In the Henry's Fork Watershed, Every Drop Leaves a Ripple

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Introduction

In the arid west, many would agree that water is our most precious natural resource, and that managing this resource is extremely challenging. Relationships among hydrology, economy, and ecology are complex, decisions can have significant consequences, opinions about priorities are diverse, and emotions run high. Well-intentioned decisions to provide more water for one group of users or resources can lead to negative consequences for other water users and resources. A great deal of energy and financial resources are now being expended to solve the complex legal and scientific problems associated with unintended consequences that resulted from past decisions.

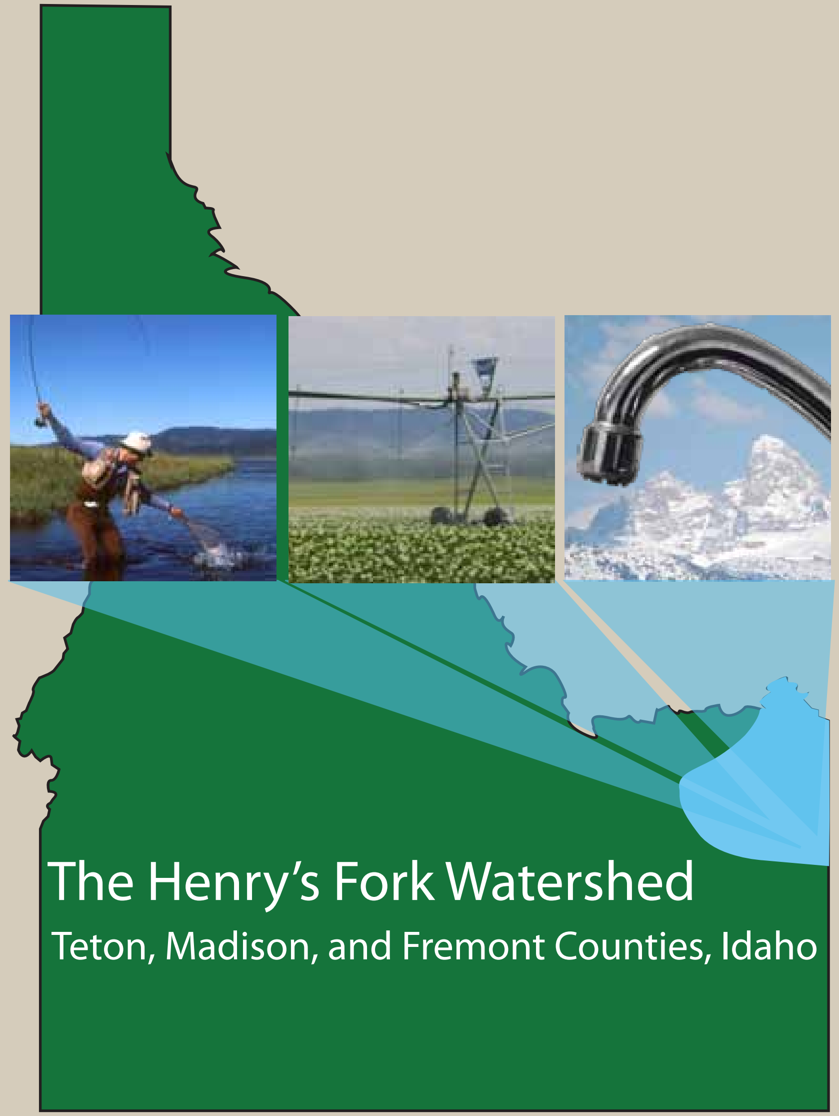
The three-year research, education, and extension project upon which this booklet is based was motivated by the desire to avoid similar types of unintended consequences as our region undergoes another major change— the replacement of irrigated farmland by other land uses, most notably residential and municipal development.

Spring-fed stream in Teton Valley

As an example, for almost a century, most of the water used for irrigation in southeast Idaho was diverted out of streams and into a vast network of canals, which transported water to individual farms. Beginning in the 1950s, new technology and inexpensive electricity became available, and farmers were able to drill wells and irrigate with previously inaccessible water from underground sources. This allowed expansion of some farms in the Henry's Fork Watershed, and many in the larger Snake River basin. Then, in the 1970s, government water "conservation" programs provided financial incentives for canal companies and farmers to replace their century-old, canal-based irrigation systems with pipe-and-sprinkler systems. These programs, along with newly available technology and favorable economic outcomes, prompted the vast majority of farmers in Southeastern Idaho to convert to sprinkler irrigation. In some cases, entire canal systems were replaced by pipelines. These "efficient" systems allowed land to be irrigated more uniformly, and later into the summer, resulting in higher crop yields. However, these new systems also had an unintended consequence. As many irrigators know, a great deal of water seeps out of unlined, earthen canals and into the ground, and even more water seeped into the ground from pre-sprinkler irrigation application methods. It is becoming clear that this seepage plays an important role in "recharging" the groundwater supply. When irrigation became more efficient, and less water seeped into the ground, the amount of available groundwater decreased at the same time that groundwater pumping increased. Since the 1950s, flows have decreased in many springs and streams in the upper Snake River basin, creating far-reaching problems for irrigators, fish, industries, and wildlife that depend on that water. A great deal of time, money, and effort is being spent to understand and resolve the complex scientific, legal, and administrative aspects of interactions between groundwater and surface water and how changes in irrigation practices can affect these interactions.

Goals

The major goals of the project were to identify changes to the hydrology of the watershed that could result from changes in land use, and to communicate these results to stakeholders and decision-makers. This booklet is a primary mechanism for this communication. Because the focus is on the transition of land from irrigated agriculture to other uses, we focus primarily on the regions of the watershed that support irrigated agriculture, namely Teton Valley and the lands surrounding the lower Fall River and Henry's Fork. We anticipate that this booklet will serve as a resource for city and county planners (including planning administrators, planning and zoning commissioners, city council members, county commissioners, and others), canal company representatives (including canal company board members and employees, ditch riders, and individual shareholders), as well as representatives of homeowners associations, and individual residents. It is not the intent of this project to advocate for a particular water use or water-dependent resource. Rather, it is our intent to provide basic information on the hydrology of the watershed and encourage our watershed's communities to work together to understand and plan for the impacts of land use on water management as our landscape continues to change.



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Canal near Chester

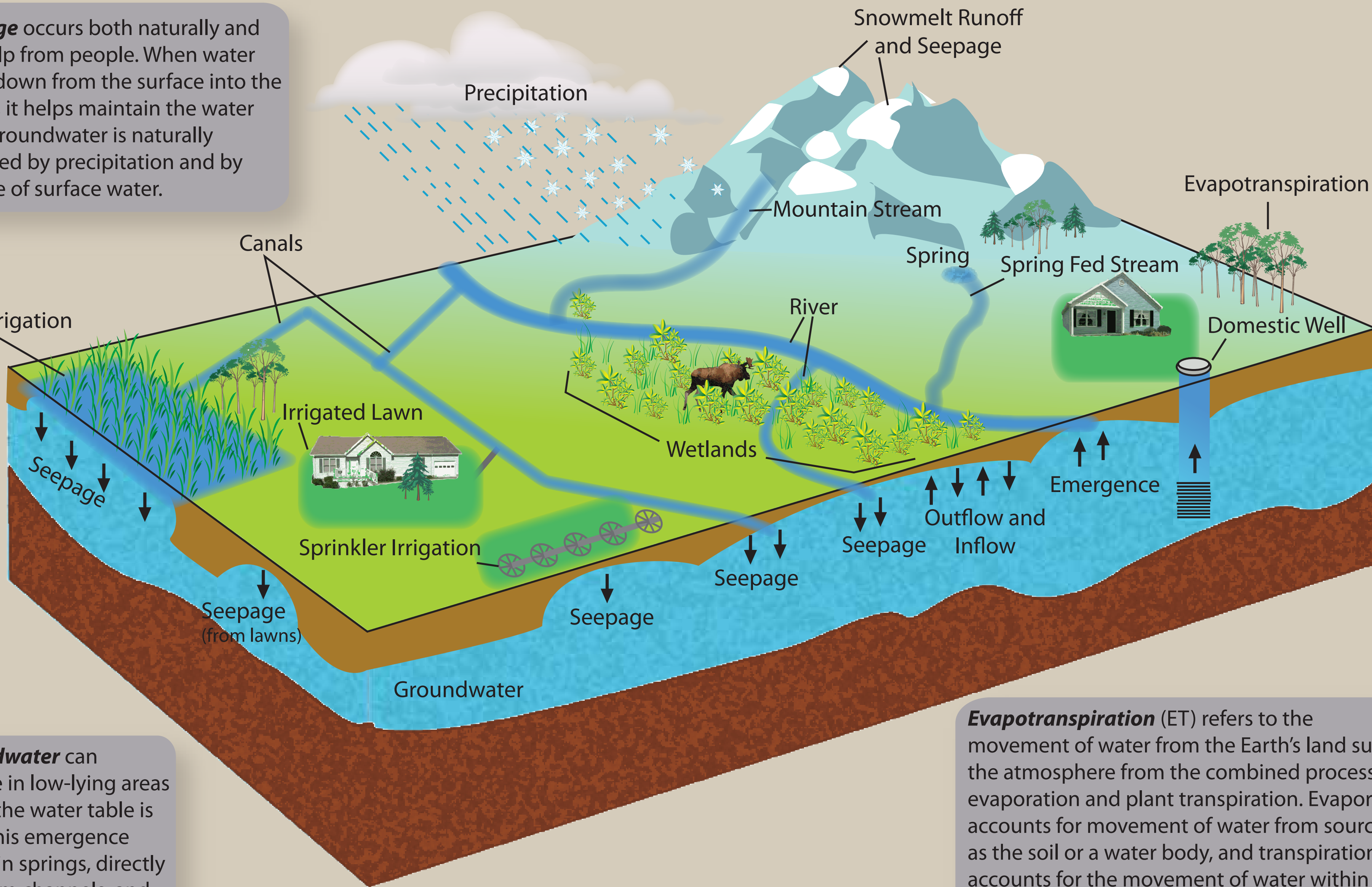
Ground and Surface Water: A Single Resource

