach. In the upper one-half of the reach between sites 1 and 15, results of the hydraulic head measurements indicated a potential for groundwater to surface-water movement, while the lower one-half of the reach from sites 15 to 31 showed more variability between subreaches (table 7). The right bank at site 15 had the largest negative differential measurement at -0.53 ft, with the right bank at site 23 also showing an indication of groundwater to surface-water movement with a measured differential of -0.34 ft. United Water operates a Ranney collector approximately 0.4 mi upstream of the observation well and was withdrawing 1.71 ft^3/s on the day measurements were taken. Despite this withdrawal, the hydraulic head measurement was similar to the February result when the collector was idle. The potential groundwater to surface-water movement in the upper one-half of the reach is consistent with expectations due to the 1.42 in. of rain received within the preceding 5 days and greater permeable surface area than exists in the lower one-half of the reach. If there was an effect by the Ranney collector on groundwater direction near the mini-piezometer at the right bank at site 15, it does not appear to have been significant on May 25, 2010, and may have been due to the recent rainfall. The variability in groundwater movement between subreaches in the lower one-half of the reach is consistent with urbanized environments where groundwater recharge due to direct precipitation is reduced because large impermeable surfaces such as roads, roof tops, and paved parking areas, with storm drainage systems can quickly carry away surface runoff (Douglas, 1983).

August Seepage Run Results and Analysis

Stream discharge measurements were conducted on August 3, 2010, along the Boise River, from downstream of the Boise River Diversion Dam to the Glenwood Bridge, with significant returns, tributaries, diversions, and withdrawals measured along the reach. A discharge of 1,770 ft^3/s was measured at site 1, downstream of the Diversion Dam at approximately 3:30 p.m. MST. Irrigation water flows were ongoing, and the National Weather Service (2008) recorded no measureable precipitation at the Boise Airport within 5 days preceding the measurements.

All subreaches had gains or losses greater than the estimates of uncertainty with the exceptions of subreaches 23–27, 27–29, and 29–31. The greatest net gain was between sites 9 and 11 with 105 ± 84.4 ft^3/s, and the greatest net loss was between sites 1 and 5 with -157 ± 62 ft^3/s (table 8). Overall, there was a net loss in the reach of -88 ± 69 ft^3/s.

In the upper one-half of the reach, subreaches 1–5 and 5–9 were found to be losing, with subreaches 9–11 and 11–15 found to be gaining. The lower one-half of the reach from sites 15 to 31 showed the same variability between subreaches as was found in May, but the gains and losses were not consistent when the subreaches were compared.

Table 7. Summary of left and right bank, surface water and groundwater hydraulic head measurements, and their difference, at selected locations along the Boise River, Idaho, May 25, 2010.

[Measurements taken from U.S. Geological Survey streamflow-gaging stations. **Hydraulic difference:** Positive values indicate a potential for groundwater to surface-water movement; negative values indicate a potential for surface-water to groundwater movement. **Abbreviations:** –, not applicable or no remarks; ft, feet; bls, below land surface; LB, left bank; RB, right bank; LBSW, left bank – surface water; RBSW, right bank – surface water; LBGW, left bank – groundwater; RBGW, right bank – groundwater]

Site No.	Station No.	Boise river sites	Mini-piezometer depth below surface (ft)		Potentiomanometer readings (ft)					
			LB	RB	LBGW	LBSW	Hydraulic difference (LB)	RBGW	RBSW	Hydraulic difference (LB)
1	13203510	Boise River below Diversion Dam	5.0	5.0	2.47	2.46	0.010	2.66	2.60	0.060
3	4333001160558	Boise River below Highway 21	4.5	7.0	2.98	2.87	0.110	2.94	2.92	0.020
5	4333431160739	Boise River above Eckert Road	6.0	5.0	2.71	2.68	0.030	2.59	2.58	0.010
9	4334101160826	Boise River above Loggers Creek Diversion (Barber Park)	7.0	4.5	2.87	2.81	0.060	2.43	2.75	0.010
11	4334301160902	Boise River above Chatburn Diversion	7.0	4.5	1.96	1.93	0.030	2.58	2.55	0.030
15	4336031161104	Boise River near MK Nature Center	3.5	4.0	2.29	2.24	0.050	2.55	3.08	-0.530
18	4336251161221	Boise River above Capitol Blvd	6.0	4.0	2.82	2.85	-0.030	2.68	2.70	-0.020
20	4336431161301	Boise River at Ann Morrison Park Foot Bridge	4.5	4.5	2.58	2.56	0.020	2.62	2.70	-0.080
23	4337221161404	Boise River below Main Street	4.5	3.0	dry	–	–	2.37	2.71	-0.340
27	4338271161454	Boise River near Willow Lane	5.0	5.0	2.64	2.50	0.140	3.03	2.98	0.050
29	4339091161600	Boise River near Remington Lane	3.5	–	2.82	2.85	-0.030	–	–	–
31	13206000	Boise River at Glenwood Bridge	6.0	3.0	3.03	3.04	-0.010	2.79	2.73	0.060

