Rationale for Protest of Permit Applications 37-22682 and 37-22852

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Introduction

The Idaho Department of Fish and Game (IDFG) is seeking to fulfill its mission of protecting, preserving, perpetuating and managing fish and wildlife resources by providing technical information to decision makers regarding fish, wildlife and affiliated resources such as riparian and riverine habitat; identifying the potential effects of the proposed water rights on the fish and wildlife; and assessing how any adverse effects can be avoided, minimized or mitigated. IDFG neither supports nor opposes managed aquifer recharge proposals for the Big Wood River (BWR). IDFG is providing this information and any recommendations to uphold the wildlife policy of the State of Idaho.

IDFG is aware of recharge applications with points of diversion on the BWR and its tributaries. The diversion and designated use associated with Water Right Applications 37-22682 and 37-22852 have the potential to affect the BWR from near Ketchum to the backwaters of Magic Reservoir. Furthermore, diversion and recharge under these rights could affect streamflow in Silver Creek, given the documented surface and subsurface water flow interaction between the BWR and Silver Creek (Smith 1960, Wetzstein et al. 1999). Application 37-22682 requests a year-round diversion rate of 154 cfs, carries a priority date of 2/10/2012, and lists numerous points of diversion upstream and downstream of the town of Hailey. Application 37-22852 requests a year-round diversion rate of 10 cfs, carries a priority date of 10/21/2013, and lists one point of diversion, which is upstream of Hailey. This report demonstrates the potential negative effect such diversions could have on fish and wildlife resources in the BWR if groundwater recharge plans are authorized and implemented without managing the timing and quantities of water diverted for recharge as they relate to hydrologic functions important to fish and wildlife resources. The ideas and principles in this discussion have broad application for impacts to riverine systems from cumulative flow reductions.

The science and management of altered flow regimes is informed by a substantial body of literature (reviewed in Poff and Zimmerman 2010). In the upper BWR basin of Idaho, irrigation and water development projects began in the 1880s, and since that time have resulted in one storage reservoir, numerous river and tributary diversions throughout the basin, and pumping of groundwater for a variety of uses. While most of the surface water in the basin has been appropriated for various beneficial uses (chiefly irrigation), in recent decades groundwater pumping has significantly increased. The increase in groundwater use, coupled with improved irrigation efficiency has resulted in declining levels of the Wood River Valley aquifer system. The connection between ground water and surface water is acknowledged in Idaho's conjunctive management rules.

This document assesses some potential effects resulting from proposed recharge diversions within the hydrologically connected BWR and Little Wood River basins, focusing on the BWR above Magic Reservoir and on Silver Creek. Surface flows in Silver Creek could be positively or negatively influenced by implementation of these water rights. Specific groundwater responses within the Wood River Valley aquifer system, and resulting effects on streamflow, would be better understood with the completion of the groundwater model being developed by Idaho Department of Water Resources (IDWR) and the U.S.

Geological Survey (USGS). In absence of the groundwater model and of specific information on timing, location, and volume of potential recharge activities, we are unable to quantify effects to Silver Creek. However, this document includes a review of hydrologic interactions between the BWR and Silver Creek and provides some hypothetical examples of how Silver Creek flow could be affected by diversion and recharge under the proposed water rights.

Areas of Fish and Wildlife Resource Concern

The BWR drainage (about 195,000 hectares) is located in southern central Idaho and travels through portions of Blaine, Camas, Gooding, and Lincoln counties (Frenzel 1982). Major tributaries include the North Fork BWR, Warm Springs Creek, Trail Creek, East Fork BWR, and Deer Creek. The BWR is a snowmelt-dependent stream system that flows unimpounded for approximately 99 km before joining Magic Reservoir (constructed in 1909). The river continues approximately 89 km downstream of Magic Reservoir Dam at which point it converges with the Little Wood River to form the Malad River. The BWR drainage originates at an elevation of over 3,600 m above sea level and terminates after it joins the Little Wood River to form the Malad River, ultimately intersecting the Snake River at an elevation of approximately 826 m (Figure 1; Thurow 1987, Rapp 2006).

The BWR is similar to mountain streams found throughout central Idaho, having a coarse stream bed primarily composed of gravels and cobbles, and in the more heavily armored sub-reaches, cobbles and boulders (Rapp 2006). The 10-yr, 100-yr, and 500-yr peak flow recurrence is estimated at 4,340, 6,740, and 8,270 cfs at the Hailey gage station (USGS gage 13139500), respectively (Rapp 2006).

The BWR upstream from the backwaters of Magic Reservoir has a history of alteration. For more than a century the river has been manipulated by shoreline hardening (riprap), bridge construction, irrigation diversions, gravel dredging, highway protection, and flood control structures (dikes and levees). Rapp (2006) estimated that 40% of the 34 km study reach from Warm Springs to Glendale was altered by levee construction and riprap installment. In the mid-1980s the U.S. Army Corps of Engineers (USACE) removed large woody debris from approximately 44 km to improve channel conveyance (USACE 1984, USACE 1985).

For the purposes of this report, the BWR from the backwaters of Magic Reservoir Dam to its headwaters was divided into three sections: (1) from Magic Reservoir upstream to Glendale Diversion, (2) from Glendale Diversion upstream to the confluence of the North Fork Big Wood, and (3) from the North Fork BWR upstream to the headwaters. This delineation is loosely based on riparian, floodplain, streamflow (gaining vs. losing), and water management characteristics.

In Section 1 the BWR flows through a combination of forested shrubland riparian and sagebrush steppe habitat. Stream gradient is lower in this section than sections 2 and 3. Surface connectivity with the upper BWR is intermittent due to natural conditions and irrigation-related water management. The lower portion of this reach, from the backwaters of Magic Reservoir to the Stanton Crossing area, maintains high quality, low-elevation forested shrubland riparian habitat (Jankovsky-Jones 1997), which is primarily held in public ownership (U.S. Bureau of Land Management and State of Idaho) and managed for fish and wildlife benefit and public recreation. This lower portion is characterized as a gaining reach heavily dependent upon groundwater emergence at springs to provide surface flows (Wetzstein et al. 1999). Conversely, the majority of the reach above Stanton Crossing is privately owned and managed for livestock grazing, industrial gravel extraction, and recreation. This reach is characterized as a losing reach (Sukow 2014), through which surface flows may not be sufficient to maintain year-round surface flow connections. Riparian habitat conditions throughout this reach are generally poor as evidenced by decadent park-like stands of cottonwood with scattered willows and an understory dominated by exotic grasses and upland shrubs (Jankovsky-Jones 1997).

Section 2 flows through similar habitats as Section 1; however, this section is heavily influenced by urban development. The Hailey stream gage station lies within this reach. Upstream of the Hailey gage, the BWR generally gains water from the aquifer, but downstream of Hailey the BWR loses water to the aquifer (Sukow 2014). Nonetheless, the BWR flows perennially throughout Section 2. Most major tributaries join the BWR in this reach, contributing substantially to mainstem flows (Skinner et al. 2007). The majority of the surface irrigation diversions on the BWR occur in Section 2, but the largest of these occur downstream of the Hailey gage. As a result, the hydrograph of the BWR at the Hailey gage has been altered only slightly due to diversion (Figure 2). We therefore use flow at the Hailey gage as a reference that represents roughly unregulated conditions.

Section 3 is upstream from most irrigation diversions and would not be altered by implementation of the proposed recharge water rights. This reach experiences perennial flows and is generally less influenced by channel alteration and urbanization. This upper reach is important for salmonid spawning.

Silver Creek is a 39-km spring fed-system that resides in the Little Wood River hydrologic basin. The Silver Creek drainage encompasses approximately 27,500 hectares and drops in elevation from 1,509 m at its headwaters to 1,448 m at the confluence with the Little Wood River (Figure 1, Thurow 1978). The majority of the basin is privately owned (about 64%) and managed for agricultural production with the remaining component being held in public ownership (USDA 1996, Ecosystem Sciences Foundation 2011). Flows in Silver Creek are maintained primarily by groundwater discharge at springs, with some influence from the diversion of BWR surface water for irrigation purposes. The major spring-fed tributaries include Stalker, Grove, and Loving creeks. The majority of streamflow in the Little Wood River past the confluence with Silver Creek is dependent upon Silver Creek discharge. Silver Creek is subject to annual streamflow fluctuations, which can negatively impact trout habitat particularly in low water years, as evidenced by The Nature Conservancy's (TNC) access closure in 2014. TNC temporarily closed access to Silver Creek through Silver Creek Preserve, citing concerns about habitat related salmonid stress and compounding angler impacts.

Description of Fish and Wildlife Resources

Fisheries

The fish community within the BWR drainage upstream of the backwaters of Magic Reservoir is a cold-water fish community comprised of both native and introduced species. Species common to all sections (1-3) include Rainbow Trout *Oncorhynchus mykiss* (hatchery and wild origin), Brook Trout *Salvelinus fontinalis,* Mountain Whitefish *Prosopium williamsoni*, Wood River Sculpin *Cottus leiopomus,* Bridgelip Sucker *Catostomus columbianus*, and Longnose Dace *Rhinichthys cataractae*. Redband Trout *Oncorhynchus mykiss gairdneri* are indigenous (Behnke 1979); however, recent genetic surveys have described the BWR *O. mykiss* population as hybridized with coastal-origin hatchery rainbow trout (Kozfkay et al. 2011). The Wood River Sculpin is the only fish species of special concern classification (Idaho status G2S2 – Imperiled: at risk due to limited distribution) found above Magic Reservoir; nevertheless, it is relatively abundant within the BWR drainage (Meyer et al. 2008).