In the Henry's Fork Watershed, water supply begins as snow. As snow melts, it can either flow across the surface, or it can be absorbed into the ground. ***Surface water*** is the term used to describe water that can be seen on the surface of the ground, such as in creeks, rivers, and lakes. ***Groundwater*** refers to water that is absorbed into the ground and stored in layers of rock, gravel, and sand. Layers of saturated rock containing groundwater are called an ***aquifer. Recharge*** of the aquifer occurs when surface water is absorbed into the ground and becomes groundwater.

In the Henry's Fork Watershed, there is a great deal of interaction between groundwater and surface water. For example, water that is absorbed into the ground in and around Yellowstone National Park emerges at Big Springs and continues to flow on the surface down the Henry's Fork River. Additional springs feed tributaries farther downstream and continue to add to the flow of the Henry's Fork. In Teton Valley, snow melting in the Teton Range flows on the surface in tributary streams such as Darby and Teton creeks. As these streams flow onto the valley floor, which is underlain with highly porous sand and gravel, some of the water is absorbed into the ground. This water returns to the surface once again in springs and wetlands near the Teton River. Some of the groundwater that seeps into the ground in the Henry's Fork Watershed travels even longer distances, finally emerging in springs near American Falls, and at Thousand Springs near Hagerman. Most of the water in the Snake River downstream of Hagerman has traveled, at least in part, through the ground. Some water passes back and forth between surface water and groundwater numerous times as it makes its way from the Henry's Fork Watershed to the Columbia River.

Water Movement in the Henry's Fork Watershed

Recharge occurs both naturally and with help from people. When water moves down from the surface into the ground, it helps maintain the water table. Groundwater is naturally recharged by precipitation and by seepage of surface water.



Groundwater can emerge in low-lying areas where the water table is high. This emergence occurs in springs, directly in stream channels, and even in basements.

Evapotranspiration (ET) refers to the movement of water from the Earth's land surface to the atmosphere from the combined processes of evaporation and plant transpiration. Evaporation accounts for movement of water from sources such as the soil or a water body, and transpiration accounts for the movement of water within a plant and the subsequent loss of water as vapor through its leaves.

Quantifying Water Availability and Use

The primary scientific objectives of this study were to quantify the amount of water available in the Henry's Fork Watershed, estimate the amount of water consumed by various uses, and develop mathematical models of how water moves through the watershed in time and space. Our calculations and models use publicly available data collected by the U.S. Geological Survey, the U.S. Bureau of Reclamation, the U.S. Department of Agriculture, and the Idaho Department of Water Resources. In addition, we collected data in the field, used results and databases published by other researchers, and performed geographic analysis using publicly available maps and satellite images. Our modeling time frame was water years 1979 through 2008, and we focused the majority of our modeling effort on the agricultural regions of the watershed irrigated by surface water. However, we also estimated water withdrawal and use in all other regions of the watershed. Although this study provides a comprehensive, watershed-scale view of water availability and use, our numerical estimates and models are not intended for administration of water rights. The numbers presented in this booklet are accurate when averaged over the 30 water years in the study and over the entire watershed, but we estimate an uncertainty of about plus-or-minus 40% in using our models to calculate specific flows or use rates at any given location and point in time. Details on our methods and results are available in numerous technical documents posted at *http://www.humboldt.edu/henrysfork/*.

Above the Ground...

Surface water is a key component of the watershed's diverse economy. Early settlers created an extensive network of canals that diverted surface water out of streams so that it could be used for irrigation. These canals are still used today to irrigate crops such as potatoes, barley, and alfalfa, and to provide water for livestock. According to U.S. Department of Agriculture figures, farming in the Henry's Fork Watershed generates around $68 million annually in income and supports over 3500 jobs. The area's thriving tourism-based economy is also dependent upon abundant surface water. The region is a renowned fishing destination, and visitors from around the world are attracted by the region's water-dependent wildlife and recreational opportunities. A Colorado State University study estimated that recreational fishing on the Henry's Fork and Henry's Lake generates $29 million in income and supports 851 jobs.

Canal and flood irrigation near Rexburg

Beneath Our Feet…

In the Henry's Fork Watershed, groundwater is the source of almost all water used for drinking, cooking, and washing in homes and businesses. Groundwater is pumped out of aquifers by individual household wells or by larger public water system wells that serve subdivisions and cities. Although most of the water used for agriculture in our watershed is surface water, groundwater is used to irrigate some farms and ranches. Groundwater is also important for fish and wildlife habitat. Groundwater contributes to the amount of water in rivers and wetlands, especially in late summer when snowmelt diminishes. Groundwater also helps to maintain the cool, consistent water temperatures that trout need to survive.

How Much Water Is Available?

In the Henry's Fork Watershed, the majority of the water that is readily available for management and use is found in stream channels and shallow aquifers. These shallow aquifers are generally less than 300 feet deep and are located in the valley areas of the watershed. Almost all of this water originates as snow and is released into the surface water/shallow aquifer system as it melts during the spring and early summer. The total supply in this system averages 2.8 million acre-feet per year but varies greatly from year to year depending on the amount of snow that accumulates in a given winter.

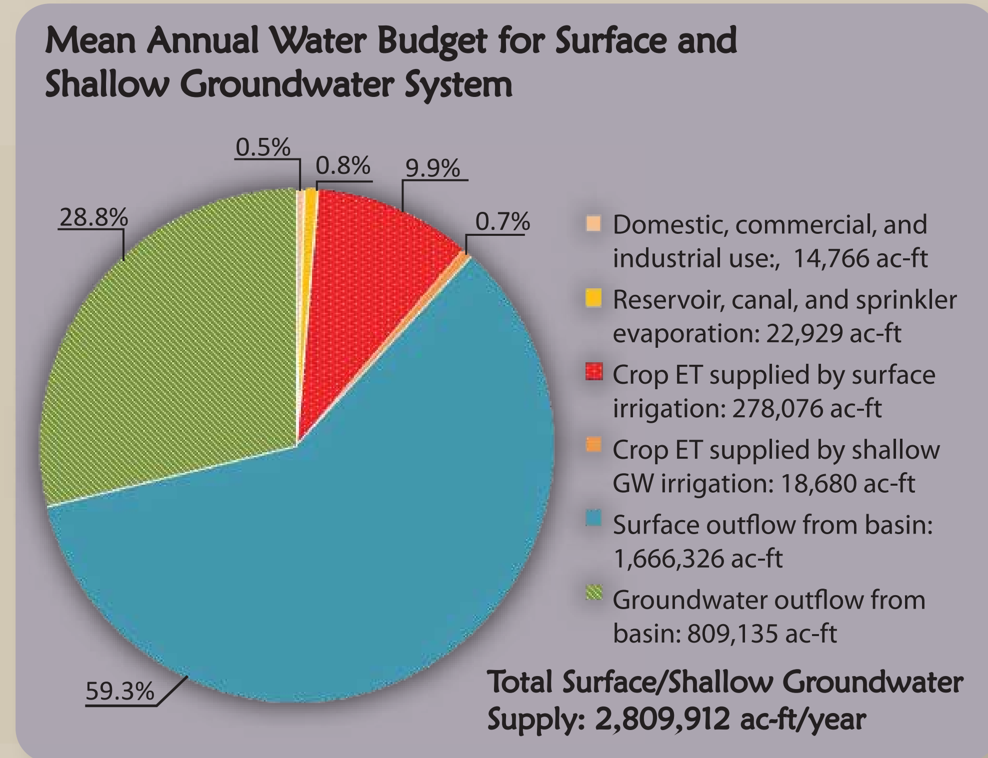
What is an Acre-Foot?