Table 8. Summary of discharge measurements, calculated gain and loss estimates, and associated estimates of uncertainty on selected reaches of the Boise River, Idaho, August 3, 2010.

[Measurements taken from U.S. Geological Survey streamflow-gaging stations. **Estimated measurement uncertainty:** Uncertainty calculations for individual measurements are determined by the instrument used for the measurement. A FlowTracker measurement outputs a statistical value in percent that should be divided by 100 and then multiplied by the mean discharge value for an estimate of the the measurement's uncertainty. StreamPro uncertainty calculations are obtained by multiplying an error factor based on the number of transects, by the measurement's coefficient of variation (CV), and then by the mean discharge value. The error factors are 1.6 for 4 transects, 0.8 for 8 transects, and 0.6 for 12 transects. Table 2 summarizes the instruments used for each measurement and the statistical values. **Associated measurement uncertainty:** Propagation of uncertainty for the streamflow gain or loss attributed to groundwater was calculated using the following formula: $s = \sqrt{(\pm a)^2 + (\pm b)_2 + (\pm n)^2}$ Where s is the uncertainty propagated from all estimated individual uncertainties and a, b, ..., n are the estimated uncertainties for the median discharge measurement at each site. **Abbreviations:** ft^3/s, cubic feet per second; $(ft^3/s)/mi$, cubic feet per second per mile; –, not applicable or no remarks; mi, miles; (e), estimate (10 percent uncertainty used in calculation)]

Site No.	Station No.	Mean mainstem discharge (ft^3/s)	Mean discharge from return/tributary (+) or diversion/ withdrawal (-) (ft^3/s)	Estimated measurement uncertainty (ft^3/s)	Estimated streamflow gain (+) or loss (-) attributed to groundwater and associated measurement uncertainty (ft^3/s)	Distance (mi)	Gain or loss (-) per mile [$(ft^3/s)/mi$]	Remarks
1	13203510	1,770	–	±56.6	–	0.0		–
2	4332391160601	–	[1](-) 14.0	±0.140	–			Value provided by IDWR - assessed an uncertainty of 1 percent based on equipment specifications, and calibration standards provided by United Water
4	4333121160658	–	(+) 1 (e)	±0.1	–			–
5	4333431160739	1,600	–	±25.6	(-) 157 ±62	2.64	(-) 59	Losing reach
6	13203758	–	(-) 441	±0.00	–			–
7	13203900	–	(+) 1 (e)	±0.1	–			–
8	13204000	–	–	–	–			–
9	4334101160826	1,030	–	±82.4	(-) 130 ±86	3.61	(-) 134	Losing reach
10	13204005	–	(-) 4.74	±0.119	–			–
11	4334301160902	1,130	–	±18.1	(+) 105 ±84.4	4.35	142	Gaining reach
12	13204010	–	(-) 78.4	±1.41	–			–
13	13204190	–	(-) 21.5	±0.344	–			–
14	4335591161033	–	[1](-) 9.04	±0.090	–			Value provided by IDWR - assessed an uncertainty of 1 percent based on equipment specifications, and calibration standards provided by United Water
15	4336031161104	1,120	–	±17.9	(+) 98.9 ±25.5	7.08	36	Gaining reach
16	13205010	–	(+) 1 (e)	±0.1	–			–
17	4336041161129	–	(+) 47.8	±1.29	–			–
18	4336251161221	1,100	–	±17.6	(-) 69 ±25	8.38	(-) 53	Losing reach
19	13205510	–	(+) 0.08 (e)	±0.01	–			–
20	4336431161301	1140	–	±18.2	(+) 39.9 ±25.3	9.05	59.6	Gaining reach
21	13205515	–	(-) 202	±3.23	–			–
22	13205609	–	(+) 20.2	±0.929	–			–

Table 8. Summary of discharge measurements, calculated gain and loss estimates, and associated estimates of uncertainty on selected reaches of the Boise River, Idaho, August 3, 2010—Continued.

