RECLAMATION
Managing Water in the West

DRAFT Henrys Fork Basin Study

Final Report

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Region
Pacific Northwest Regional Office
Snake River Area Office
Boise, Idaho

February 2014

Version 3

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Photograph on front cover: Fly fishing, irrigated agriculture, and wildlife habitat are important activities in the Henrys Fork River basin

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Produced in partnership with the

State of Idaho Water Resource Board

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Abbreviations and Acronyms

AWEP	Agricultural Water Enhancement Program
Basin Study	Henrys Fork Basin Study
CBWTP	Columbia Basin Water Transaction Program
cfs	Cubic feet per second
CIG	Conservation Innovation Grant Program
CRP	Conservation Reserve Program
ESA	Endangered Species Act
ESPA	Eastern Snake Plain Aquifer
ESPA CAMP	Eastern Snake Plain Aquifer Comprehensive Aquifer Management Plan
ESPAM	Eastern Snake Plain Aquifer Model
FERC	Federal Energy Regulatory Commission
FMID	Fremont-Madison Irrigation District
GCMs	Global Circulation Models
Henrys Fork River	Henrys Fork of the Snake River
Idaho CREP	Idaho Conservation Reserve Enhancement Program
IDFG	Idaho Department of Fish and Game
IDWR	Idaho Department of Water Resources
IWRB	Idaho Water Resource Board
IWTP	Idaho Water Transactions Program
LRP	Local rental pools
LW/D	Less warming and drier climate scenario

LW/W	Less warming and wetter climate scenario
MC	Minor change climate scenario
NEPA	National Environmental Policy Act
NFRC	North Fork Reservoir Company
NRCS	U.S. Department of Agriculture, Natural Resources Conservation Service
NWSRS	National Wild and Scenic River System
Plan	Comprehensive State Water Plan
Recharge Program	Managed Aquifer Recharge Program
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
RMP	Teton River Canyon Resource Management Plan
State	State of Idaho
USGS	U.S. Geological Survey
Watershed Council	Henry's Fork Watershed Council

.EXECUTIVE SUMMARY

Introduction

The Bureau of Reclamation (Reclamation), in cooperation with the Idaho Water Resource Board (IWRB), developed this *Final Report of the Henrys Fork Basin Study* (*Final Report*). Reclamation and IWRB entered into a partnership under the auspices of Reclamation's WaterSMART Basin Study program to identify opportunities for developing water supplies, improving water management, and sustaining environmental quality in the Henrys Fork River basin. Because the Henrys Fork River basin overlies part of the Eastern Snake Plain Aquifer (ESPA), opportunities for managed recharge within the basin were explored for the benefit of the ESPA Comprehensive Aquifer Management Plan (CAMP). A stakeholders working group (Workgroup) comprised of organization and agency personnel that worked through the Henry's Fork Watershed Council collaborated with Reclamation and the IWRB to develop alternatives that would potentially improve the water supply reliability in the Henrys Fork River basin and the ESPA.

The Workgroup, Reclamation, and IWRB initially identified 51 alternatives to address the Henrys Fork River basin water needs. From these 51 alternatives, a screened group of about 18 alternatives were evaluated and the results were documented in the *Final Henrys Fork Basin Special Study Interim Report* dated July 2013 (Reclamation 2013a). Those alternatives were assessed so that only the most viable alternatives were passed on for more scrutiny and detail for viability. The results of these assessments were presented to the Workgroup for input and the proposed alternatives were further filtered down to a group of 11 that were carried forward for additional analyses under in this Basin Study.

The final analyses refined and revised the alternatives to a group of 12 alternatives which included the addition of one new alternative (canal piping and lining) and the recognition that the water marketing alternative would essentially become a potential element with all of the final alternatives. The 12 alternatives were grouped into three major categories: surface storage alternatives, managed groundwater alternative, and conservation, water management, and demand reduction alternatives. While not universally agreed upon, these alternatives provide a cross-section of structural and management alternatives that have a reasonable path forward and have met multiple assessments for viability (i.e., acceptability, effectiveness, efficiency, and completeness).

This *Final Report* provides the summation of the final evaluations of the 12 alternatives that were the most viable, but does not provide a decision on the best alternatives for implementation. All of the alternatives can potentially benefit one or more of the water needs, but each alternative or group of alternatives has different requirements and issues for implementation. IWRB will follow the release of this *Final Report* with a companion

document providing the best paths forward. The data and evaluations contained in these two documents will allow future decision makers to have the best available information in order to determine what future actions to take and when to take them.