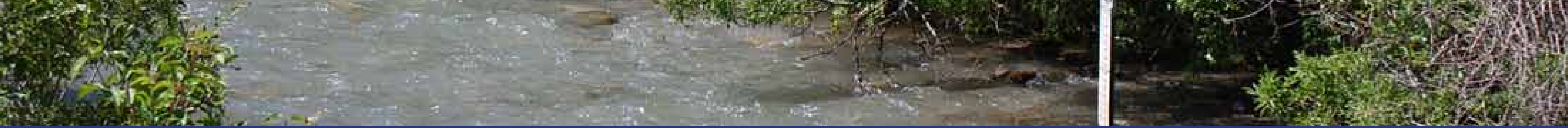
One acre-foot of water is the amount of water required to cover one acre (roughly the area of a football field) with water one foot deep. One acre-foot is equal to 325,900 gallons. Farmers and water managers measure water in acre-feet because this measurement unit makes it easy to calculate the amount of water needed to grow crops. You simply multiply the number of acres on which you are growing crops by the water requirement of those crops. Most crops grown in our watershed require about two feet of water per year. So, one acre of cropland requires two acre-feet of irrigation each year. A farmer who has 100 acres of cropland would need 100 acres × 2 feet = 200 acre-feet of irrigation water each year. For comparison, Island Park Reservoir holds 135,000 acre-feet of water, and Henry's Lake holds 90,000 acre-feet. The entire upper Snake River reservoir system holds over 4 million acre-feet, enough to irrigate about 2 million acres.

Island Park Reservoir

How Much Water Do We Use?

Of the total supply of 2.8 million acre-feet per year, irrigated crops and pasture consume about 297,000 acre-feet of water per year, 10.5% of the supply in the surface/shallow groundwater system. Another 23,000 acre-feet of water is lost to evaporation from irrigation reservoirs, canals and sprinklers. All other uses, including household, commercial and industrial, consume a little less than 15,000 acre-feet per year. This means that 88% of the supply remains unconsumed. At any given time, this unconsumed water is distributed among reservoirs, stream channels, irrigation canals, and shallow groundwater. However, most of this water—about 1.7 million acre-feet per year—is eventually delivered by the Henry's Fork, Fall River, Teton River and irrigation drainage canals to the lower Henry's Fork, near Rexburg. This water then flows out of the watershed in the main Henry's Fork, which joins the South Fork to form the Snake River. The rest—about 800,000 acre-feet—flows out of the watershed as groundwater, which returns to the Snake River farther downstream. Water passing out of the Henry's Fork Watershed provides benefits all the way through the system, from instream fish and wildlife habitat, to storage and use by water rights holders downstream.
In addition to water used from the surface/shallow aquifer system, about 160,000 acre-feet per year are withdrawn from deeper aquifers to irrigate crops in parts of the watershed where surface water and shallow groundwater are not easily accessible. This withdrawal has very little effect on the surface/shallow aquifer system and is a very small fraction of the annual recharge to deep aquifers.





Section 3: Irrigation and Canals

A Vast Network of Canals

Between 1880 and 1920, farmers began moving to the Henry's Fork Watershed and initiated great changes to the landscape. At that time, the only way to use the abundant supply of water for irrigation was to divert it from creeks and rivers upstream of where it was needed and let gravity move it downhill through a network of canals and ditches. Using primarily horse-drawn equipment and manual labor, these early irrigators constructed hundreds of miles of canals and ditches to deliver water from the streams to their fields. Although some canals in the watershed have been replaced by pipelines, about 90% of the original, 19th-century canal system remains in use today. Over 500 miles of canals, and hundreds more miles of small ditches, spread across the valley areas of our watershed in a dense, web-like network. This network spreads water previously restricted to stream channels and their immediate zone of influence to a much larger area that extends many miles away from the streams.

How is Irrigation Water Applied?

Ask anyone who has driven from Ashton to Boise during the summer what they saw, and the answer will almost certainly include "lots of sprinklers." But it hasn't always been that way. The first irrigators in our area did not have pump-pipe-sprinkler technology, so they applied irrigation water directly to the ground surface using a variety of techniques, including flooding of fields. These direct-application methods required a system of small ditches to distribute water from the main canals to individual fields. Beginning in the 1970s, farmers began converting their surface irrigation systems to pipe-and-sprinkler systems, in which the small ditches have been replaced by pipelines to carry water from the main canals to the fields. These systems allowed land to be irrigated more uniformly, and later into the summer, resulting in higher crop yields. Today, 80 to 90% of the irrigation water in our watershed is applied with sprinkler systems.

How does Irrigation Affect Hydrology?

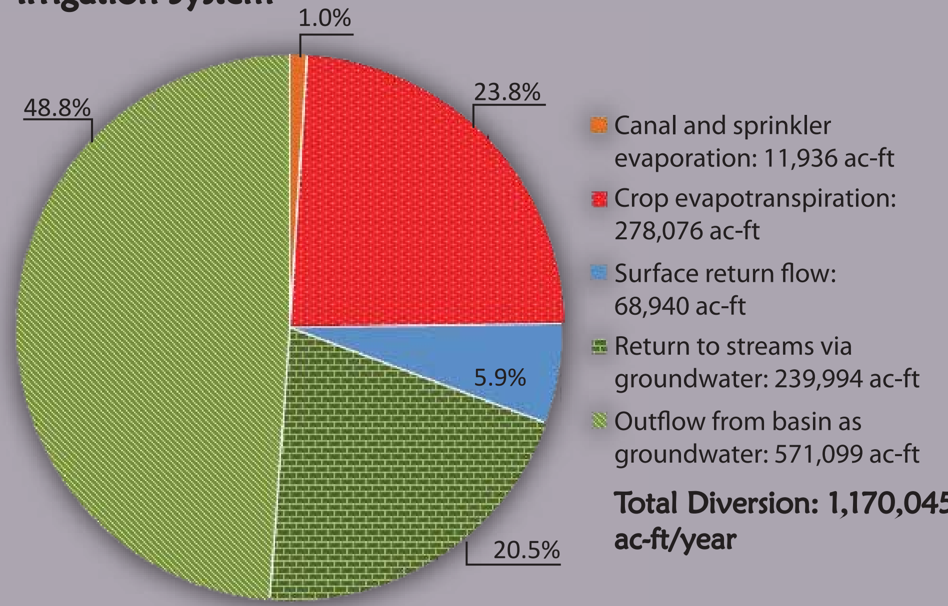
Early farmers knew that by constructing canals, they could harness snowmelt and use it to grow crops on land far from streams. They also understood that by flooding fields in the early spring, they could raise groundwater levels enough to water the roots of crops long after the snowmelt had subsided. However, we are just now beginning to fully understand the extent to which irrigation has affected the hydrology of our watershed.