[Measurements taken from U.S. Geological Survey streamflow-gaging stations. **Estimated measurement uncertainty:** Uncertainty calculations for individual measurements are determined by the instrument used for the measurement. A FlowTracker measurement outputs a statistical value in percent that should be divided by 100 and then multiplied by the mean discharge value for an estimate of the the measurement's uncertainty. StreamPro uncertainty calculations are obtained by multiplying an error factor based on the number of transects, by the measurement's coefficient of variation (CV), and then by the mean discharge value. The error factors are 1.6 for 4 transects, 0.8 for 8 transects, and 0.6 for 12 transects. Table 2 summarizes the instruments used for each measurement and the statistical values. **Associated measurement uncertainty:** Propagation of uncertainty for the streamflow gain or loss attributed to groundwater was calculated using the following formula: $s = \sqrt{(\pm a)^2 + (\pm b)_2 + (\pm n)^2}$ Where s is the uncertainty propagated from all estimated individual uncertainties and a, b, ..., n are the estimated uncertainties for the median discharge measurement at each site. **Abbreviations:** ft^3/s, cubic feet per second; $(ft^3/s)/mi$, cubic feet per second per mile; –, not applicable or no remarks; mi, miles; (e), estimate (10 percent uncertainty used in calculation)]

Site No.	Station No.	Mean mainstem discharge (ft^3/s)	Mean discharge from return/tributary (+) or diversion/ withdrawal (-) (ft^3/s)	Estimated measurement uncertainty (ft^3/s)	Estimated streamflow gain (+) or loss (-) attributed to groundwater and associated measurement uncertainty (ft^3/s)	Distance (mi)	Gain or loss (-) per mile [$(ft^3/s)/mi$]	Remarks
23	4337221161404	996	–	±15.9	(+) 37.8 ±24.5	10.22	32.3	Gaining reach
24	13205622	–	(-) 17.8	±0.552	–			–
25	13205640	–	(-) 183	±2.56	–			–
26	4338231161441	–	[2](+) 17.0	±0.816	–			Value provided by City of Boise - assessed an uncertainty of 4.8 percent based upon measurement information from treatment facility
27	4338271161454	801	–	±25.6	(-) 11.2 ±30.3	11.79	(-) 7.13	Difference in measured discharge in subreach is less than the associated measurement uncertainty
28	13205647	–	(+) 8.58	±0.120	–			–
29	4339091161600	820	–	±26.2	(+) 10.4 ±36.7	13.08	8.08	Difference in measured discharge in subreach is less than the associated measurement uncertainty
30	4339361161642	–	(+) 1.30	±0.092	–			–
31	13206000	809	–	±38.8	(-) 12.3 ±46.9	13.95	(-) 14.1	Difference in measured discharge in subreach is less than the associated measurement uncertainty
		Overall net gain (+) or loss (-) throughout the reach = (-) 88 ±69						Losing reach

[1]Value provided by Idaho Dept. of Water Resources (IDWR).

[2]Value provide by City of Boise.

Conclusions

A four-season comparison, provided by a snapshot of normal conditions in the study reach found the following trends. Groundwater gains and losses in the reach tended to be smaller during fall and winter when there were low stream discharges. During the higher spring and summer stream discharges, the upper end of the reach between sites 1 and 15 had greater magnitude in losses and gains [-134 to 142 cubic feet per second per mile ($ft^3/s/mi$)] (table 9). This is in contrast to the lower one-half of the reach between sites 15 and 31 where the range of variability was only -53–59.6 (ft^3/s)/mi (table 9). Subreaches 1–5 consistently gained during low flows, and lost during high flows. Subreaches 9–11 behaved in the opposite manner and always had the greatest gains during high stream discharge regimes and the greatest losses during low stream discharge conditions of any subreach normalized per mile. Subreaches 11–15 gained during all sampling periods, and different stream discharge regimes (fig. 3).