The fish community in Section 1 differs from Section 2 and 3 due to a slight influence from Magic Reservoir. Warm- or cool-water reservoir species including Smallmouth Bass *Micropterus dolomieu* and Yellow Perch *Perca flavescens* are found in low numbers in this section of the BWR. Non-game fish species found in this section include Speckled Dace *Rhinichthys osculus* and Redside Shiner *Richardsonius balteatus*. Although found in sections 1 and 2, resident and adfluvial Brown Trout *Salmo trutta* are most prevalent in Section 1. The majority of Brown Trout spawning occurs in the lower portions of Section 1, since surface-flow connectivity needed for migration to the upper drainage (Section 2) is often lacking during the fall spawning period. Some Rainbow Trout spawning occurs within this section, but most wild resident and adfluvial Rainbow Trout migrate upstream from Section 1 to spawn in the mainstem, side channels, and tributaries in sections 2 and 3. Rainbow Trout spawning migrations occur from March through May. While Section 1 is highly accessible to anglers, angling effort is relatively low when compared to upstream sections of the BWR (Thurow 1986, Stanton et al. 2013).

The relative abundance of Brown Trout, both the resident and adfluvial form, is substantially lower in Section 2 than Section 1, making up only 6% of the catch in a 2009 survey near Hailey and 0% in reaches upstream of Gimlett, Idaho (Stanton and Megargle 2014). Although much of the shoreline is privately owned, there is substantial public access provided through public property, private easements, and public right-of-ways. Thurow (1987) estimated anglers fished a combined total of 29,222 hours on 11 sections of the BWR from Easley to above Magic Reservoir between June 14 and November 14, 1986. Subsequent surveys in three of the 11 sections generated cumulative angler effort estimates of 6,450, 9,200, 11,950, and 8,737 hours in 1986, 1987, 1993, and 2008, respectively (Thurow 1986, Thurow 1987, Partridge and Warren 1993, Stanton and Megargle 2014).

Based on catch composition in past surveys the fish community in Section 3 is less diverse relative to sections 1 and 2 (IDFG, unpublished data). Catch composition in a 2009 survey showed the presence of Rainbow Trout, Mountain Whitefish, Bridgelip Sucker, and Wood River Sculpin. Rainbow Trout made up 87% of the total trout catch.

The BWR has a long history of fisheries population and habitat monitoring by IDFG (Table 1). General fish population and habitat surveys and angler effort and harvest studies have been undertaken for decades (Table 1). Fish population surveys continue to be conducted at three year intervals. Trout abundance estimates have varied among these surveys and will not be addressed specifically in this report. However, it is worth mentioning that Thurow (1988) suggested BWR trout densities and growth were comparable to those found in Silver Creek and the Henrys Fork of the Snake River. Warren and Megargle (2009) inferred stream discharge was influencing trout abundance, based on a decline in abundance following a series of low annual peak flows.

IDFG has commissioned a number of long-term research projects on fish populations and habitat in the BWR. In the mid-1980s Thurow (1987, 1988, and 1990) conducted an in-depth evaluation of the biological impact of habitat alteration (floodplain development and flood control structures) on BWR game fish populations. Trout densities were eight to ten times larger in unaltered reaches, where cover components were present, than in reaches with rock revetments or no cover. Further, densities of wild rainbow trout increased as the area of woody debris cover increased.

The fish community in Silver Creek from its mouth to its headwaters is a cold-water community comprised of both native and non-native sport and nongame fish species. Currently, four sportfish species are found in the system including Rainbow, Brown, Brook Trout, and Mountain Whitefish. Nongame species include Bridgelip Sucker, Longnose Dace, Speckled Dace, Redside Shiner, and Wood River Sculpin (Hauck 1947, Gebhards 1963, Bell 1966, Riehle et al. 1989, Wilkison 1996). With the exception of Mountain Whitefish, all salmonid species are introduced (Mallet 1978, Williams et al. 2000). Brown Trout abundance has increased and Rainbow Trout and Mountain Whitefish have decreased since the early 1970's (Parker and Riehle 1987, Wilkison 1996, Ryan et al. 2013). Brown Trout abundance is generally greater in the lower reaches of Silver Creek; however, their numbers have been increasing over the past decade throughout the entire drainage.

Silver Creek is considered a renowned, blue-ribbon trout fishery and is one of Idaho's destination fly fishing areas. Anglers are attracted to this fishery because of its challenging fishing, remarkable habitat, and the attraction to a very productive spring-creek system. Because of the high fishery value of Silver Creek, numerous research projects have been implemented by private organizations, universities, and State agencies. The Silver Creek fishery is a staple for local outfitters and guides, who provide services to both resident and non-resident anglers. Thurow (1978) estimated anglers spent 19,735 hours fishing during the fishing season in 1977, and Mallet (1978) estimated 32,033 hours of effort the following year. That creel survey was duplicated ten years later and it was estimated anglers spent 20,931 hours fishing (Riehle et al. 1989). Ryan et al. (2013) generated a similar estimate in 2009 with an angler effort estimate of 29,764 hours.

As described in DerHovanisian (1995), fish entrainment (fish loss) in canals has been documented throughout the western U.S., including Idaho (Hauck 1949, Gebhards 1958, Thurow 1980, Thurow 1981, Thurow 1987, Elle et al. 1987, Thurow 1988, DerHovanisian 1997a, DerHovanisian 1997b, DerHovanisian and Megargle 1998), and in some instances the level of entrainment has limited the fishery (Spoon 1987, Jensen 1971, Jensen et al. 1988). The effect of canal entrainment has been evaluated in the BWR drainage. Megargle (1999) evaluated fish exploitation (% lost from natural stream), within-canal movements, and population influences in four BWR canals. The rate of canal entrainment was stochastic and unique to each diversion. Entrainment potential was generally based on headgate location (both longitudinally and with respect to stream orientation), headgate design, seasonality, and proportion of streamflow captured at the diversion (DerHovanisian and Megargle 1998, Megargle 1999). These studies concluded that the majority of fish losses attributed to canals were juvenile trout and that exploitation (mortality) was substantial but not necessarily additive under existing water management and fishing pressure. It is unknown what population effect might occur if diversion occurs outside of the traditional irrigation season.

The Idaho Water Resources Board currently holds three minimum streamflow water rights in the BWR. IDFG first evaluated the BWR flow requirements necessary for the maintenance of fisheries, wildlife, habitat, recreation, aesthetics, and other uses in the late 1970s (Cochnauer and Buettner 1978, Horton 1982). Two minimum streamflow water rights (37-8307 and 37-7919) provide for a combined instream discharge of 189 cfs from the mouth of Warm Springs downstream approximately 30 km to the Bellevue Canal Diversion. The most junior of these rights has a priority date of 10/16/1987. A third minimum streamflow water right (37-8258) provides for 200 cfs in the BWR from the Sawtooth National Recreation Area boundary downstream approximately 15 km to the mouth of Warm Springs. This reach lies primarily within Section 3 but extends a short distance into Section 2.

Riparian Habitat, Wildlife, and Plants

The BWR supports extensive black cottonwood forested riparian wetlands and scrub-shrub riparian habitats (e.g., willows *Salix spp.*, Redosier Dogwood *Cornus sericea*, Woods' Rose *Rosa woodsii*, Mountain Alder *Alnus viridis*, etc.) throughout the reaches affected by current and proposed water diversions. In addition to the aesthetic and recreational values provided, floodplain cottonwood forests function as habitat for many bird and mammal species, ranging from Mule Deer *Odocoileus hemionus* and Beaver *Castor canadensis* to Lewis's Woodpecker *Melanerpes lewis* and Wood Ducks *Aix sponsa* (Jankovsky-Jones 1997). This riparian habitat stabilizes river banks (preventing excess sediment contribution to aquatic habitats) and shades the river (lowering water temperatures during the summer), and is therefore important for sustaining populations of cold-water dependent trout and the endemic Wood River Sculpin. Where the river is less constrained by flood control levees, spring and early summer flood flows are attenuated by overflow side channels in the floodplain and slowed by dense vegetation (Jankovsky-Jones 1997). The health of riparian black cottonwood floodplain ecosystems has been declining across western North America, including along the BWR (Jankovsky-Jones 1997), due to long-term impacts from water diversions, clearing of floodplain habitats for urban and agricultural uses, livestock grazing, flood control, and other land uses (Braatne et al. 1996, Jankovsky-Jones 1997, Rood et al. 2003, Hauer and Lorang 2004).

Bald Eagles *Haliaeetus leucocephalus*, a seasonal resident along the BWR, were delisted from Endangered Species Act (ESA) in 2007 but are currently protected by the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act, and are designated as a Species of Greatest Conservation Need in Idaho. Mid-winter surveys of the BWR, conducted as part of the annual nationwide Midwinter Bald Eagle survey, have found 6-12 wintering Bald Eagles from Hailey to Magic Reservoir. Winter habitats are typically characterized by available open water or other food sources (e.g., carrion), and suitable roost sites (large trees) that provide protection from wind and precipitation. One active nest, located in the Stanton Crossing area, and one unconfirmed nest, located in the vicinity of the Starweather Bridge, occurs in forested riparian habitats along the BWR. Preferred breeding sites include forested habitats adjacent to water in areas with minimal human disturbance.

On October 3, 2014, the USFWS published a final rule designating the western U.S. population of Yellow-billed Cuckoo as threatened under the Endangered Species Act (USFWS 2014a). Following the Listing Rule, the USFWS proposed designation of 25,311 acres of critical habitat in Idaho, including 1,129 acres along a 7-mile reach of the BWR downstream of Bellevue to Magic Reservoir (USFWS 2014b). The Yellow-billed Cuckoo is a riparian-dependent species that breeds in low- to moderate-elevation native forests lining rivers and streams. Cottonwood-willow forests are most often used for breeding. The last confirmed observation of a Yellow-billed Cuckoo along the BWR occurred in 2004 (IDFG, unpublished data), although a recently completed habitat assessment and field survey commissioned by the Idaho Transportation Department detected an individual bird along the BWR near Stanton Crossing (PaTT Enterprises 2014).

The river and spring habitats of the BWR delta are occupied by several aquatic invertebrates currently listed as Species of Greatest Conservation Need by IDFG. *Centroptilum selanderorum*, *Bolshecapnia milami*, and *Malenka tina* are all found in reaches of the BWR from Ketchum downstream to Hailey (IFWIS 2014a). As with many other aquatic invertebrates these mayflies and stoneflies spend the majority of their lives in riverine habitats (IDFG 2005).