Sprinkler Irrigation near Ashton

Our research has shown that canals have served a much greater role than simply moving water out of streams and onto fields. The majority of canals in the Henry's Fork Watershed are little changed from their original state; they are earthen structures lined with rock and gravel. As a result, about 40% of the water that is diverted into canals never makes it to the fields; instead, it seeps into the ground. This seepage plays a significant role in recharging the aquifer. It is not only canals that contribute to groundwater levels, however. When water is applied to fields, only a portion of that water is actually used by crops. The rest seeps into the ground, recharging the aquifer. When surface irrigation methods were widely practiced, the ratio of water recharged to water diverted was especially high. However, the application of irrigation water to fields still contributes a substantial amount to groundwater recharge, particularly because most soils in the Henry's Fork Watershed are very coarse. Only about 25% of the surface water withdrawn for irrigation is actually consumed by crops.

Our research shows that, together, canal seepage and irrigation application seepage account for about two-thirds of the total recharge to shallow aquifers in the lower elevations of our watershed. However, the amount of water diverted into the canal system as a result of conversion from surface irrigation to pipe-and-sprinkler methods and other factors has decreased about 20% since the late 1970s, reducing irrigation-dependent recharge by about 15%. Direct precipitation and seepage from stream channels account for the rest of the recharge to shallow aquifers.

Mean Annual Water Budget for Surface Irrigation System



What Are the Effects of These Changes?

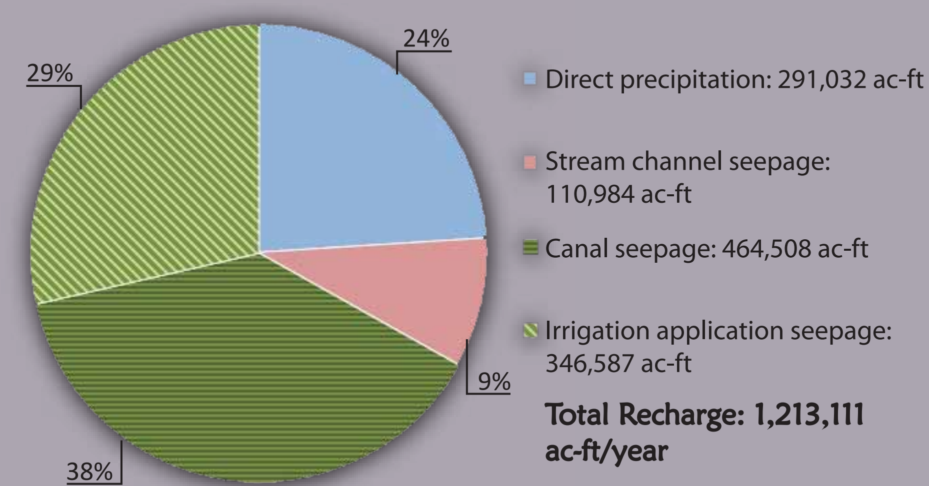
The findings of this study suggest that managing water for irrigation in the Henry's Fork Watershed primarily affects the timing and physical location of water as it moves through the watershed. Changes in irrigation practices that have occurred since the 1970s have had minimal effect on overall water quantity. Regardless of whether water flows through stream channels, canals, irrigated fields, aquifers or some combination of those, the total amount of unconsumed water in the watershed—2.5 million acre-feet—remains the same. However, irrigation has changed our watershed's hydrologic system from one that was previously dominated primarily by snowmelt to one that is now largely dominated by groundwater recharge and discharge. This has had a substantial effect on both groundwater levels and stream flows. Understanding these effects is essential as we plan for a vibrant and sustainable future for our watershed.

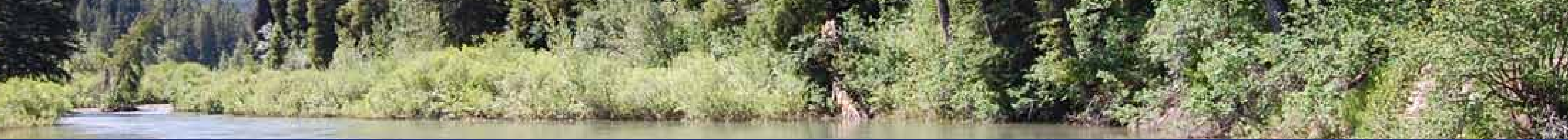
Water seeping into the ground beneath canals and irrigated fields has increased groundwater levels. In some parts of the watershed, this has increased the amount of groundwater available for use. Some irrigators rely almost completely on water that has seeped into fields higher in the watershed and re-emerges at lower elevations. Groundwater recharge due to irrigation has increased the amount of water in some springs, wetlands, and stream reaches lower in the watershed, such as along the main stem of the Henrys Fork, especially during fall and winter. Native waterfowl and wetland-dwelling mammals, as well as nonnative trout, have benefitted from the increased water in these areas. In other stream reaches, irrigation return flow and/or release of irrigation water from upstream storage reservoirs can increase the amount of water available for fish, wildlife and water users at certain times of the year.

On the other hand, in some parts of the watershed, providing ample water for crops means that stream reaches from which the water is diverted become completely dry for much of the summer and fall. This is particularly true for tributary streams higher in the watershed, such as those in Teton Valley. Sensitive species that rely on stream flow are threatened by the dewatering of their habitats. Species of concern, including native Yellowstone cutthroat trout and cottonwood ecosystems, have been particularly impacted. Dewatered streams can also have a negative impact on the value of developed land.

In summary, because groundwater and surface water systems are so tightly connected, any changes to water use and management patterns in the watershed will have impacts on other uses, including natural resource needs, irrigation supply, and/or municipal supply. This illustrates how challenging water management actually is, and consequently, how imperative it is that water resource decisions are made only after carefully considering the impacts to other water uses. The information produced by this study will help hydrologists and water managers quantify the effects of future water management scenarios on timing and location of water as it travels through our watershed in streams and aquifers.

Mean Annual Shallow Groundwater Recharge in Valley Areas





Section 4: Habitats and Species

Trout and Their Habitat

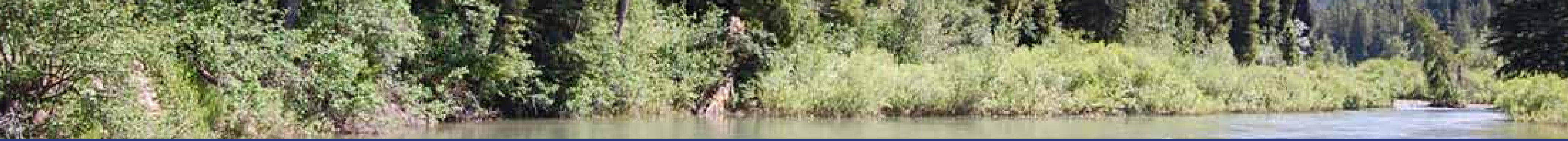
Only a small fraction of the popular recreational trout fishing opportunities available in the Henry's Fork Watershed are supported by stocked fish that were raised in a hatchery. Thus, our famous fisheries rely on natural reproduction in streams and rivers. In order to spawn and rear successfully, trout require cool water, clean gravel, and hiding places provided by wood, rocks, and vegetation on the stream bottom or along the stream banks. Throughout much of the watershed, trout populations are healthy and stable. However, there are some stream reaches that do not support abundant trout populations for various reasons related to use and management of water. Below large storage facilities such as Island Park reservoir, trout have been negatively impacted by low winter stream flows during the time when reservoirs are being filled. Below irrigation diversions, trout have been negatively impacted by low summer stream flows during the time when water is being diverted into irrigation canals. In groups like the Henry's Fork Watershed Council, irrigators, landowners, water and fisheries managers, scientists, and conservationists are working together to find win-win solutions that benefit both humans and trout.

Yellowstone Cutthroat Trout

The only trout native to the Henry's Fork Watershed is the Yellowstone cutthroat trout, which is one of the 13 subspecies of cutthroat trout native to the United States. For a variety of reasons, cutthroat trout are not as widespread and abundant in the Henry's Fork Watershed as nonnative trout, which include rainbow, brook, and brown trout. The first nonnative trout were introduced into the watershed as early as the 1870s, before the first irrigation canals were dug. Cutthroat trout did not evolve in the presence of other trout species. As a result, nonnative fish out-compete them for food and space. Yellowstone cutthroat trout are closely related to rainbow trout, and the two can reproduce to form hybrid offspring.

Additionally, during the spring and early summer, adult cutthroat trout migrate upstream out of lakes and rivers and into small headwaters streams to spawn. Dams and other structures can block upstream migration of adults. After hatching, young cutthroat trout migrate back downstream in the late summer or early fall, when stream flow is low and irrigation demand is high. In some stream reaches, irrigation diversion can result in very low flows or even dry stream channels. This prevents successful downstream migration of young cutthroat trout and can also strand adults in rapidly diminishing pools.