Evaluations of Alternatives

The group of 12 alternatives formulated by Reclamation, IWRB, and the Workgroup during the Basin Study were in response to the region's needs as described in the *Water Needs Assessment* (Reclamation 2012, Appendix A) (Table 1). Of these 12 alternatives, the 3 storage alternatives of Lane Lake Dam, Island Park storage increase, and Ashton Dam raise appear to have broad support by all interested stakeholders. That broad support also extends to the alternatives of canal automation, Egin Lake recharge site expansion, water markets, irrigation canal piping, and demand reduction.

The four storage alternatives that involve dams located on a river or creek (Spring Creek Dam, Moody Creek Dam, Upper Badger Creek Dam, and Teton Dam) do not have broad stakeholder support. Conservation groups have clearly articulated their objection to these alternatives because of potential impacts to Yellowstone cutthroat trout, scenic beauty, and free-flowing rivers. While considerable storage potential exists with these alternatives, the current social, cultural, and environmental issues would be significant.

Table 1. Summary of alternatives from the Henrys Fork Basin Study.

Alternative	Cost	Effect to Water Budget	Effects to Environment
Lane Lake Dam	$462, 000,000 ($4,600 per acre-foot)	101,000 acre-feet additional stored water	Increased flows during low flow season; impacts to fisheries and hydrology
Spring Creek Dam	$41,760,000 ($3,900 per acre-foot)	10,800 acre-feet additional stored water	Increased flows during low flow season; impacts to fisheries and hydrology
Moody Creek Dam	$123,920,000 ($3,600 per acre-foot)	10,800 acre-feet additional stored water	Increased flows during low flow season; impacts to fisheries and hydrology
Upper Badger Creek Dam	$128,940,000 ($2,700 per acre-foot)	47,000 acre-feet additional stored water	Increased flows during low flow season; impacts to fisheries
Teton Dam	$492,210,000 ($1,900 per acre-foot)	202,000 acre-feet additional stored water	Increased flows during low flow season; impacts to fisheries and hydrology
Island Park Storage Increase	$6,400,000 ($240 per acre-foot)	26,700 acre-feet additional stored water	Increased flows during low flow season
Ashton Dam Raise	$28,210,000 ($1,382 per acre-foot)	20,400 acre-feet additional stored water	Impacts to river hydrology
Managed Groundwater Recharge	$10,064,000 ($,000 per acre-foot)*	2,500 acre-feet additional recharge	Increased flow in Henrys Fork River and in ESPA
Water Market	Varies with the program*	No increase in supply; better management of existing supply	None
Canal Automation	estimated average of $941 per acre-foot*	No increase in supply; better management of existing supply	Positive impacts overall; negative impacts during low flows
Piping and Lining of Irrigation Canals	$8.5 million with North Fremont Gravity Pipeline Project*	Reduction of groundwater and stream flows	Negative impacts except in the North Fremont irrigated region
Demand Reduction	$161 per acre-foot of water saved (one time savings); $3,612 per acre-foot saved amortized over 50-year period*	Increase in flows except for Teton Valley and Lower Watershed irrigated regions during low flows	Potential fisheries impacts during low flows

*Costs for the non-structural alternatives are difficult to calculate because State and Federal programs may be involved and participation is voluntary. Costs in the table are based on averages. See Section 5.0 for more details on how these costs were derived.

While each of the alternatives discussed in Section 5.0 has the potential to decrease the gap between demand and supply for water in the Henrys Fork River basin, no single alternative would likely solve all of the challenges. The degree of complexity varies among the alternatives and significant obstacles remain for implementation, particularly for some of the alternatives. Public acceptability, funding, legal ramifications, and regulatory compliance issues would need to be resolved before moving any of these alternatives toward implementation.

Findings

Surface Storage Alternatives

Five of the seven surface storage alternatives proposed building new dams and reservoirs of various configurations. These alternatives, except for the Teton Dam alternative, proposed off-stream structures that would be fed by pressurized pipelines and pumps from water sources away from the reservoir site. Only the Teton Dam alternative would involve building a new structure instream. The Island Park and Ashton dam raise alternatives proposed altering existing dams to increase the volume of water stored in their reservoirs. All of the alternatives would capture stored water during seasonal peak flows and redistributing that water during periods of higher demand. Withdrawals may impact conservation populations of Yellowstone cutthroat trout in Conant Creek, Fall River, and Teton River. The stored water would satisfy unmet irrigation demands and enhance downstream flows during seasonal low flow periods which would benefit some environmental needs as well. These alternatives may have significant impacts to big game winter range, and moderate impact to lands designated as eligible for Federal wilderness status and Endangered Species Act (ESA)-listed terrestrial species (grizzly bear [designated as threatened] and wolverine [designated as a candidate for listing]).