Green River Pebblesnail *Fluminicola coloradensis* is an aquatic gastropod found in the delta portion of the BWR in the Timmerman area, and is typically associated with rocky substrates and clean, spring-fed water sources (Frest 1999). Within Idaho, populations were historically widespread in southeast Idaho, occurring in springs and tributaries in the Bear River and upper Snake River drainages. Colonies currently exist only within Blaine, Bear Lake, Caribou, and Oneida counties (Frest 1999).

The cottonwood riparian forest along the BWR serves as a movement corridor for Mule Deer and Elk *Cervus canadensis* that migrate annually from high elevation summer habitats in the upper BWR drainage and its tributaries to low elevation winter habitats in southern Blaine County and beyond. The riparian forest also provides good habitat for resident populations of Elk and Mule Deer, small numbers of White-tailed Deer *Odocoileus virginianus*, and a burgeoning Moose *Alces alces* population.

Wetlands associated with the BWR provide habitat for seven plant species of concern; including an endemic, Bugleg Goldenweed *Pyrrocoma insecticruris* (IFWIS 2014b). This species occurs in a wide range of habitats including seasonally wet swales. It has been documented to occur in eight locations within 5 miles of the BWR, and there may be other undocumented locations. Bugleg Goldenweed is a U.S. Forest Service Region 4 sensitive species and has a NatureServe conservation rank of G3S3, meaning the species has a moderate risk of extinction or elimination due to a restricted range, relatively few populations, recent and widespread declines, or other factors.

The BWR drainage contains potentially suitable habitat for Ute Ladies'-Tresses *Spiranthes diluvialis* (Jankovsky-Jones 1997), a federally threatened species that has been found in southeastern Idaho (IFWIS 2014b) and neighboring states. The orchid occurs in association with alluvial substrates along riparian edges, gravel bars, old oxbows, and moist to wet meadows in the floodplains of perennial streams. This species has not been documented from south-central Idaho, but the area has received limited survey effort.

Hunting and Fishing

The BWR from its source downstream to Magic Reservoir and Silver Creek are two of the most popular fisheries in southern Idaho, providing substantial recreational fishing opportunity and economic benefit to the citizens of Idaho. IDFG estimated angler use and accompanying fishing-related spending associated with the BWR and Silver Creek as part of statewide angler economic surveys conducted in 2003 (Grunder et al. 2008) and 2011 (IDFG, unpublished data). In 2003, anglers made 89,035 trips to the BWR, contributing over $8 million dollars to Idaho's economy. In 2011, anglers made over 98,000 trips to the BWR, contributing nearly $10 million dollars to the local economy. In comparison, anglers made 8,667 trips in 2003 and over 12,000 trips in 2011 to Silver Creek, contributing over $2 million dollars and over $5 million to the local economy, respectively. Combined, the BWR and Silver Creek accounted for over 66% of fishing-related spending on Blaine County fisheries in 2011. Much of this direct spending occurs in Idaho communities near the river and generates additional economic activity (economic multiplier) well beyond the figures for direct spending. This information, for fishing activity alone, shows that the BWR and Silver Creek under current water management practices represents an important public trust resource that has tangible value to Idaho citizens, visitors, and communities.

The BWR and Silver Creek are included in game management units (GMU) 48 and 49, which provide a variety of hunting opportunity to Idaho hunters. Big game hunting opportunities along the BWR and Silver Creek are found on small, isolated parcels of State Endowment and BLM administered lands and for hunters able to gain permission from private landowners. In 2013, 1,462 hunters spent in excess of 6,000 days hunting deer in GMU 48 while 564 hunters spent over 3,000 days hunting elk. In GMU 49 2,447 hunters spent nearly 10,000 days hunting deer while 1,239 hunters spent 7,384 days hunting elk in 2013. Moose hunts in these units are closely regulated through controlled hunt permits and are intended to provide an exceptional hunting experience.

General Riverine Ecological Concepts

Stream dynamics and their alteration

Anthropogenic impacts to river function often involve alteration of the hydrologic regime. Poff et al. (1997) described the hydrologic regime as the magnitude, timing, frequency, duration and rates of change of streamflow. The character of the drainage and native landscape interact with the flow regime to drive ecological processes and establish natural habitats within which native and resident species have adapted. These complex, dynamic ecosystems are made up of a network of channels and floodplains that are intermittently connected via changes in flow (Humphries et al. 2014), and the ecological processes that support these ecosystems are generally predictable with respect to the longitudinal and lateral changes in production, discharge, and function (Vannote et al. 1980). Substantial alteration to the aforementioned characteristics of the natural hydrologic regime will therefore alter natural habitat, ultimately affecting the dependent fish and wildlife species (Vannote et al. 1980, Junk et al. 1989, Thorp and Delong 2002, Thorp et al. 2008). Throughout the nation standards have been developed to protect natural stream processes, defining bounds for consumptive and non-consumptive use in order to preserve natural hydrologic regimes and subsequent river function (e.g., environmental flows, ecological flows, ecosystem flows, biological flows, etc.; Baron et al. 2002, Hauer et al. 2004, Apse et al. 2008, MacDonnell 2009, Petts 2009, Smith 2009, DePhilip and Moberg 2013).

Hydrograph stratification

Hauer et al. (2004) highlight five primary time intervals during the water year, with each interval having specific and largely distinct ecological constraints. Interval 1 is the winter period, which generally extends from early November to late February or early March. In the BWR, the primary winter ecological constraint is adequate fish habitat in the form of sufficient streamflows, especially for Rainbow Trout, Brown Trout, and Mountain Whitefish. Interval 2 is the initiation of spring snowmelt, usually in March or April. This is the period where flows gradually begin increasing from the low flows experienced during the winter. Spring-spawning fish species typically begin migrating to spawning grounds in this interval. Interval 3 is the spring high-flow period, usually from April through June, when under natural conditions, snowmelt generates the flows necessary to accomplish channel maintenance work in the river channel and maintain a functioning river-floodplain interface. The high-flow period is essential for maintaining riparian habitats and for those wildlife species that are dependent on healthy riparian habitat. Interval 4 is the period after high flow, usually in late June and July, and is important because the rate of the decline in the falling limb of the hydrograph can affect the regeneration and sustainability of the riparian cottonwood forest. Interval 5 focuses on the summer and fall hydrograph recession period (generally from July through October), up to the onset of winter.

Within the proposed aquifer recharge time period, all intervals would potentially experience altered flow because the water rights have a year-round season of use. In the rare instances when the proposed aquifer recharge might occur during Interval 5, impacts from flow alterations under the current proposal would likely be substantial in most years if not for the minimum streamflow requirements on the BWR. Interval 1 (winter flow) will be considered as a separate time period for addressing biological concerns relative to recharge events. Intervals 2-4 will be considered collectively as the period of spring-summer high flows that includes the ascending, peak, and descending limbs of the hydrograph.

Effects of winter streamflow reductions on fish and wildlife (Interval 1)

In northern latitude rivers, winter can be a very stressful period for stream-dwelling fish. In fact, overwinter survival may be the most prominent limiting factor for stream-dwelling salmonids (Cunjak 1996) when they face a variety of stressful conditions. First and foremost, water temperatures can be extremely cold. Because salmonids are poikilotherms that do not hibernate, cold water temperatures limit their swimming and acceleration abilities, which make them more susceptible to displacement and predation (Huusko et al. 2007). Moreover, metabolic processes are slowed at such temperatures, and stream-dwelling trout often suffer a metabolic deficit during acclimation to rapidly declining water temperatures at the onset of winter (Cunjak and Power 1987, Cunjak et al. 1987). Consequently, energy reserves may not be sufficient to survive the winter, and any added stress, such as flow reductions, may exacerbate their metabolic deficit.

A second difficulty for salmonids in winter is that streamflow is usually reduced to the lowest levels of the year. The availability of suitable physical habitat is already considered the primary factor regulating stream trout populations in winter (Chapman 1966), and additional streamflow reductions, which might occur during aquifer recharge diversions, may magnify this shortfall, further limiting habitat availability and reducing food supplies for stream-dwelling fish.

A third winter stressor on stream-dwelling salmonids in northern latitudes is ice formation. Three types of ice – frazil ice, anchor ice, and surface ice (such as ice shelves) – are common in streams, and all can be harmful to salmonids. Shelf ice can collapse, crushing fish underneath (Needham and Jones 1959), trapping fish in concealment habitat, or preventing them from accessing concealment habitat. In some situations, anchor ice may fill pools where trout would normally aggregate during winter (Brown and Mackay 1995, Jakober et al. 1998), the result being increasing stream velocities in whatever habitat remains. The shallower the river, the more detrimental ice will likely be to stream-dwelling fish.

Numerous studies have noted the common winter behavior exhibited by salmonids of daytime concealment in rocky substrate, woody debris, and other complex habitat structure (e.g., Schrader and Griswold 1992, Griffith and Smith 1993, Meyer and Gregory 2000). In larger rivers, salmonids conceal almost exclusively along shore (Schrader and Griswold 1992, Griffith and Smith 1993). Salmonid concealment during the day is likely a behavior adopted to provide protection from many of the above-mentioned stressors. For instance, concealment may provide protection from physical damage due to ice formation (Brown et al. 2011). Daytime concealment also reduces a fish's exposure to endothermic predators such as birds and mammals (Valdimarsson and Metcalfe 1998). Concealment in cobble/boulder substrate may also provide a thermal benefit (Smith and Griffith 1994).

Whether Mountain Whitefish conceal during winter is not known. Davies and Thompson (1976) reported that Mountain Whitefish overwintered in shallow backwater habitat, which could be dewatered by recharge withdrawals, potentially impacting overwinter survival of whitefish. Other large-bodied, adult fish in the BWR probably overwinter in deep pools where depth provides adequate cover, since suitably sized concealment spaces are usually limited for most adult-sized fish. The accumulation of frazil ice may compromise the utility of pools, and in such cases, side-channel and backwater habitat may at times provide the only available habitat for large-bodied fish during winter (Cunjak 1996).