A comparison of groundwater hydraulic potential at low and high stream discharge, on the left and right banks, showed an overall groundwater to surface-water hydraulic trend throughout the reach with the greatest positive hydraulic head differential measured at site 1, at low stream discharge, of 0.38 ft; however, there are some notable exceptions. Site 15 on the right bank, during both high and low stream discharge, had the largest negative hydraulic head differentials of -0.53 and -0.47 ft, respectively, indicating a strong potential for surface-water to groundwater movement at this site. The third largest negative hydraulic head differential occurred on the right bank at site 23 during high flows, with a measured difference of -0.34 ft (fig. 4).

Table 9. Seasonal summary of mainstem discharge measurements, with calculated gain and loss estimates, and associated estimates of uncertainty, during water year 2010, on selected reaches of the Boise River, Idaho.

[**Abbreviations:** ft^3/s, cubic feet per second; (ft^3/s)/mi, cubic feet per second per mile; –, not applicable or no remarks; mi, miles]

Site No.	Station No.	Distance (mi)	Mean mainstem discharge (ft^3/s)	Estimated streamflow gain (+) or loss (-) attributed to groundwater and associated measurement uncertainty (ft^3/s)	Gain or loss (-) per mile [(ft^3/s)/mi]
Autumn – November 5, 2009					
1	13203510	0.0	218	–	–
5	4333431160739	2.64	227	(+)13.1 ±7.08	4.96
9	4334101160826	3.61	228	(+)1.00 ±6.32	1.03
11	4334301160902	4.35	213	(-)15.0 ±6.08	(-) 20.3
15	4336031161104	7.08	200	(+)32 ±8	12
18	4336251161221	8.38	221	(+)5 ±8	4
20	4336431161301	9.05	210	(-)11.0 ±7.36	(-) 16.4
23	4337221161404	10.22	231	(+)20.0 ±5.77	17.1
27	4338271161454	11.79	230	(-)18.0 ±6.09	(-) 11.5
29	4339091161600	13.08	246	(+)16.0 ±7.54	12.4
31	13206000	13.95	245	(-)1.00 ±7.43	(-) 1.15
Net gain (+) or loss (-) throughout the reach = (+) 42 ± 8					

Table 9. Seasonal summary of mainstem discharge measurements, with calculated gain and loss estimates, and associated estimates of uncertainty, during water year 2010, on selected reaches of the Boise River, Idaho—Continued.

[**Abbreviations:** ft^3/s, cubic feet per second; $(ft^3/s)/mi$, cubic feet per second per mile; –, not applicable or no remarks; mi, miles]

Site No.	Station No.	Distance (mi)	Mean mainstem discharge (ft^3/s)	Estimated streamflow gain (+) or loss (-) attributed to groundwater and associated measurement uncertainty ($ft^{3/}s$)	Gain or loss (-) per mile [$(ft^3/s)/mi$]
			Winter – February 8, 2010		
1	13203510	0.0	240	–	–
5	4333431160739	2.64	242	(+) 7.50 ± 7.20	2.84
9	4334101160826	3.61	258	(+) 16.0 ± 6.93	16.5
11	4334301160902	4.35	235	(-) 23.0 ± 6.43	(-) 31.1
15	4336031161104	7.08	222	(+) 30.2 ± 8.95	11.1
18	4336251161221	8.38	245	(+) 3 ± 10	2
20	4336431161301	9.05	243	(-) 2.00 ± 7.87	(-) 2.99
23	4337221161404	10.22	263	(+) 19.1 ± 7.40	16.3
27	4338271161454	11.79	260	(-) 20.0 ± 7.49	(-) 12.7
29	4339091161600	13.08	264	(+) 4.00 ± 11.3	3.10
31	13206000	13.95	281	(+) 17.0 ± 11.1	19.5
			Net gain (+) or loss (-) throughout the reach = (+) 52 ± 7		
			Spring – May 25, 2010		
1	13203510	0.0	2,410	–	–
5	4333431160739	2.64	2,330	(-) 72 ± 52	(-) 27
9	4334101160826	3.61	1,880	(+) 32 ± 36	33
11	4334301160902	4.35	1,910	(+) 34.0 ± 25.3	46.0
15	4336031161104	7.08	1,890	(+) 80.0 ± 46.8	29.3
18	4336251161221	8.38	1,920	(-) 32.2 ± 50.9	(-) 24.7
20	4336431161301	9.05	1,900	(-) 21.5 ± 38.1	(-) 32.1
23	4337221161404	10.22	1,750	(-) 6.10 ± 41.6	(-) 5.21
27	4338271161454	11.79	1,590	(+) 24.5 ± 47.4	15.6
29	4339091161600	13.08	1,560	(-) 33.9 ± 47.4	(-) 26.2
31	13206000	13.95	1,580	(+) 19 ± 38	22
			Net gain (+) or loss (-) throughout the reach = (+) 24 ± 51		
			Summer – August 3, 2010		
1	13203510	0.0	1,770	–	–
5	4333431160739	2.64	1,600	(-) 157 ± 62	(-) 59
9	4334101160826	3.61	1,030	(-) 130 ± 86	(-) 134
11	4334301160902	4.35	1,130	(+) 105 ± 84.4	142
15	4336031161104	7.08	1,120	(+) 98.9 ± 25.5	36
18	4336251161221	8.38	1,100	(-) 69 ± 25	(-) 53
20	4336431161301	9.05	1,140	(+) 39.9 ± 25.3	59.6
23	4337221161404	10.22	996	(+) 37.8 ± 24.5	32.3
27	4338271161454	11.79	801	(-) 11.2 ± 30.3	(-) 7.13
29	4339091161600	13.08	820	(+) 10.4 ± 36.7	8.08
31	13206000	13.95	809	(-) 12.3 ± 46.9	(-) 14.1
			Net gain (+) or loss (-) throughout the reach = (-) 88 ± 69		