Of the seven surface storage alternatives, three alternatives, Lane Lake, Teton Dam, and Island Park Dam raise, were selected for in-depth hydrology and climate change analyses at the request of IWRB and the Workgroup (Reclamation 2013b). These three alternatives represented an off-stream storage alternative, an on-stream storage alternative, and an existing facility alternative and the results were used to extrapolate information about the other alternatives. The analyses were conducted knowing that reservoir diversions and storage cannot negatively affect instream flows. In general, water may be available for storage high or average water years (approximately 80 percent of the time), but may not be available during dry years. These projections also hold even with forecasted climate changes.

After considering all the evaluation factors for each alternative, study participants were able to determine those storage alternatives they can support for further study and evaluation. Conversely, clear indications have been provided regarding alternatives that either do not

have broad support (including agency support) or would be actively opposed by participating stakeholder groups. Figure 1 illustrates a ranking of the alternatives based on the input received.

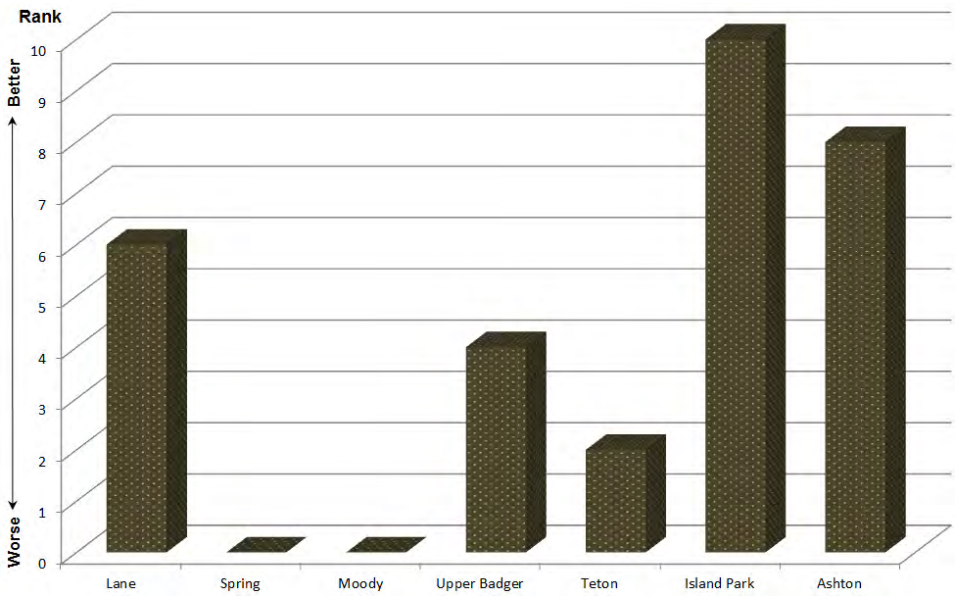

Figure 1. Relative ranking of storage alternatives based on the viewpoints of agencies and stakeholders.

Groundwater Recharge Alternative

Three locations in the Henrys Fork River basin were considered as part of this Basin Study: 1) Egin Lake recharge site expansion, 2) lower Teton River, and 3) Teton Valley tributaries. Of these, only the expansion of the existing Egin Lake recharge operation was assessed; however, the other two sites may hold potential for future assessment and action.

Expansion of the Egin Lakes recharge program would provide additional water storage for the Henrys Fork River basin, effectively enhancing water supply by improving aquifer storage and increasing ecological flows in the river. Expansion of the Egin Lakes recharge program would enhance the in-basin water budget by annually recharging an additional 2,500 to 5,000 acre-feet (7,500 to 10,000 acre-foot total). The increase in recharge at the Egin Lakes site would not involve a substantial increase in the size of the recharge site itself nor the route of the canal delivering water to the site; however, the capacity of the canal would need to be expanded.

Expanding recharge volume at the Egin Lake site would have few, if any significant adverse environmental impact and may have beneficial impacts on streamflow (especially temperature) below the St. Anthony gage. The only potentially adverse consequence would be in direct effects on a priority rainbow trout fishery in the Henrys Fork River.