Because of the above-mentioned conditions during Interval 1, salmonids have a reduced ability to respond to changes in their environment. Unfortunately, water temperatures, discharge, and ice conditions are rarely constant during winter (Brown et al. 2011), so fish are already required to rapidly adapt to changing conditions during a stressful period of the year. Because juvenile salmonids conceal almost exclusively along shore, fluctuations in discharge, especially during the day, can result in fish stranding, and may lead directly to fish mortality (Bradford et al. 1995, Bradford 1997). The availability of backwater habitat in rivers may decrease the numbers of fish that are caught in the current and forced to move downstream, such as during ice break-up events, and if these habitats are unavailable, mortality rates for salmonids may increase.

Mountain Whitefish and Brown Trout, two important salmonids in the BWR, are fall spawners, and eggs of these species incubate through the winter before fry emerge in the spring (Scott and Crossman 1973, Northcote and Ennis 1994, Elliott and Hurley 1998). Egg deposition can occur in extremely shallow water for both Mountain Whitefish (Brown 1952) and Brown Trout (Shirvell and Dungey 1983), and any dewatering or freezing of these spawning areas before or soon after emergence may decrease the survival rate of emerging juvenile fish (Elliott 1985).

The BWR provides important winter foraging habitat for Bald Eagles, and the riparian cottonwoods provide important winter perch and roost habitat. Steenhof et al. (1980) found that Bald Eagles preferred tree perches compared to cliffs, ice, logs, or the ground, and preferred stout, horizontal branches. In this study, nearly all perches were within 30 m of the river, 58% of the perches were within 5 m of the river bank, and eagles preferred mature cottonwood trees. During winter, Bald Eagles forage on fish and waterfowl that are accessible and/or abundant in open water habitat. Bald Eagle foraging could be affected by loss of open water habitats due to winter aquifer recharge efforts.

<u>Effects of reduced spring peak flows on fish and wildlife (Intervals 2 – 4)</u>

It has long been recognized that high streamflows are a necessary component of the annual hydrograph (Leopold et al. 1964). As reviewed in the seminal paper by Poff et al. (1997), naturally-occurring high flow events are crucial to the long-term health of river and floodplain ecosystems because they put in motion a number of important stream ecosystem processes. Bankfull streamflow initiates bedload transport and scouring of vegetation, which helps maintain channel morphology. High flows inundate the floodplain, which sustains and regenerates important streambank and floodplain vegetation such as cottonwoods and willows. High flows also recruit new woody material to the channel and rearrange existing woody debris, creating a mosaic of complex habitat that is important for fish, invertebrates, and other animals. Finally, high flows help flush spawning habitat for salmonids, cleaning fine sediment from the gravel beds where salmonids build redds to incubate their eggs.

Bankfull discharge can be determined empirically by measuring the discharge at which flooding begins to flow out of the stream channel and across the floodplain. However, because this data is often not available, it is more commonly determined based on the knowledge that, in most gravel-bed river drainages, bankfull discharge occurs at roughly a 1.5 year recurrence interval (Leopold et al. 1964, Schmidt and Potyondy 2004). This translates to roughly the 33rd percentile of the annual maximum daily flow over the period of record. For the BWR, based on streamflow during water years 1975-2014 at the Hailey gage station, bankfull discharge was estimated to be 1,709 cfs.

Fundamentally, the shape and function of the river channel, and therefore the habitat for fish and other aquatic organisms, is determined by the physical processes of moving water and sediment in the channel and between the channel and the floodplain (Poff et al. 1997). Rivers migrate across their floodplain by eroding material from the outside bank of meander bends and depositing material on the inside of meander bends, and this occurs primarily at or above bankfull discharge (Leopold et al. 1964). Along the BWR, this “shifting habitat mosaic” and associated functions (e.g., hyporheic exchange, base flow support, thermoregulation, etc.) and outcomes (e.g., cottonwood forest) are present, but are negatively influenced by decades of flow alterations (Hauer and Lorang 2004). Channel maintenance flows in the BWR are vital to maintaining fish habitat, riparian vegetation, and a functioning floodplain. For example, Root (2006) noted wide-spread braiding, channel widening, and channel instability on a 34 km section of the BWR between Warm Springs and Glendale diversion. Climate and precipitation patterns, changes in sediment supplies, and land-use activities in upstream reaches had isolated channel segments from its floodplain, eliminated or restricted in-channel sediment storage functions, and increased stream power (Rapp 2006).

The ability of a river to scour its channels and maintain functioning floodplains is dependent not only on regular attainment and exceedance of bankfull flows, but is also dependent on the duration of bankfull flow events. While it is true that bankfull flows are not needed every year and naturally do not occur every year, it is also true that attainment of bankfull discharge for only a few days each year may not be adequate for maintaining channel capacity and floodplain function (Schmidt and Potyondy 2004). Indeed, the highest-magnitude streamflows, those with a recurrence interval of 50 or more years, may be necessary for creating important pool habitats and rearranging the largest bedload particles in rivers (Whiting 2002).

Schmidt and Potyondy (2004) describe and highlight the following ecological benefits of channel maintenance flows:

- Conveyance of water and erosion products from tributary areas through the stream system without aggradation or degradation;
- Maintenance of the relationship between the channel and floodplain by temporarily storing flood flows on the floodplain;
- Maintenance of pools, riffles, meanders, and other physical habitats necessary to sustain aquatic ecosystems;
- Providing navigation conduits on larger streams and rivers for recreational floating and power boating;
- Stabilization of streambanks by riparian vegetation and rootwads which protects banks from erosion and collapse;
- A vegetation filter that removes and stabilizes sediments and nutrients moving toward the stream from adjacent slopes;
- Surface roughness on the floodplain favorable for recharging groundwater systems;
- Effective floodplain soil conditions to detain flood water for later release to sustain low flows;
- Moist corridors that act as natural fuel-breaks, fire line anchor points, and safety zones;
- Large woody debris which helps create structural features that form pools and bars;
- Shade to the stream that maintains cooler water temperatures necessary to sustain cold-water aquatic life.

Maintenance of healthy riparian and aquatic habitat is essential for existing fish populations as well as for Yellow-billed Cuckoo, Bald Eagles, endemic plants, aquatic invertebrates, and big game species that use the BWR corridor from its headwaters to the backwaters of Magic Reservoir.

In October 2014 the USFWS determined that the Yellow-billed Cuckoo Western DPS is threatened due to the destruction, modification, and degradation of its riparian breeding habitat (USFWS 2014). The cited primary causes are the loss and degradation of habitat from altered watercourse hydrology and natural stream processes, livestock overgrazing, encroachment from agriculture, and conversion of native habitat to predominantly nonnative vegetation (USFWS 2014). Furthermore, USFWS (2014) states that "the hydrologic regime (streamflow pattern) and supply of (and interaction between) surface and subsurface water is a driving factor in the long-term maintenance, growth, recycling, and regeneration of western Yellow-billed Cuckoo habitat". The condition of potential Yellow-billed Cuckoo habitat in Section 1 above Stanton Crossing is generally poor (Jankovsky-Jones 1997). Maintaining Yellow-billed Cuckoo habitat along the lower BWR requires flow management that considers the ecology of cottonwood riparian forests including maintenance and recruitment (USFWS 2014). IDFG comments show the BWR basin possesses some high quality habitat that is periodically occupied by Yellow-billed Cuckoo. It is a relatively small isolated expanse of Cottonwood fragmented by Highway 20, agricultural lands and water diversions.

Because of the reliance of Bald Eagles on mature cottonwoods for nesting and winter roosting and perching along the BWR, the loss or degradation of riparian vegetation, particularly reduced recruitment and survival of cottonwoods, will likely result in a reduction of the number Bald Eagles able to utilize this habitat.

Ute Ladies' Tresses sites in southeastern Idaho include bank, floodplain, and oxbow sites having moist sandy soil with a high water table (Moseley 2000). Sites typically receive seasonal flooding, and occur on terraces about 0.4 to 1.2 m above summer base flows (Moseley 2000). Ute Ladies' Tresses grow in sunny, herbaceous habitats on the margins of cottonwood, willow, or other shrub assemblages, where associated vegetation is kept short by flooding or other disturbances (Moseley 2000). If this threatened orchid species does occur within the BWR drainage, it would have a high likelihood of being impacted by alterations in spring-time flows, which are needed to maintain the water table and other suitable habitat characteristics.

The three aquatic invertebrates listed as Species of Greatest Conservation Need that currently occupy the BWR (*Centroptilum selanderorum, Bolshecapnia milami* and *Malenka tina*) spend the majority of their lives in riverine habitats. Alteration and degradation of aquatic habitat is the primary concern for these species. In general, mayfly and stonefly populations are affected by changes to aquatic habitat, such as alteration of flow patterns, streambed substrate, thermal characteristics, and water quality (e.g., Rader and Ward 1988, Miserendino et al. 2008, Haidekker and Hering 2008).

The Green River Pebblesnail inhabits cold, clear spring-fed streams. The species is associated with gravel, cobble, and boulder substrates, usually absent of macrophytes (Frest 1999). Habitat loss and degradation arising from stream channel dewatering and altered water quality is the greatest threat to this species. Potential causes of habitat loss include groundwater drawdown and surface water diversions (Frest 1999).

<u>Potential adverse effects of reduced spring peak flows on cottonwood forests (Intervals 2 - 4)</u>

Seed germination and seedling survival of cottonwoods is dependent on the combination of flood events, which provides necessary moisture at the right time, and the shifting habitat mosaic produced by flood scouring and deposition, which provides the ideal barren soil seed bed (Rood et al. 1995, Braatne et al. 1996, Mahoney and Rood 1998, Rood et al. 2003). Critical to cottonwood seedling success is the timing and rate of decline of the falling limb of the hydrograph (Mahoney and Rood 1998). In a typical year of a natural system, cottonwoods release their short-lived seeds after the peak flood flow has dramatically declined. Seeds land on moist, barren sand and cobble bars left after the flood. They rapidly germinate but rely on a slow decline of water levels to maintain soil moisture needed for seedlings to survive the summer drought. Numerous studies from across the West have shown that when this process is disrupted by flow alteration and/or diversion during or after spring flood flows, cottonwood recruitment declines (Rood et al. 1995, Braatne et al. 1996, Merigliano 1996, Rood et al. 2003, Braatne et al. 2007).