Yellowstone Cutthroat Trout



Although many people, agencies, and organizations in the watershed are working hard to preserve Yellowstone cutthroat trout, it is a complex and challenging undertaking. For example, rebuilding a diversion dam to improve fish passage may help cutthroat trout migrate upstream to spawn, but it may also allow rainbow trout to invade farther upstream. Reducing water use by replacing an earthen canal with a pipeline may increase stream flow but may affect irrigators or other wildlife that have become dependent on elevated groundwater levels. These are just two of the many examples of how well-intentioned actions taken to help cutthroat trout, if not carefully planned, can have negative effects on other resources, and perhaps even on the cutthroat trout themselves.

Wetland Habitats

Ecologically important wetlands of many types are found throughout the Henry's Fork Watershed. During the summer, wetlands become breeding and nesting habitats for many species of birds. Moose, deer, and other animals graze on the rich variety of plants within their borders. During the winter, wetlands are important wintering grounds for birds like the trumpeter swan. Many of the watershed's wetlands, such as those around Big Springs, have been present for thousands of years. However, in valley areas where irrigation-dependent seepage has raised groundwater levels, some wetlands have increased in extent since irrigation began.

Riparian Habitats

In the Henry's Fork Watershed, high-quality habitat exists not only within creeks and rivers, but also along their banks. This ***riparian habitat*** is critically important to a diverse array of plants and animals.

As the richest biological zones in the west, cottonwood forests are among the most important riparian habitat types. They receive year-round use by wildlife and serve as important migration corridors. In the spring, cottonwoods provide nesting areas for many species of birds, and bald eagles overwinter in the forests. Moose, deer, elk, and black bears are year-round residents. Riparian cottonwoods also play an important role in dissipating energy and anchoring stream banks during flood events. In spite of their importance, western cottonwood forests are in critical condition. Cottonwood groves were often removed when homes and farms were built near streams. Damming of waterways and diversion of stream flow during runoff has also had a negative effect on the trees, which need flooding during the spring snowmelt in order for their seeds to germinate. New cottonwoods are not growing at the rate needed to replace the older trees, which sprouted after large floods. Older trees are more prone to disease and insects when they are water-deprived.

On the other hand, the extensive network of canals in our watershed has allowed establishment of smaller strips of riparian habitat along canal and ditch banks. Although these habitats are dominated by willows rather than by cottonwoods, they provide habitat for many species of birds and other wildlife within the irrigated landscape. Using satellite imagery, we have estimated that canals in the Henry's Fork watershed support 1,000 acres of riparian habitat.

Species of Concern

When a plant or animal is listed as a ***species of concern***, it means that the species is considered "at risk" due to low or declining population numbers; however, it is not currently designated as a federally protected Endangered Species. A number of Idaho species of concern live in the Henry's Fork Watershed; these include, among others, sandhill cranes, trumpeter swans, bald eagles, peregrine falcons, and Yellowstone cutthroat trout. Yellowstone cutthroat trout rely on cold, abundant water for spawning and rearing young. Sandhill cranes and trumpeter swans rely on wetland and riparian habitats for nesting, feeding, and protection from predators. Bald eagles rely on the fish in the streams, creeks, and rivers for food, and peregrine falcons hunt the diversity of smaller birds that live in wetland and riparian vegetation.

Section 5: Water Management

Who Manages Our Water?

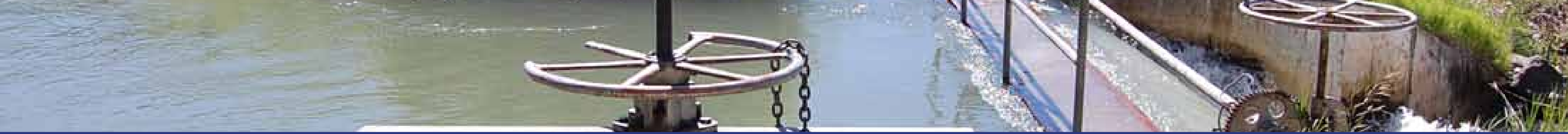
Water management in our part of the country is shared among a network of agencies and organizations that is almost as complex as the network of rivers, reservoirs, and canals they manage. Although some of the watershed lies in Wyoming, the majority of decisions affecting water use in the Henry's Fork Watershed are made by the State of Idaho. The State has the ultimate authority to determine who can use a given water source at any given time and place. Statewide water policy is guided by the Idaho Water Resources Board, and the Idaho Department of Water Resources (IDWR) regulates water use throughout the State. Our watershed lies in Water District 1, the largest of Idaho's water districts. The ***watermaster*** of Water District 1 has authority and responsibility to allocate water to users in the district, in accordance with Idaho law.

The U.S. Bureau of Reclamation owns and operates most of the storage reservoirs in the region, including Island Park Reservoir and Grassy Lake. Henry's Lake is owned and operated by a private irrigation company. The Reclamation reservoirs store water for ***irrigation districts***, which are then responsible for delivering this water to its members. Storage water in the Henry's Fork watershed is administered by Fremont-Madison Irrigation District. An additional body of appointed representatives—the "Committee of Nine"—advises these agencies and districts.

In addition to these primary water management agencies and organizations, numerous other state and federal agencies have legal jurisdiction over other resources that can affect water management decisions. For example, the Idaho Department of Environmental Quality sets and enforces water quality standards, and the Idaho Department of Fish and Game manages fish and wildlife resources. A variety of nongovernmental and quasi-governmental organizations also participate in water management at the local and regional level.

Water-resource stakeholders in the Henry's Fork Watershed are lucky to have the Henry's Fork Watershed Council, an active, effective, and long-standing watershed council that promotes collaboration and communication among the many different people and organizations that have a stake in management of our water resources.

Gage station on canal in Fremont County



Who Manages the Canals?

Canals are managed by ***canal companies,*** also known as irrigation companies. Canal companies are organized groups of irrigators that hold water rights. Canal companies are responsible for distributing surface water for irrigation and are usually managed by a few irrigators. ***Ditch riders*** are hired or appointed by members of a canal company to control flow levels in a canal by adjusting head gates at points of diversion or delivery. Many of the canal companies in the Henry's Fork Watershed have storage water rights with the Fremont-Madison Irrigation District in addition to their natural flow rights. By purchasing ***shares*** in a canal company, a shareholder becomes entitled to use some of the canal company's water right.

Challenges in Water Management

With all of the entities involved in water management, it is not surprising that things do not always go smoothly. As land-use decision-makers and water managers know, there is often a governance gap when it comes to coordination between these two groups. This gap occurs due to a lack of communication between municipal and county land-use planners, and the canal companies and state and federal entities that play a role in managing water. In the Henry's Fork Watershed, this lack of communication has contributed to a variety of problems, from farmers and ranchers not being able to irrigate crops, to flooded basements in new housing developments, to arguments over how water should be managed. A primary goal of this study is to identify strategies that can help close this governance gap, while increasing water availability for agriculture and enhancing ecological benefits in key stream reaches.

Over the past forty years, many changes have occurred in the way land is used in our watershed. Where irrigated fields used to dominate the landscape, we now have a patchwork of farms, cities, resorts, and subdivisions. Although only about 5% of the irrigated agricultural land in our watershed has been replaced with other uses, this fraction is much higher in some locations—around the City of Rexburg and in Teton Valley, for example. Development across the region also tends to be highly fragmented, resulting in checkerboard patterns of cropland interspersed with residential subdivisions. Not surprisingly, changes in land use have changed the way water is used and managed. This creates both opportunity and challenge for water users, streams, aquifers, and fish and wildlife habitat.