Water Marketing Alternative

Water markets do not increase the water supply, but they provide a means of managing water supplies. The economic and/or environmental value of water can be maximized by exchanging water rights that might otherwise be unused or forfeited and minimizing the consequences of water shortages. IWRB has an advanced water market system and coordinates efforts to enhance existing programs. This alternative should be considered in conjunction with all of the other alternatives.

Conservation Alternatives

Automated Canals Alterative

Automated canals allow irrigators to match diversions with irrigation requirements and reduce the demand for water, especially with late-season withdrawals. Installation of automated gates at nine principal stream diversions points would cost approximately $1.6 million and conserve approximately 1,687 acre-feet annually. Both total annual and peak flows would increase in all of the irrigated regions with this alternative, but has mixed results during low flow periods. Nonpeak flows would increase in the North Fremont irrigated region, but decrease in the other irrigated regions which would have negative environmental impacts. Potential climate change impacts were analyzed and indicated that there may be a shift in timing of high flows to earlier in the year. A decrease in water delivery may occur in the latter part of the irrigation season or warmer months.

Canal Lining Alterative

The lining of canals was shown to be beneficial only in the North Fremont irrigated region. Irrigators in this region have installed several gravity pressurized pipeline systems which have reduced demand for Fall River flows and increased total annual, peak, and nonpeak flows. In the other irrigated regions, late summer flows would decrease because of the interconnection between groundwater and recharge by irrigation water. This would have a negative environmental impact to the Henrys Fork and Teton rivers.

Demand Reduction Alternative

Agricultural demand reduction means reducing the number of irrigated acres or changes farming practices to use less water. The cost of converting irrigated cropland to dryland farming or simply ceasing irrigation is estimated to be $1,860 per acre. Deficit irrigation, meaning the acre would be partially irrigated, is approximately $3,600 per acre. This alternative would generally have positive environmental impacts in the North Fremont, Egin Bench, and upper Teton Valley irrigated regions, but have negative environmental impacts in the lower Teton Valley and Lower Watershed irrigated regions with a decrease in nonpeak flows.

Potential Implementation of Alternatives

A single alternative cannot meet all of the water demands in the Henrys Fork River basin; however, grouping of alternatives may be necessary to facilitate decisions regarding implementation of one or more of the alternatives and meet the broadest set of needs in the Henrys Fork River basin. Groups of projects would involve discussions of the likelihood and risk of funding and developing the facilities; the viability of the combination; and the irrigation, environmental, fisheries, and ESPA components to assure that all four needs are addressed. Even when implementation details are finalized, more rigorous analyses would be necessary before progressing with the project or group of projects. In the end, IWRB will decide what actions it can take to address the challenges and how it will move forward to resolve the remaining issues of funding and implementation.

In completing the efforts of the Basin Study, Reclamation and IWRB agreed to utilize a two-document approach. This *Final Report* contains the technical information and the discussions of the Basin Study. A companion document will be produced by the IWRB in collaboration with the Workgroup and Reclamation to document IWRB's decisions regarding the path forward in future actions in the Henrys Fork River basin; the recommendations and prioritization for which alternatives to pursue; and the sequence of steps for the recommended alternatives or group of alternatives. The Path Forward document will be submitted to the Governor and the Legislature to comply with the State Senate Bill 1511 and inform those officials of the recommendations and prioritization of alternatives, the investments in water management infrastructure most advantageous to the State, and seek further financial support to help implement alternatives.

A Path Forward document does not preclude any member of the Workgroup from independently developing its own vision for a path forward. Since the Basin Study presents an array of alternatives, any person or group, private or public, may seek to move an alternative(s) forward as they deem appropriate.

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1.0 INTRODUCTION

1.1 Purpose and Objectives

The Henrys Fork Basin Study (Basin Study) is sponsored and led by the Bureau of Reclamation (Reclamation) in cooperation with State of Idaho Water Resource Board (IWRB). The purpose of the Basin Study is to assist State and local planning efforts by exploring potential action alternatives for both (1) meeting the complex water supply and management challenges in the basin and (2) implementing the Eastern Snake Plain Aquifer (ESPA) Comprehensive Aquifer Management Plan (CAMP) and Idaho State Water Plan. Figure 2 and Figure 3 show the location of the Henrys Fork of the Snake River (Henrys Fork River) basin in context with the watershed and the ESPA.

The Henrys Fork River basin provides irrigation water for over 280,000 acres and sustains a world-class trout fishery. Agricultural changes; population growth and its consequent urban development; drought conditions; and climate changes are impacting water resources. These factors are increasing the need to identify adaptation and mitigation strategies to resolve water supply imbalances and preserve ecological resiliency in the basin.