Flow diversions for irrigation or other purposes that reduce base flows have also been shown to negatively impact cottonwoods. Persistence of cottonwoods is dependent on sufficient streamflow, which maintains the local alluvial groundwater table during drought periods (Braatne et al. 1996, Mahoney and Rood 1998, Rood et al. 2003). For example, cottonwoods along sections of the Big Lost River completely died in 5 years when channels were dewatered for irrigation (Rood et al. 2003). The same result has occurred on the BWR south of Bellevue. When the extent of wetted area within river channels is reduced due to irrigation diversion, seedlings may opportunistically find suitable sites for growth below the baseflow level, but they are scoured the following spring during even small floods (Braatne et al. 2007).

Upstream of Bellevue, the hydrograph of the BWR is approximately that of a natural river system (Figure 2). However, diversions for agricultural, commercial, and domestic irrigation progressively reduce river flows downstream until eventually, the river below Glendale is dewatered for some period of time during most years. In areas targeted for new diversions, the flows necessary to mobilize channel sediments and create barren alluvial bars necessary for cottonwood seed germination (Hauer and Lorang 2004) will become less frequent if flows during late spring or early summer are appreciably reduced. Since cottonwoods are a relatively short-lived tree (100-200 years), alteration causing a decline in seedling recruitment could lead to an age structure of the cottonwood community dominated by older individuals. Without sufficient recruitment of new seedlings, the long-term health of the riparian cottonwood ecosystem along the floodplain of the BWR is in jeopardy. Additional diversions would further truncate flood flows necessary for creating sand and cobble bars for cottonwood seed germination and would further alter the rate of decline of the falling limb of the hydrograph—both causing worse conditions for cottonwood persistence.

Analyses of likely streamflow alterations under current recharge proposals

To evaluate the potential effects that implementation of the current aquifer recharge water right application might have on the existing BWR hydrograph, we related the recharge application to the daily flow record at the Hailey gage station over water years 1975-2014. We made the following assumptions:

- The full rate of 164 cfs under the proposed rights could be diverted upstream of or near the Hailey gage.
- The existing minimum streamflow rights upstream of Bellevue were always satisfied ahead of the proposed recharge rights.
- Sufficient water measurement protocols were in place to monitor and measure recharge water as well as other water diversions and flow in the river reaches where the minimum streamflow rights apply.
- The infrastructure necessary to divert all of the recharge water right would be available at all times of the year.
- Potential gains to the river due to recharge were ignored, since gains would likely be temporally and spatially dislocated from the recharge event. Furthermore, without the forthcoming groundwater model, reach gains due to future recharge cannot be quantified.
- Bankfull discharge for the BWR at Hailey was equal to the 1.5-year recurrence interval of the annual maximum daily flow, which for the period of 1975-2014 was 1,709 cfs.

General effects on streamflow

In this analysis, we assumed that the full 164 cfs could potentially be diverted at or near Hailey every day of the water year as long as such diversions did not result in discharge downstream to the Bellevue Canal being reduced below the 189 cfs minimum streamflow right. If such diversions were implemented during water years 1975-2014, water would have been available for diversion on a total of 8,287 days, for an average of 207 days per year. A total of 1,884,594 acre-feet of water (47,115 acre-feet per year on average) would have been available for diversion over these water years.

Of course, this scenario ignores senior water rights that would need to be filled ahead of the proposed recharge rights. We did not undertake a thorough analysis of availability of water for diversion under the proposed rights, according to supply and water-rights priority. However, cursory analysis suggested that the proposed rights would only rarely be in priority between the end of the peak-flow season (early July) and the end of irrigation season (October 31). Outside of irrigation season, storage rights in Magic Reservoir would generally limit the amount available for diversion upstream, but we considered the possibility that this storage water could be leased and used instead for recharge upstream of Magic Reservoir. Thus, we analyzed the effects of diversion under the proposed applications during periods of time when these junior rights would most likely be in priority, namely the peak-flow period, the winter low-flow period, and the spring Rainbow Trout migration period. Although the spring migration period extends from early March to early June, we limited our analysis to the period between March 1 and April 14, under the assumption that beginning on April 15, senior irrigation rights would prevent additional diversion of water under the proposed recharge rights until snowmelt increased streamflow enough to meet all rights senior to the recharge rights. At that point, flows are generally high enough to maintain connectivity even with the additional diversion.

Potential effects on peak-flow characteristics

Based on the assumptions above, we found that during the time period of 1975-2014, bankfull discharge at Hailey was reached or exceeded a total of 748 days, for an average of 18.7 days per year (Figure 3). The earliest day of the year that bankfull discharge was reached during this time period was April 23rd (in 1986 and 2012) and the latest day of the year was July 21st (in 1995).

Assuming that the proposed rights are always in priority when discharge at Hailey exceeds 1,709 cfs, diversion of an additional 164 cfs during these peak flow period would have reduced the number of days that BWR discharge exceeded bankfull flows in those water years from 748 days to 611 days, or an average of 15.3 days per year. What impact such reductions would have had on channel maintenance and fish and wildlife habitat is difficult to determine, because the duration of time that stream channels need to be at or above bankfull discharge over time in order to maintain a functioning stream channel is not well defined (Schmidt and Potyondy 2004) and likely varies across the landscape based on soil types, agricultural or residential development, and other characteristics of the watershed.

However, in order to protect the number of bankfull-discharge days that occurred during the period of record, we evaluated a scenario in which recharge diversions on days where stream discharge exceeded the bankfull level (1,709 cfs) should be allowed to reduce discharge only down to bankfull level. In other words, when discharge at Hailey was between 1,709 cfs and 1,873 cfs, we allowed diversion under the proposed rights to reduce flow only down to 1,709 cfs, assuming that the recharge rights are always in priority during these high-flow periods. At flows exceeding 1,873 cfs, we assumed that the full 164 cfs would be diverted. Very high flows are invaluable for cottonwood forest regeneration and large-scale channel reformation (Whiting 2002), but we assumed that an additional 164 cfs diversion would have little impact on channel maintenance over the long term at such high flows. During the period of 1975-2014, flows regularly exceeded 5,000-6,000 cfs. In our analysis the protection of bankfull conditions had minor impacts on the hydrograph and resulted in a small loss of recharge opportunity. We estimated only 23,782 acre-feet of water would have been lost as potential recharge diversion over the 40-year period of record, which on average would have been only 595 acre-feet of water per year.

Potential effects on low flows

Regarding the low-flow winter period of November 1 – February 28 (Interval 1), the 189 cfs minimum streamflow water right for the BWR from Warm Springs Creek downstream to the Bellevue Canal generally prevents additional diversion of water during this time period. For this reason, the low-flow period will likely be minimally affected if existing water rights are enforced (Figure 4, top panel). For example, Tenant (1976) suggests that from November 1 – February 28, 30-40% of mean annual flow should provide excellent to outstanding flows for fish, wildlife, and related environmental resources. For the BWR at Hailey, that translates to 134-178 cfs. Based on the natural hydrograph for the 1975-2014 water years, between November 1 and February 28, 69% of the days had river discharge that would be classified as "excellent" or better by the Tenant method. Because no water recharge diversions could reduce flows below 189 cfs, these numbers would be unchanged.

Potential effects on connectivity during Rainbow Trout spawning migration period

The spring period of March 1 – April 14 (Interval 2) is a crucial time of year for salmonid spawning migrations in the BWR. As such, main channel connectivity is paramount at this time of year, particularly in the losing reach between Hailey and Stanton Crossing. Sukow (2014) has estimated that mean channel loss between Hailey and Stanton Crossing during the month of March is about 125 cfs. Thus, we assumed that discharge at Hailey, minus diversions downstream, would need to be at least 125 cfs during the March 1 – April 14 period to maintain surface-flow connectivity between Hailey and Stanton Crossing. Unfortunately, there are already times when streamflow is inadequate to keep the lower and upper portions of the river connected, and this could be greatly exacerbated by implementation of recharge diversions during this time of the year. For example, for the water years 1975-2014, there were 95 days when streamflow in the BWR at Hailey was below 125 cfs, for an average of 2.4 days per year when connectivity was likely lost (Figure 5). Although the BWR has a year-round minimum streamflow requirement of 189 cfs, this requirement extends downstream only to the Bellevue Canal, which is located about half-way between Hailey and Stanton Crossing. If minimum streamflow requirements were met in the BWR downstream to the Bellevue Canal, but recharge diversions were made downstream of this point but above Stanton Crossing, then recharge implementation could have resulted in an additional 1,257 days lacking connectivity, a 13-fold increase (Figure 5).

Potential effects on streamflow in Silver Creek

Additional diversion of water from the BWR under the proposed recharge applications has immediate, direct and readily quantifiable effects on streamflow and dependent ecological processes in the BWR. However, both the additional diversion itself and the recharge of that diverted water will have indirect effects on the entire Wood River Valley aquifer system. The direction (positive or negative) and magnitude of effects on groundwater that may result from diversion and recharge under the proposed applications will vary with location and timing of recharge and with location at which the groundwater effects are measured. One particular groundwater-dependent resource of concern to IDFG is Silver Creek. Review of literature demonstrates that flow in Silver Creek is sensitive to changes in hydrologic conditions throughout the aquifer system. In this section, we briefly review relevant literature and identify potential scenarios through which the proposed recharge applications could affect flow in Silver Creek. Specific effects of the recharge applications on Silver Creek flow cannot be quantified until and unless timing and location of potential recharge are known and the groundwater water model currently under development by IDWR is completed.

The majority of groundwater movement through the Wood River Valley aquifer system occurs in valley-fill sediments and basalt of Quaternary age (Smith 1960, Brockway and Kahlown 1994, Bartolino and Adkins 2012). North of Bellevue, the sediments are generally coarse-grained, restricted to a very narrow corridor immediately adjacent to the BWR, and less than 150 feet in thickness. These sediments host an unconfined aquifer. South of Bellevue, valley-fill sediments are as thick as 350 feet and include a layer of fine-grained lacustrine material deposited during periods when the flow of the BWR was dammed by basalt flows (Skinner et al. 2007, Bartolino and Adkins 2012). This fine-grained layer separates the over-lying unconfined aquifer from a deeper, confined aquifer (Wetzstein et al. 1999, Bartolino and Adkins 2012). The confining layer slopes to the southeast, and the unconfined and confined aquifers merge southeast of Gannett (Bartonlino and Adkins 2012). Basalts underlying the valley-fill sediments are important for groundwater movement only in the southeastern corner of the aquifer system, where the valley fill sediments are thinner and the system interacts with the regional Eastern Snake Plain Aquifer.