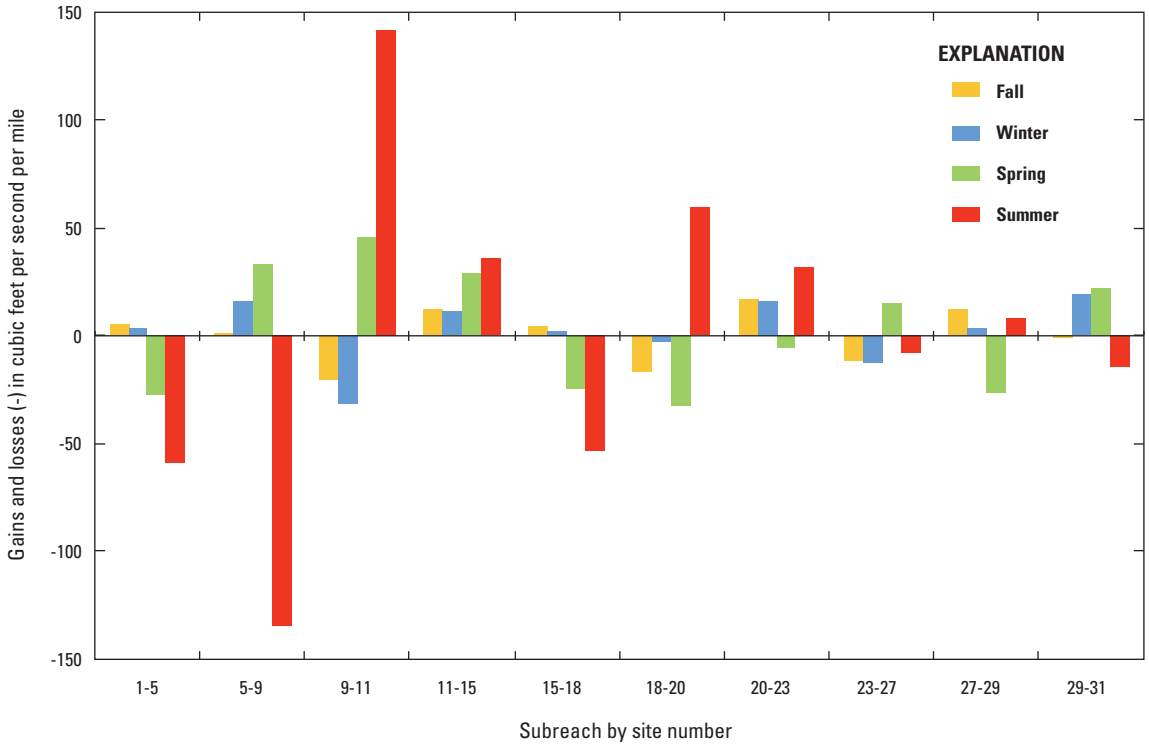


Figure 3. Cumulative seasonal representative gains and losses along subreaches of the Boise River from below the Diversion Dam to the Glenwood Bridge, Boise, Idaho (see figure 1 and table 1 for subreach locations and descriptions).