In a broader context, the western portion of the Henrys Fork River basin overlies the ESPA so opportunities in the basin could support the objectives of the ESPA CAMP for stabilizing the ESPA (Figure 3). One-third of the upper Snake River flow in eastern Idaho comes from the Henrys Fork basin, supplying groundwater recharge to local aquifers and the ESPA downstream. These aquifers are tapped for municipal, industrial, and agricultural water. The upper Snake River region, including the Henrys Fork River basin, produces approximately 21 percent of all goods and services in the State of Idaho, resulting in an estimated value of $10 billion annually (IDWR 2009). Water is the critical element for this productivity. This Basin Study complements the objectives of ESPA CAMP and policies of the State Water Plan by identifying specific alternatives to improve water supplies and water management in the upper Snake River basin.

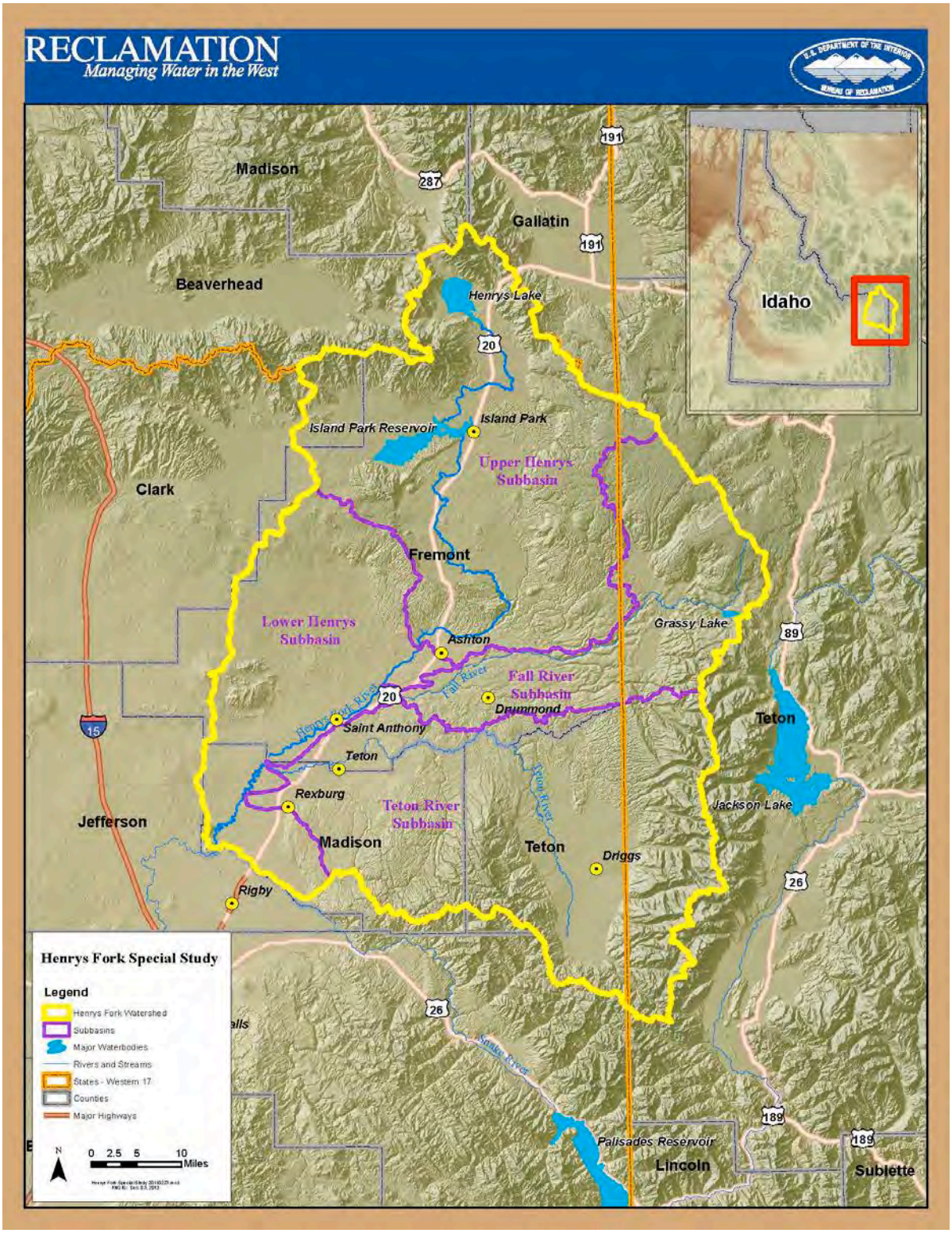

Figure 2. Map of Henrys Fork River basin and its subbasins, major tributaries, and reservoirs.