Primary recharge sources to the aquifer system are tributary-basin underflow, channel losses from the BWR, seepage from irrigation canals, deep percolation of excess irrigation water, and direct precipitation (Smith 1960, Brockway and Kahlown 1994, Wetzstein et al. 1999, Bartolino 2009). Estimates of the amount and relative proportions of each of these primary sources, along with minor recharge sources such as septic-system percolation, depend on the area and time period over which the estimates were made and the methods used. In general, groundwater flows from north to south, toward the Timmerman and Picabo Hills, which form the southern boundary of the valley-fill aquifer. A groundwater divide that runs generally north-south and just east of Highway 75 splits this flow into two pathways: one that trends southwest and another that trends southeast (Smith 1960, Wetzstein et al. 1999, Bartolino and Adkins 2012). Groundwater that flows southwest emerges in springs that discharge to the BWR in the vicinity of Stanton Crossing. Groundwater that flows southeast emerges in springs that feed Silver Creek, which derives the majority of its flow from aquifer discharge (Smith 1960, Brockway and Kahlown 1994). In addition to spring discharge at the southwest and southeast edges of the aquifer, pumping of groundwater for irrigation and other uses is a major component of aquifer discharge (Wetzstein et al. 1999, Bartolino 2009).

Flows in Silver Creek have been declining since the 1970s, prompting concern over fisheries and other ecological resources. These concerns have provided a great deal of the motivation for much of the recent hydrologic research in the BWR basin (Brockway and Kahlown 1994, Wetzstein et al. 1999, Skinner et al. 2007, Bartolino 2009, Bartolino and Adkins 2012, Loinaz 2012). Declines in Silver Creek flows have reflected a general decrease in groundwater levels in the southern portion of the Wood River Valley aquifer system (Skinner et al. 2007). At coarse spatial and temporal scales, decreased groundwater levels and discharge, both to the BWR and to Silver Creek near Stanton Crossing, are attributable to a combination of decreased recharge, increased groundwater pumping, and potentially increased overall consumptive use of water in the Wood River Valley (Brockway and Kahlown 1994, Wetzstein et al. 1999, Skinner et al. 2007). In turn, decreased recharge has resulted from decreased diversion of water from the BWR into irrigation canals, replacement of surface water with groundwater as an irrigation source, lining or abandonment of irrigation canals, and increased irrigation "efficiency" (Brockway and Kahlown 1994, Wetzstein et al. 1999, Bartolino 2009). The greatest increases in efficiency have occurred through transition from surface application of irrigation water to sprinkler application. In 1975, 13% of irrigated agricultural land in the Wood River Valley was irrigated with sprinklers; by 1994 the amount of sprinkler irrigation was 74% (Brockway and Kahlown 1994).

The decline in Silver Creek flow shows the same pattern as declines in groundwater discharge in other areas of the Eastern Snake Plain Aquifer (Figure 6). Furthermore, the apparent cause of decline in Silver Creek flow—increased groundwater pumping and decreased recharge incidental to irrigation—has been well documented throughout the Intermountain West (Johnson et al. 1999, Venn et al. 2004, Kendy and Bredehoeft 2006, Gosnell et al. 2007, Boggs et al. 2010, Peterson 2011, Van Kirk et al. 2012). Along with the direct evidence cited above, similarities between Silver Creek and other streams around the West provide indirect evidence that flow in Silver Creek is responding to water-use and management factors such as changes in irrigation practices that act on the scale of whole aquifer-stream systems and not simply to local conditions in the immediate surface-water drainage. The relevance of this observation is that flows in Silver Creek are intimately tied to management and use of surface and groundwater throughout the Wood River Valley. Any changes to the timing, location, and amounts of recharge to and/or pumping from the Wood River Valley aquifer system will result in further changes to flows in Silver Creek (Wetzstein et al. 1999, Bartolino 2009). Bartolino (2009) noted that location of changes to aquifer recharge or pumping within the aquifer system could have a larger effect on Silver Creek flows than the net magnitude of changes in consumptive use. For example, decreases in delivery of BWR water into the District Canal would decrease the amount of water recharged on the east side of the groundwater divide, hence reducing discharge to Silver Creek.

As noted above, it is impossible to quantify specific effects on Silver Creek flows without a detailed groundwater model and without knowledge of timing and location of future recharge. As the converse to Bartolino's (2009) observation, one potential scenario is that water that currently flows past Glendale could be diverted under the proposed applications and delivered to a recharge location on the east side of the groundwater divide, thereby increasing discharge in Silver Creek. Other potential scenarios could reduce discharge in Silver Creek, particularly if new recharge mitigates new consumptive uses of groundwater and the recharge occurs on the west side of the groundwater divide. As a simple example, suppose that diversion occurs downstream of Bellevue, which is very likely, given that the minimum streamflow right will frequently prevent diversion upstream of Bellevue. Furthermore, suppose that the recharge of this diverted water occurs on the west side of the groundwater divide, which is also very likely for water diverted downstream of Bellevue, unless it is deliberately delivered to the east side of the divide. Lastly, suppose that this recharge is simply offset by an equal amount of groundwater use near or upstream of Hailey. This groundwater pumping upstream of Hailey would reduce the amount of groundwater that flows south toward the Bellevue fan, where some of it would end up on the east side of the groundwater divide. The net effect of such a scenario would be no change in consumptive use, increased recharge west of the divide, increased discharge to springs that feed the BWR near Stanton Crossing, decreased recharge east of the divide, and decreased discharge to Silver Creek. This example, along with Bartolino's (2009) observations, illustrates that more detailed information and models are necessary to quantify the effects of recharge under the proposed applications on flow in Silver Creek.

Conclusion and Recommendations

The upper Big Wood River Valley and the hydrologically connected Silver Creek Valley support some of the most important fish and wildlife habitat in the Magic Valley Region. These valleys are relatively unaltered by large-scale irrigation diversion and storage, and the natural hydrograph remains relatively intact. Nevertheless, decreased groundwater levels and discharge, both to the BWR and to Silver Creek, can in part be attributed to consumptive use of water in the basin. Consequently, the IDFG is concerned that implementation of the current recharge proposal without timing and volume consideration will further alter and reduce natural river flows in the BWR and/or Silver Creek, which could have detrimental impacts on fish, wildlife, and plants in and along these two important rivers.

The BWR and Silver Creek represent important public resources that have tangible value to Idaho citizens, visitors, and communities. Current recharge applications need to be conditioned to maintain adequate streamflow regimes throughout the year. Of particular concern to IDFG is maintaining peak flows in the BWR for channel maintenance during the spring runoff period, and maintaining stream connectivity in the BWR during the during the late winter-early spring trout spawning migration period. In light of these two primary concerns for the BWR, and based on the analyses presented here, IDFG proposes the following recommendations in the event that any aquifer recharge water rights are approved:

1. In order to maximize the number of days that bankfull discharge is realized in the BWR, IDFG recommends that on days when flows exceed the bankfull discharge of 1,709 cfs at the Hailey gage, diversions for recharge should not be allowed to reduce discharge any lower than 1,709 cfs.
2. In order to maximize the number of days that stream connectivity occurs between March 1 and April 14 (which is necessary for salmonids to complete their spawning migration), IDFG recommends that water recharge diversions only be allowed on days when flows exceed 125 cfs at the Hailey gage. Water recharge diversions should not be allowed to reduce discharge any lower than 125 cfs downstream of the Bellevue Canal.
3. IDFG recommends installation and operation of a streamflow gage (capable of capturing data equivalent to other gages in the basin) in the BWR immediately above the Bellevue Canal so that the minimum flow rights can be managed down to that point throughout the water year.

In the absence of a groundwater model and more specific information about timing, location, and volume of potential recharge activities, IDFG is unable to quantify effects on the BWR and Silver Creek at this time. IDFG is concerned that implementation of water recharge diversions without timing and volume considerations, such as we have recommended, may have detrimental impacts on fish, wildlife, and plants in and along the BWR and Silver Creek.

Table 1. Relevant IDFG fisheries research and management reports specific to the BWR.

Author(s)	**Publication Year**	**Study Focus**
Irizary	1968, 1969	Stream alterations and habitat
Thurow	1986, 1987, 1988, 1990	Angling regulation evaluation, trout distribution and abundance, angler surveys, stream alterations and habitat
Bell	1967, 1972, 1977, 1978, 1979	Angler surveys, trout abundance below Magic, streamflow
Partridge and Corsi	1990, 1993, 1995	Trout abundance, Brown Trout redd survey
Stanton et al.	2013	Trout abundance, Brown Trout redd survey, angler surveys
Partridge et al.	1990	Trout abundance
Ryan et al.	2008	Stream habitat, trout abundance
Warren and Partridge	1994, 1995	Trout abundance, Brown Trout redd survey, angler surveys
Warren and Megargle	2009	Trout abundance, streamflow
Warren et al.	2001, 2003, 2004	Trout abundance, Brown Trout redd survey
Partridge and Warren	1993, 1994, 1995	Angler surveys, trout abundance, Brown Trout redd survey