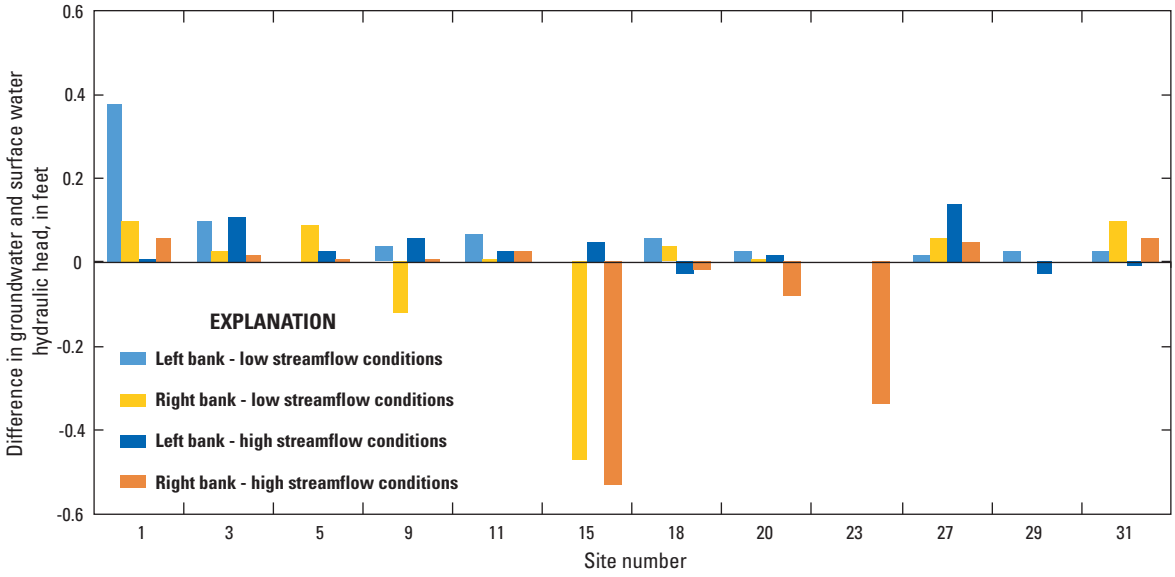


Figure 4. Representative seasonal summary of the difference in hydraulic head measured at transect sites along the Boise River, Idaho (see figure 1 and table 1 for transect locations and descriptions).

Summary

The U.S. Geological Survey in cooperation with the Idaho Department of Water Resources Treasure Valley Comprehensive Aquifer Management Planning effort investigated seasonal groundwater gains and losses on the Boise River, Idaho, starting in November 2009 through August 2010. The investigation was conducted using seepage runs in 11 subreaches over a 14-mile reach from downstream of the inactive streamgage, Boise River below Diversion Dam (U.S. Geological Survey station No. 13203510) to the active Boise River at Glenwood Bridge streamgage (U.S. Geological Survey station No. 13206000). The seepage runs measured mainstem discharge, and significant tributary contributions and diversions along the reach. In addition, an evaluation of the groundwater hydraulic gradient was simultaneously conducted through shallow groundwater mini-piezometers adjacent to the river during February (low stream discharge) and May (high stream discharge) measurement timeframes.

November discharge estimates, representative of autumn, had gains and losses that varied by subreach with an overall net gain of 42 ± 8 cubic feet per second (ft^3/s). This finding compares favorably to a previous U.S. Geological Survey seepage investigation in November 1996 that found a gaining reach with an estimated gain of 52 ft^3/s. This finding also is supported by a U.S. Geological Survey investigation in the study reach in November 1971 that estimated a gain of 74 ft^3/s, which largely came from groundwater. The February discharge estimates, representative of winter conditions, showed variability in the reach with a net gain of 52 ft^3/s with an uncertainty estimate of ±7 ft^3/s, which is consistent with the low stream discharge findings from November 2009. This finding is further supported by the differential hydraulic head measured at transect sites that qualitatively indicated groundwater to surface-water movement with few exceptions. The May discharge estimates, representative of the spring-time conditions, were gaining or potentially gaining in all but one of the upper subreaches between Boise River below Diversion Dam and Boise River near MK Nature Center sites, with seepage run results supported by hydraulic head differentials indicating a groundwater to surface-water movement. The lower end of the study reach between Boise River near MK Nature Center and Boise River at Glenwood Bridge sites showed more variability with observed hydraulic head differentials that partially supported the potential gains or losses in the reach. Overall, the reach had a calculated net gain of 24 ± 51 ft^3/s; because the net gain does not exceed the estimate of uncertainty, this estimate may or may not reflect the actual conditions in the reach. The groundwater gains and losses in August, representative of summer conditions, varied in both the upper and lower parts of the reach, with a net loss of -88 ± 69 ft^3/s.