Patchwork development

Lawns vs. Crops

Although the large-scale effects of land-use changes on water use depend on many factors, a meaningful assessment of water use between agricultural and residential land uses can be made by comparing per-acre water use during the summer growing season, when the majority of water used by residences is applied to lawns and landscaping. Dividing the total growing-season volume of water used at a residence by the area of the lot gives a use rate in inches, which is then directly comparable to use rates for agricultural crops. Water-use records for a sample of 263 residences in 19 different subdivisions from around the watershed showed that growing-season water use rates ranged from 8 inches to 42 inches, with an average of 23 inches. By comparison, well-established calculation methods that incorporate geographically specific growing conditions and daily climatic data showed that annual evapotranspiration rates for lawns and landscaping in the Henry's Fork watershed ranged from 20 inches to 34 inches over the period 1979-2008, with an average of 27 inches. These same models showed that annual evapotranspiration rates for the typical mix of agricultural land-cover types found in the watershed ranged from 21 inches to 29 inches, with an average of 25 inches. To put this comparison into more familiar units of measure, growing-season water use on a 1/4-acre residential lot averages about 156,000 gallons, versus about 170,000 gallons for a typical crop on that same 1/4 acre of ground, a difference of less than 10%. Application of appropriate statistical methods to these data showed that although there is a large amount of variability in water-use rates across individual residences and subdivisions, the average per-acre use of water during the growing season is not statistically different between agricultural crops and residences, nor does it differ between actual use and theoretical water requirements for lawns.

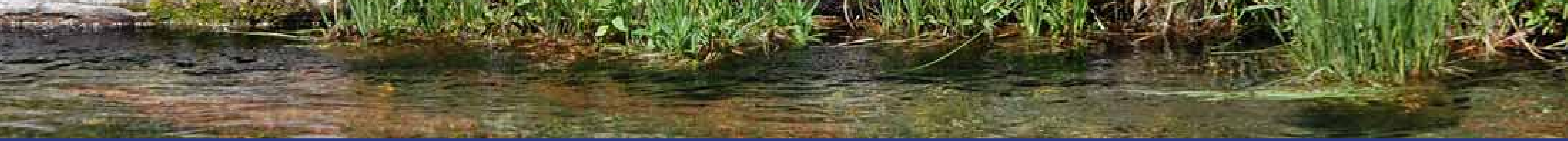
What does differ is that the source of irrigation water tends to change when land is developed. As described in previous chapters, most farms and ranches in the Henry's Fork Watershed irrigate with surface water that is diverted from creeks and rivers and transported through canals. In some cases, when previously irrigated land is developed, the water rights or canal shares associated with the land are transferred with ownership. However, in other cases, the surface water goes unused, and homeowners end up irrigating lawns with ground water intended for domestic use. This occurs for a variety of reasons. In some cases, developers or cities didn't build the infrastructure needed to carry surface water to individual lots, or homeowners may simply not realize that they do in fact have access to surface water. In other cases, even though they may have access, homeowners find that surface water is difficult to use or available only for a portion of the summer, or they have had difficulty in communicating with their canal company.

Although it might seem that the reduction in surface water use on developed land would result in less diversion from tributary streams, this is not usually the case. Typically, surface water continues to be diverted at the pre-development rate. The water is either put to use on land elsewhere within the canal service area, or is simply run through the canal, where much of it seeps into the ground. In a few cases, canal companies and developers with water rights are beginning to look at options for leasing unused water into the Idaho Water Bank. The Idaho Water Bank was set up specifically to help water users retain their water rights while leasing unused water into the bank. Individuals or canal companies can temporarily lease a portion of a water right into the water bank, and may receive a payment for doing so. For agricultural irrigators, leasing excess water can be a way to increase profits. For developers or homeowners, water leasing can be a way to retain water rights when land use changes and may increase the value of land. In many cases, leased water can also be used to improve flows for fish and wildlife.

Challenges for Canal Managers

Canals and canal companies were originally developed to serve small numbers of farmers irrigating large tracts of farmland. Over the generations, ditch riders perfected the fine art of delivering the correct amount of water to each of these shareholders through the canal system. As some of these large tracts of farmland have been subdivided and purchased by new owners, the number of shareholders has increased, while the acreage irrigated by each shareholder has decreased. Today, canal companies are serving not only large farms, but also subdivisions with many small yards. Once comprised of a small group of farmers irrigating hundreds of acres of land, some canal companies are now comprised of hundreds of people, many irrigating an acre or less. Accounting for and delivering small amounts of water through the canal system to numerous people is extremely difficult. Simply communicating with all of these additional people can be difficult for canal company personnel; this is further exacerbated by the fact that many new residents have never irrigated with surface water and may not understand how the delivery system works, or what their responsibilities are as shareholders. In addition to the increase in the number of landowners, the patchwork nature of development has added to the challenge of managing water in the Henry's Fork Watershed. Developers and planners may not realize that building houses near irrigated fields may result in flooded basements during irrigation season. Residents may not realize that using more surface water than they are legally entitled to can make it more difficult for downstream users to use their water rights, and can further reduce flows in tributary streams. Landowners may not realize that failing to maintain the canal flowing through their property can result in farmers not being able to irrigate crops. Canal companies may not realize that county and city planners are not aware of existing canal easements and are thus unable to help protect these easements.

Canal running through subdivision in Driggs.



Two Stream Reaches: Two Strategies

As described in this booklet, there is no single, "one size fits all" strategy for managing water in the Henry's Fork Watershed. In some areas, where stream flow is limited and fish recovery is a priority, finding ways to put water back into specific reaches of rivers and creeks may be warranted. In other areas, there may be creative ways to make use of abundant stream flow for out-of-stream uses. As these contrasting stories illustrate, by considering the site-specific hydrology, resource values, and economic value of individual stream reaches, communities have been able to work together to find water management solutions that make sense for a specific area while minimizing unintended consequences.

The Henry's Fork Below Island Park Reservoir: Improving Stream Flow

The Henry's Fork is one of the most famous fly fishing destinations in the United States, drawing anglers from around the world in search of large, abundant rainbow trout. The section of river below Island Park Dam is one of the most popular, and it is blessed with plentiful spawning habitat, an abundant food supply, and a steady source of cold water. The Henry's Fork also sustains more than 250,000 acres of highly productive irrigated agricultural land.

In the late 1990s, research conducted below Island Park Dam documented that low winter flow releases from the dam resulted in high mortality rates in juvenile trout. The research strongly suggested that although juvenile trout need adequate flows all winter, flows in the early- to mid-winter period are most critical to their survival. Winter, however, is also the time of year that Island Park Reservoir is being filled with irrigation water to supply agricultural needs in the coming summer. For the reservoir managers to be able to meet their obligations to supply water to irrigators, it is imperative that they have the ability to capture water during non-irrigation periods and have flexibility to operate the facility so they can fill sufficiently to avoid a shortage, or discharge to avoid overfilling. Because of the unpredictable nature of inflow, this can be very challenging. Consistent with other findings of this report, balancing these seemingly competing uses comes down to cooperation among stakeholders to carefully manage the timing and location of flow.

Careful observers of water releases below Island Park Dam will have noted that, in recent winters, flows from mid-October to late December have often been very low (ranging from 80 to 100 cubic foot per second), but that in early January the flows have increased to the 200-250 cubic foot per second range. This is no accident. In 2003, the Department of the Interior required that a drought management plan be prepared for the Henrys Fork watershed. Since that time, the Bureau of Reclamation and Fremont-Madison Irrigation District have been working closely with the Henry's Fork Foundation, Idaho Department of Fish and Game and other partners to take into account the needs of both irrigators and wild trout. Since 2003, both the timing and the volume of flows have been sufficient to protect juvenile wild trout through the critical early- to mid- winter months, while also ensuring that the reservoir fills adequately to meet irrigators' water needs.

Egin Bench: Improving Aquifer Recharge

By contrast, on the lower Henry's Fork, FMID's priority has been diverting water out of the river, rather than leaving it in. West of the town of St. Anthony, water diverted to the Egin Lakes is being used to recharge the Eastern Snake Plain Aquifer. The Eastern Snake Plain Aquifer (ESPA) is a key element of southern Idaho's economy, producing approximately 21 percent of all goods and services within the State of Idaho. Water is the critical element for this productivity.

For a variety of reasons, as discussed in the introduction to this booklet, groundwater levels in parts of the ESPA have been in decline since the 1950s. This has resulted in decreased flows in springs and in the Snake River itself, affecting a variety of agricultural, commercial, and industrial users who depended upon those flows. In order to address the water supply-and-demand imbalance, the Eastern Snake Plain Aquifer Comprehensive Aquifer Management Plan (CAMP) was passed into law by the Idaho State Legislature in 2009.