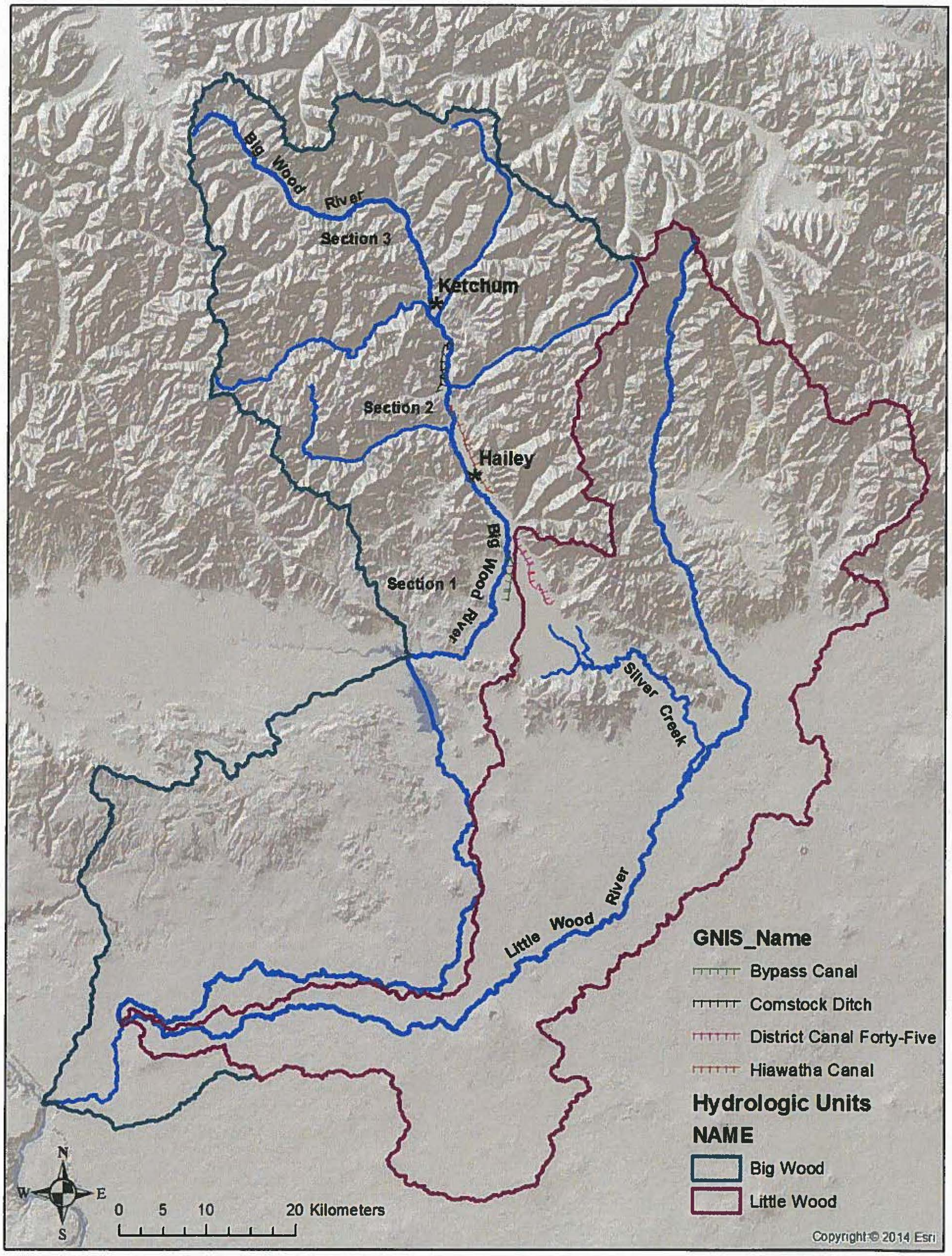

Figure 1. Big Wood River and Silver Creek drainages.

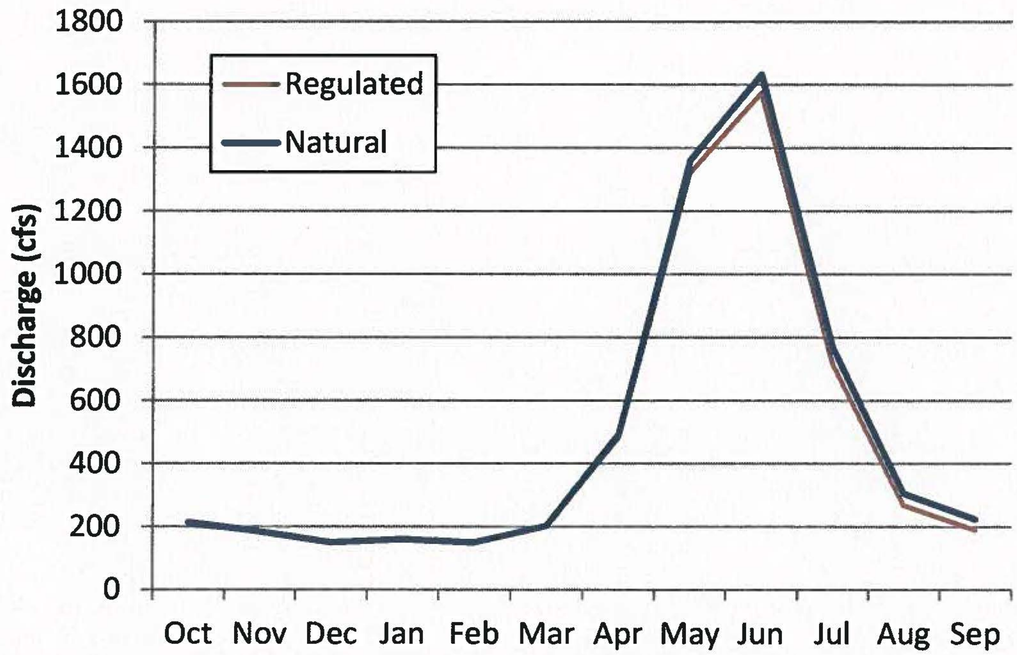

Figure 2. Regulated and natural mean monthly flows in the BWR at Hailey, water years 1995-2012. Natural flow was calculated by adding total diversions upstream of Hailey to observed (regulated) flow at the Hailey gage.

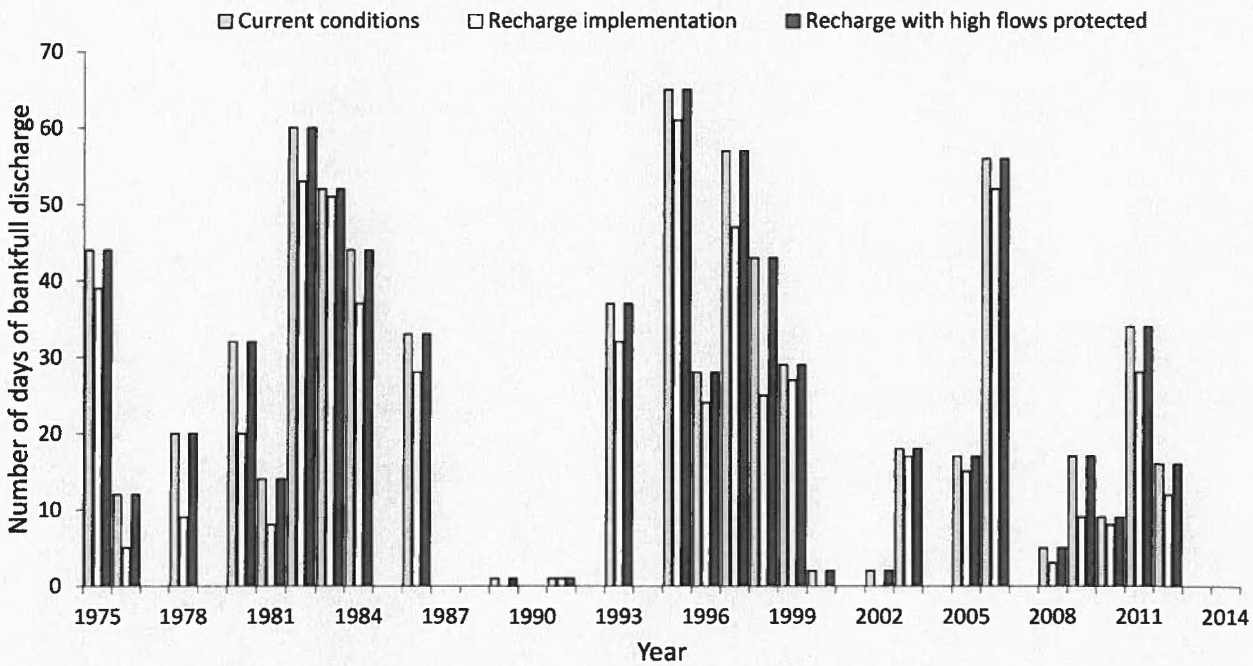

Figure 3. The number of days at or exceeding a bankfull discharge of 1,709 cfs for the Big Wood River at the Hailey gage from water years 1975 to 2014. See text for descriptions of each of the three scenarios.