Overall, the reach experienced a net gain from groundwater at low stream discharges (November and February), a net loss to groundwater at moderately high stream discharge (August), and an ambiguous finding at a higher stream discharge (May). The hydraulic head differentials measured between the groundwater and surface water largely supported the calculated gain and loss estimates in the subreaches, with a potential for groundwater to surface -water movement at low stream discharge in February, and variability during high stream discharge conditions in May.

Acknowledgments

I would like to thank the Idaho Department of Water Resources and United Water for their support and cooperation for the duration of this study, and the USGS Boise Field Office and Idaho Water Science Center personnel who spent long hours in the field conducting all measurements on single sampling days. Their dedication and support was essential in providing dependable data for this investigation. I would also like to thank Molly Wood, the Idaho Water Science Center's Surface Water Specialist for her encouragement and support during this investigation, and Rhonda Weakland, for her assistance on the study area map.

References Cited

Berenbrock, C., 1999, Streamflow gains and losses in the lower Boise River basin, Idaho, 1996–97: U.S. Geological Survey Water-Resources Investigations Report 99–4105, 25 p.

Douglas, I., 1983, The urban environment: Edward Arnold, 240 p.

Mueller, D.S., and Wagner, C.R., 2009, Measuring discharge with acoustic Doppler current profilers from a moving boat: U.S. Geological Survey Techniques and Methods 3A–22, 72 p. (available online at http://pubs.water.usgs.gov/tm3a22).

National Weather Service, 2008, Observed Weather Reports—Preliminary Monthly Climate Data (CF6)—Boise, Idaho: NOAA National Weather Service Forecast Office database, accessed May 20, 2011 at http://www.weather.gov/climate/index.php?wfo=boi.

Oberg, K.A., Morlock, S.E., and Caldwell, W.C., 2005, Quality-assurance plan for discharge measurements using acoustic Doppler current profilers: U.S. Geological Survey Scientific Investigations Report 2005–5183, 35 p.

Rantz, S.E., and others., 1982, Measurement and computation of streamflow—volume 1, measurement of stage and discharge: U.S. Geological Survey Water Supply Paper 2175, 284 p.

Rosenberry, D.O., and LaBaugh, J.W., 2008, Field techniques for estimating water fluxes between surface water and ground water: U.S. Geological Survey Techniques and Methods 4–D2, 135 p. (available online at http://pubs.usgs.gov/tm/04d02)

Simonds, F.W., and Sinclair, K.A., 2002, Surface water - ground water interactions along the Lower Dungeness River and vertical hydraulic conductivity of streambed sediments, Clallam County, Washington, September 1999–July 2001: U.S. Geological Survey Water Resources Investigation Report 02–4161, 69 p.

SonTek/YSI, 2009, FlowTracker handheld ADV technical manual, firmware version 3.7, software version 2.30: SonTek/YSI, San Diego, CA, 116 p.

Thomas, C.A., and Dion, N.P., 1974, Characteristics of streamflow and ground-water conditions in the Boise River valley, Idaho: U.S. Geological Survey Water-Resources Investigations Report 74–38, 56 p.

Wheeler, J.D., and Eddy-Miller, C.A., 2005, Seepage investigation on selected reaches of Fish Creek, Teton County, Wyoming, 2004: U.S. Geological Survey Scientific Investigations Report 2005–5133, 22 p.

Winter, T.C., LaBaugh, J.W., and Rosenberry, D.O., 1988, The design and use of a hydraulic potentiomanometer for direct measurement of differences in hydraulic head between groundwater and surface water: Limnology and Oceanography, v. 33, no. 5, p. 1209–1214.

Publishing support provided by the U.S. Geological Survey
Publishing Network, Tacoma Publishing Service Center

For more information concerning the research in this report, contact the
Director, Idaho Water Science Center
U.S. Geological Survey
230 Collins Road
Boise, Idaho 83702
http://id.water.usgs.gov