The CAMP sets forth a long-term plan for managing water supply and water demand in the ESPA through a mix of management measures. One of these measures is active aquifer recharge, and the Egin Lakes area has played an important role. Since 2009, FMID has been working with the Idaho Water Resource Board to divert water each spring and fall into a series of porous canals and shallow lakes in the Egin Bench area. Preliminary studies have indicated that the water slowly seeping into the ground from these lakes and canals has had a positive effect on the Eastern Snake Plain Aquifer, without negatively impacting stream flow in the Henry's Fork during times when water is withdrawn. The project also provides a financial benefit for FMID, helping to offset the increased costs of managing water in a changing landscape.

Section 7: Summarizing What We Have Learned and Moving Forward

Interpreting the Results

In summary, our research has shown that, while humans use only a small portion of the Henry's Fork Watershed's total water supply, substantial changes have occurred to the region's hydrology as a result of moving water out of streams and into canals. Currently, irrigated agriculture is still the dominant land use, and most of the water that is diverted from streams for irrigation use seeps into the ground. This has resulted in more groundwater available for domestic, commercial, or industrial use and groundwater irrigation. When this water re-emerges on the surface, it benefits some species of wildlife and fish, as well as irrigators and commercial and industrial users downstream. Conversely, these same changes to hydrology have resulted in less, or even no, water in other stream reaches, compromising fish and wildlife resources and ecosystem processes. Some of these streams support species of concern, including native cutthroat trout.

We have also found that, when land use changes in the watershed, water management also tends to change. Although average, per-acre water use rates are quite similar across different land uses, subdivisions tend to use more groundwater and less surface water than the agricultural fields they replaced. Furthermore, small canal companies and remaining farmers find it increasingly difficult to maintain and operate their canal-based irrigation systems when lands are fragmented into a patchwork of developed lands and smaller agricultural parcels. As a result, it is important to carefully plan land use to avoid increasing demands on groundwater or reducing recharge to the aquifer.

Working Together to Manage Change

As we have learned in this booklet, hydrology and water management in the Henry's Fork Watershed is complex and varies greatly from one part of the watershed to the next. In some portions of the watershed, land use is dominated by irrigated agriculture, while in others, significant residential and commercial development has occurred. In some places, irrigation has resulted in dewatered streams, while in others, stream flow has been increased. In many cases, taking steps to improve water availability for one group of people, set of resources, or species of wildlife may have negative impacts on another.

It is not the intent of this project to advocate for a particular water use or water-dependent resource. Rather, it is our intent to encourage land use planners, canal company managers and shareholders, development professionals, conservation groups, homeowners associations, and individual residents of our watershed's counties and communities to work together to understand, communicate about, and plan for the effects of changes in land use on water management. This will not be an easy task. Emotions run high when it comes to discussing water, there is no single management strategy that could effectively apply to the entire watershed, and every strategy is likely to have both benefits and drawbacks. However, as reflected in the stories on the previous page, communities can work together to make conscious, informed decisions that consider local hydrology and local priorities, and reduce unintended consequences to our precious water resources. The following are this study's recommendations for land use planners, canal company representatives, homeowners association representatives, and private landowners.

Recommendations for Land Use Planners

As described in this booklet, changes in land use can have a substantial effect on water management. Planning for these changes, and prioritizing the resources that need to be protected, can help to reduce unintended consequences of land use change. Based on our research, we recommend that county and municipal land use planners (including planning administrators, planning and zoning commissioners, city council members, county commissioners, and others) do the following to work toward bridging the gap between water management and land use planning:

Incorporate representative water users, water resource managers, and water-resource-dependent businesses into planning efforts by:

- ☐ Determining community-wide priorities for water resource management, based on local hydrology, local economic conditions, and local resource availability
- ☐ Offering educational materials, workshops, and/or presentations on water use, water management, and water planning
- ☐ Including water managers when creating both visionary comprehensive plans and actionary ordinances and zoning

Incorporate water resource protection into the formal planning process. This may include one or more of the following, as appropriate for your community:

- ☐ Incorporating hydrologic impact zones into Comprehensive Plans
- ☐ Incentivizing specific water uses, such groundwater recharge or instream flow, as appropriate
- ☐ Ensuring that development plans include a hydrologic impact analysis
- ☐ Limiting hydrologic impacts in specific areas or from specific land uses, and/or limiting groundwater withdrawal and encouraging continued use of surface water use within residential developments

Work with canal companies to:

- ☐ Develop a system for communicating land ownership changes, shareholder changes, and potential changes to surface water use
- ☐ Use a "development checklist" that ensures developers obtain a signature of approval from a specific, designated canal company representative
- ☐ Document and publish canal infrastructure and record easements when possible
- ☐ Develop a system for minimizing the effects of land use changes on the canal infrastructure system (such as preventing culvert changes, alteration of ditches, harm to easement areas, etc.)

Work with developers to:

- ☐ Ensure that the immediate, local hydrologic impact of each development project is assessed and, if appropriate, mitigated
- ☐ Ensure that development projects have appropriate water rights for all intended water uses, with valid proof from IDWR, prior to approval
- ☐ Ensure that there is an effective system for managing irrigation water delivery and for transferring canal shares and water management responsibilities to homeowners associations when appropriate
- ☐ Where feasible, encourage the use of surface water for irrigation
- ☐ In cases where groundwater will be used to irrigate, find ways to mitigate the impact to groundwater resources via alternative water uses, which may include active recharge, stream flow restoration, and other strategies as appropriate

Recommendations for Water Managers

As described in this booklet, canals play an important role in the hydrology of the Henry's Fork Watershed. In order to avoid unintended impacts on other water users, our research shows that it is important to maintain a functioning canal system even as land use changes. At the same time, there may be opportunities for canal companies to lease unused water without detriment to groundwater resources. Based on our research, we recommend that water managers (which may include canal company board members and employees, ditch riders, and individual shareholders) do the following to work toward bridging the gap between water management and land use planning:

Be accessible to the growing pool of water users within your service area:

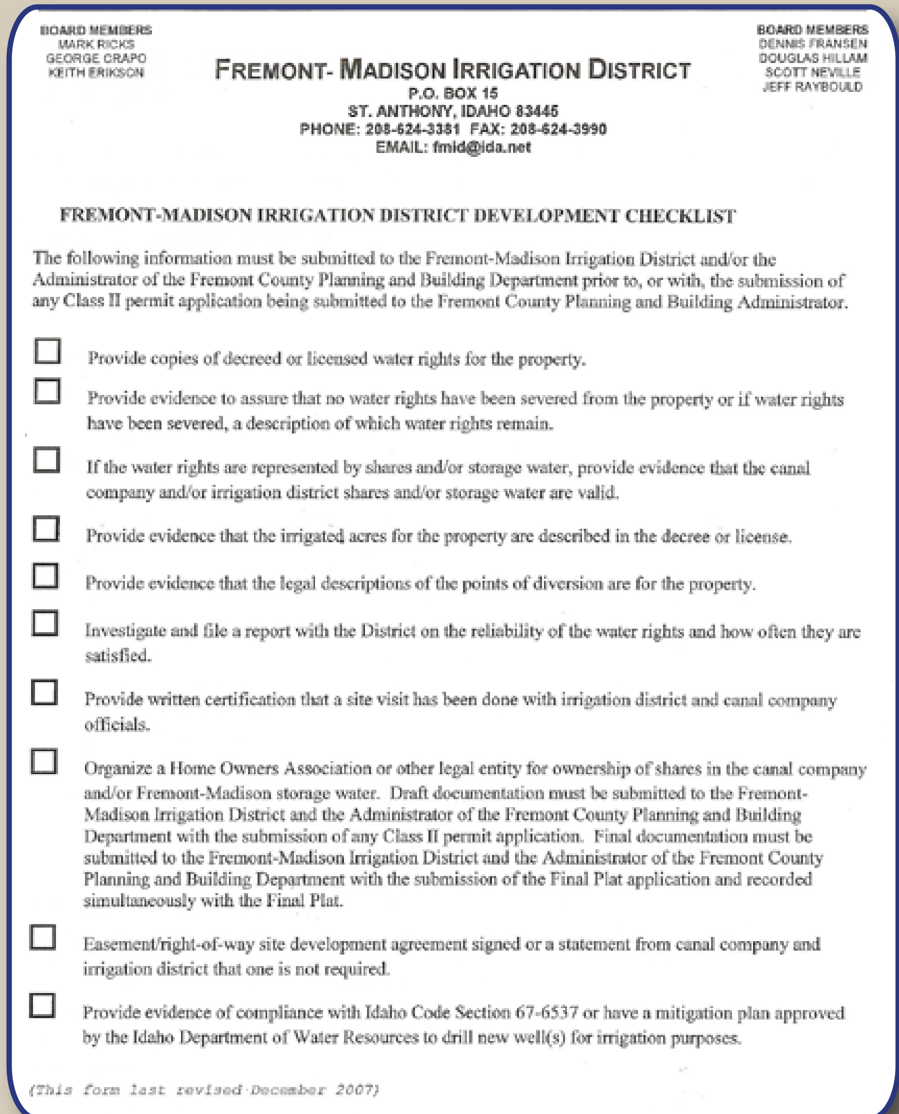
- ☐ For each subdivision in your service area, designate one or two homeowners association representatives who will be responsible for communicating with the ditch rider and collecting shareholder dues
- ☐ Take advantage of new technologies (email, Facebook, or text messages, for example) to increase the ease with which you communicate with all of the people you serve.
- ☐ Consider working together with other canal companies, non-profits, and/or government entities to offer educational materials, workshops, and/or presentations for new residents on how to use and maintain canals
- ☐ Consider developing and distributing a schedule for providing water to your residential customers. This may take effect at all times, or only during water shortages. (For example: Sage Flats receives water Monday, Wednesday and Friday; Creekside Hollow receives water Tuesday, Thursday and Saturday.)