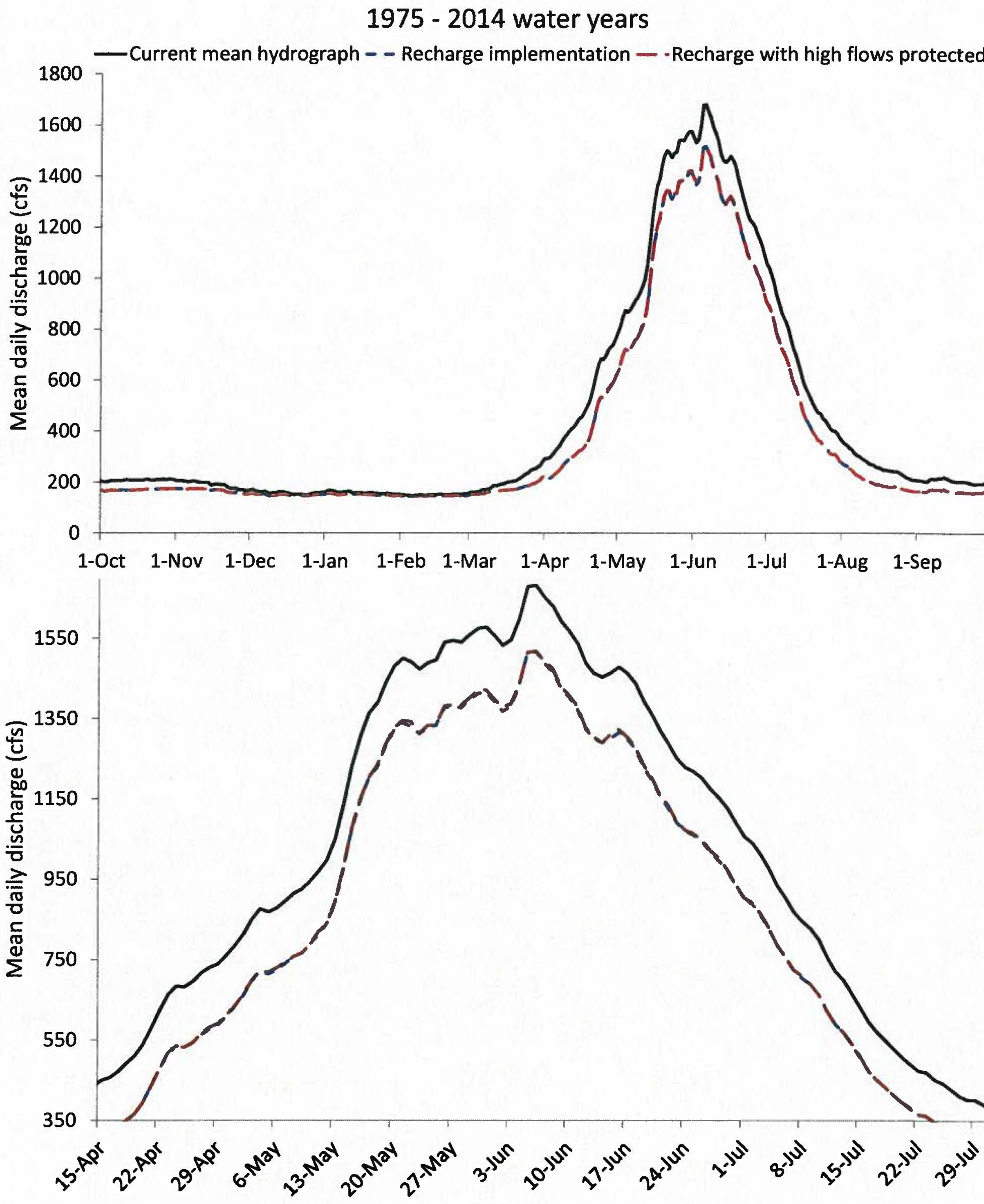

Figure 4. Mean water-year hydrograph for the Big Wood River at the Hailey gage (upper panel) and close-up view of the hydrograph during the 15 April – 31 July runoff period (lower panel). See text for descriptions of each of the three scenarios. Protecting high flows during recharge implementation alters the hydrograph very little, making it graphically almost indistinguishable from recharge implementation without protecting high flows.

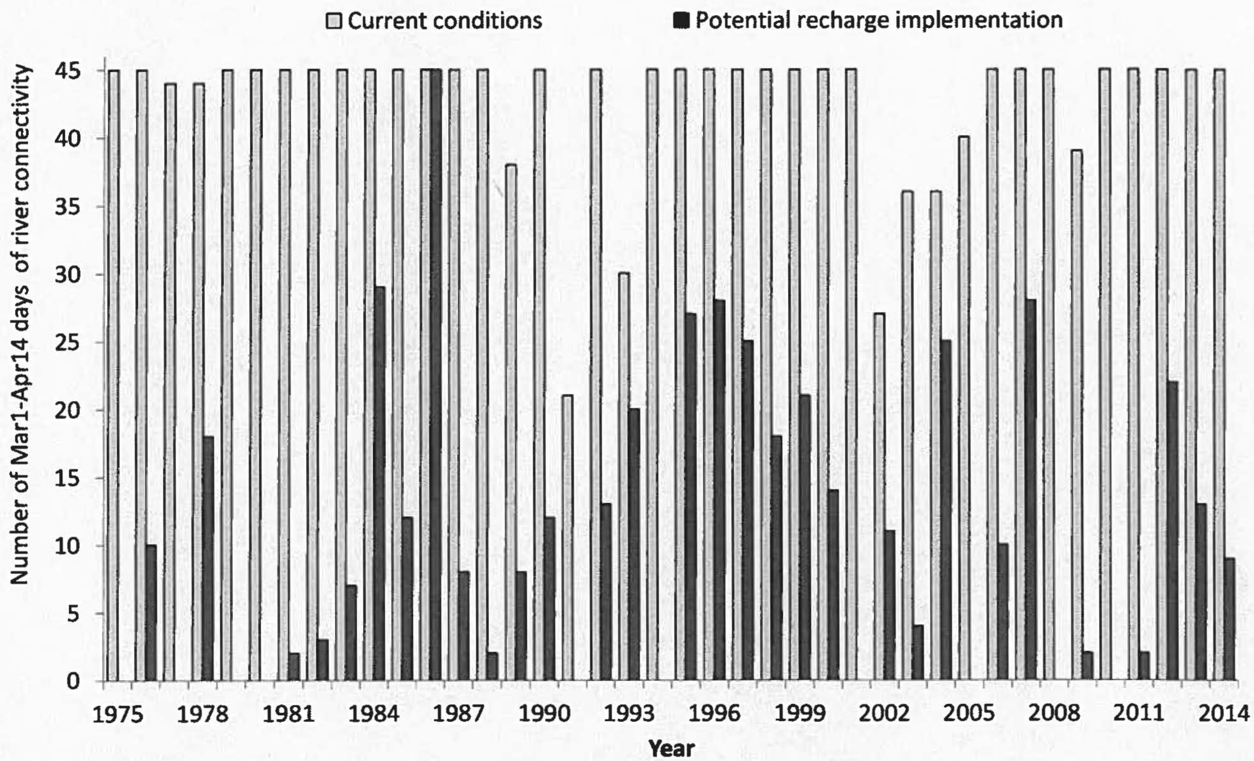

Figure 5. Number of days the main channel of the Big Wood River (downstream of Hailey) was likely connected to upstream habitats during the salmonid spawning migration period of March 1 – April 14. Also depicted is the potential reduction in connectivity due to recharge implementation.

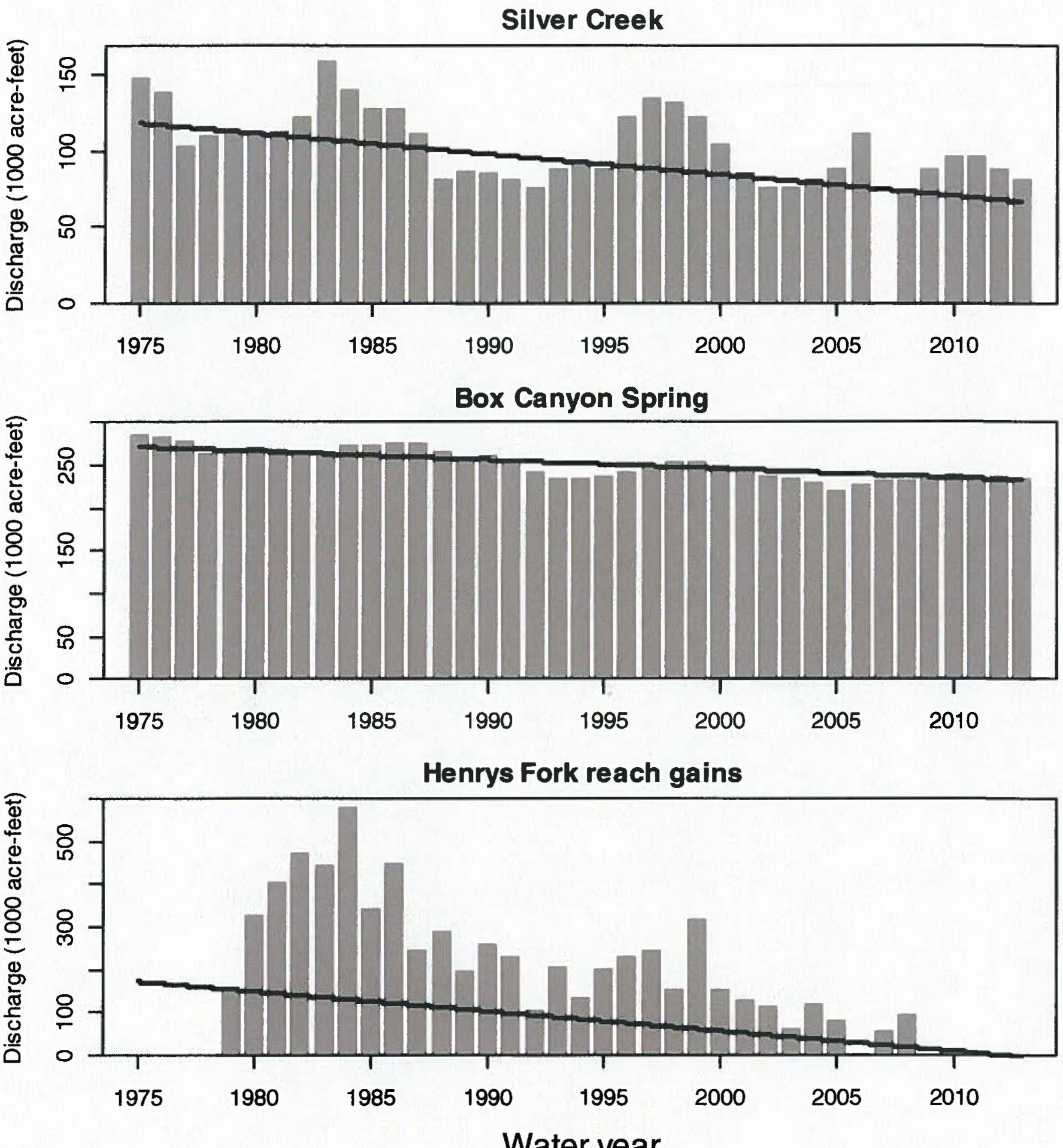

Figure 6. Annual discharge from groundwater-dominated systems across southern Idaho, including 1979-2008 trend line. Silver Creek and Box Canyon Spring data are from USGS gaging stations 13150430 and 13095500, respectively. Henrys Fork reach gains represent total gain from groundwater to the Henrys Fork and Teton rivers (Van Kirk, unpublished data).

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