Develop mechanisms to ensure that shareholder dues/assessments cover the cost of operation and maintenance. These may include:

- ☐ Educating shareholders about the importance of paying on time
- ☐ Implementing a tiered payment system in which developments with many lots and users pay more than a single irrigator with many acres, in order to offset increased service costs
- ☐ Developing and enforcing consequences for shareholders who do not pay on time

Work with county/city land use planning entities to:

- ☐ Develop a system for communicating land ownership changes, shareholder changes, and potential changes to surface water use
- ☐ Use a "development checklist" that ensures developers obtain a signature of approval from a specific, designated canal company representative
- ☐ Document and publish canal infrastructure and record easements when possible
- ☐ Develop a system for minimizing the effects of land use changes on the canal infrastructure system (such as preventing culvert changes, alteration of ditches, harm to easement areas, etc.)
- ☐ Encourage shareholders to become more involved in the land use planning process
- ☐ Mitigate reductions to groundwater recharge if unlined, earthen canals are phased out



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FREMONT-MADISON IRRIGATION DISTRICT DEVELOPMENT CHECKLIST

The following information must be submitted to the Fremont-Madison Irrigation District and/or the Administrator of the Fremont County Planning and Building Department prior to, or with, the submission of any Class II permit application being submitted to the Fremont County Planning and Building Administrator.

☐ Provide copies of decreed or licensed water rights for the property.

☐ Provide evidence to assure that no water rights have been severed from the property or if water rights have been severed, a description of which water rights remain.

☐ If the water rights are represented by shares and/or storage water, provide evidence that the canal company and/or irrigation district shares and/or storage water are valid.

☐ Provide evidence that the irrigated acres for the property are described in the decree or license.

☐ Provide evidence that the legal descriptions of the points of diversion are for the property.

☐ Investigate and file a report with the District on the reliability of the water rights and how often they are satisfied.

☐ Provide written certification that a site visit has been done with irrigation district and canal company officials.

☐ Organize a Home Owners Association or other legal entity for ownership of shares in the canal company and/or Fremont-Madison storage water. Draft documentation must be submitted to the Fremont-Madison Irrigation District and the Administrator of the Fremont County Planning and Building Department with the submission of any Class II permit application. Final documentation must be submitted to the Fremont-Madison Irrigation District and the Administrator of the Fremont County Planning and Building Department with the submission of the Final Plat application and recorded simultaneously with the Final Plat.

☐ Easement/right-of-way site development agreement signed or a statement from canal company and irrigation district that one is not required.

☐ Provide evidence of compliance with Idaho Code Section 67-6537 or have a mitigation plan approved by the Idaho Department of Water Resources to drill new well(s) for irrigation purposes.

(This form last revised December 2007)

Fremont-Madison Irrigation District Development Checklist

Work together with a variety of partners, (including the Idaho Department of Water Resources, Idaho Fish and Game, the Idaho Water Board, the Henry's Fork Foundation, Friends of the Teton River, the Natural Resource Conservation Service, and/or city and county governments) to explore site-specific, non-traditional water use options, such as:

- ☐ Using water for designated aquifer recharge projects
- ☐ Establishing partial-season, temporary, or full-season leases through the Idaho Water Bank
- ☐ Participating in incentive programs for reducing water consumption, such as those offered by the Natural Resource Conservation Service and the Idaho Department of Water Resources
- ☐ Exploring a variety of site-specific options that can maintain or increase agricultural water availability while restoring instream flows in key ecological reaches. These may include point of diversion changes, source water switches, wastewater re-use, and other options as appropriate for your location

Recommendations for Homeowners Associations and Individual Homeowners

As described in this booklet, residential development can have a substantial impact on water availability and water management. In order to avoid unintended impacts on other water users, our research shows that it is important for all users to understand and regulate their own water use. Based on our research, we recommend that individuals and homeowners association (HOA) representatives do the following to reduce the impacts of residential development on water resources:

Find out if you have a canal share, and:

- ☐ Where feasible, use canal water to irrigate lawns and landscaping, rather than water from your well
- ☐ If you live in a subdivision, be sure your HOA has appointed a representative to be the point of contact between the canal company and individual homeowners
- ☐ Ensure that you have the correct contact information for your canal company or HOA representative
- ☐ Be sure that you (or your HOA) pay annual shareholder dues and attend shareholder meetings
- ☐ Be sure you (or your HOA) know the expectations for maintaining your canal and canal easement
- ☐ Check with the county planning and zoning department and the canal company before making any alterations to a canal
- ☐ Take advantage of new technologies, (such as email, Facebook, or text messages) to learn about and communicate with your canal company
- ☐ Encourage your canal company to work together with a variety of partners to explore site-specific, non-traditional options for unused water

Encourage your neighbors/members of your HOA to learn about:

- ☐ The legal restrictions on water use for domestic wells, such as not irrigating more than one-half acre with your well and using no more than 13,000 gallons per day
- ☐ Water conservation techniques you can in your home and in your landscaping
- ☐ Water rights, and the legal uses for a water right you may hold
- ☐ Site-specific, non-traditional options for using excess water, such as water leases, water conservation incentive programs and aquifer recharge
- ☐ Visit the Idaho Department of Water Resources (www.idwr.idaho.gov) or Friends of the Teton River (www.tetonwater.org) to learn about any of these topics

Home in Teton County

About this Publication

This project was funded by the U.S. Department of Agriculture through a competitive grant awarded to Humboldt State University (HSU). The project director and primary author of the grant proposal was Dr. Rob Van Kirk, an HSU professor who has been conducting hydrology and fisheries research in the Henry's Fork Watershed since 1994. He has also been an active member of the Henry's Fork Watershed Council since that time. The project team includes HSU professors Dr. Yvonne Everett, Dr. Mark Baker, Dr. Steven Steinberg, and Dr. Brad Finney, graduate students Brian Apple, Kimberly Peterson, and Lora Liegel, undergraduate student Veronica Orosz, GIS technician Jason Barnes, and Dale Swensen from Fremont-Madison Irrigation District, Amy Verbeten from Friends of the Teton River, and Steve Trafton and Kim Ragotzkie from the Henry's Fork Foundation.

The quantitative information presented in this booklet came directly from measurement, scientific data analysis, and mathematical modeling conducted by the project team over a three-year period. Many community members have reviewed this booklet. The contents of the booklet have also been reviewed and endorsed by the Henry's Fork Watershed Council.

For more information, visit the project website at *www.humboldt.edu/henrysfork/index.html*

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Project Partners:

Henry's Fork Foundation
- *www.henrysfork.org*

Henry's Fork Watershed Council
- *www.henrysfork.org/?q=watershed-council*

Friends of the Teton River
- *www.tetonwater.org*

Fremont-Madison Irrigation District
- *no website*

Humboldt State University
- *www.humboldt.edu*

United States Department of Agriculture
National Institute of Food and Agriculture