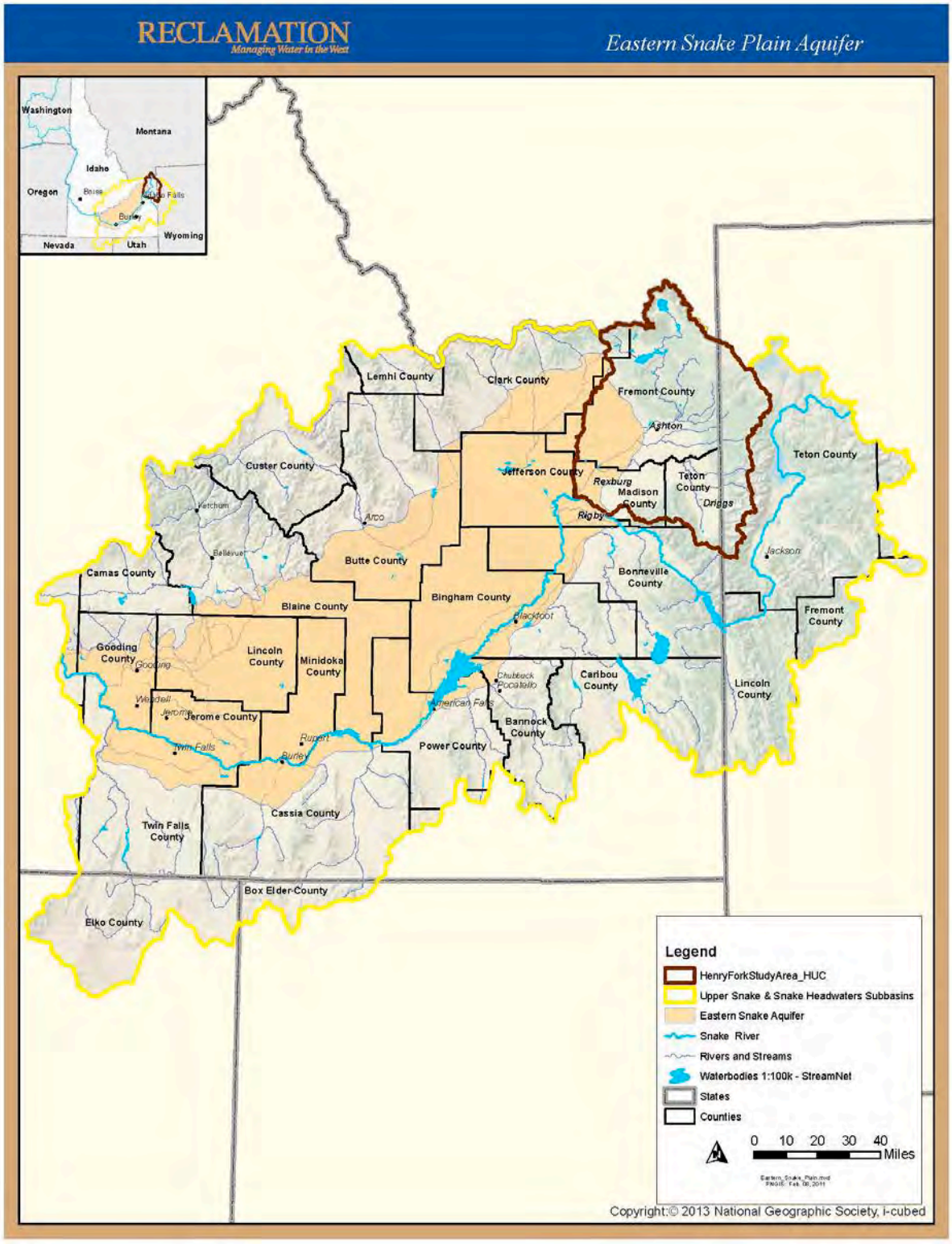

Figure 3. Map showing the spatial relation of the Henrys Fork River basin to the Eastern Snake Plain Aquifer.

This Basin Study focused on identifying opportunities for developing water supplies, improving water management, and sustaining environmental quality in the Henrys Fork River basin. Opportunities for improved or expanded groundwater management were also assessed. The objectives of the Basin Study were to analyze projected water supplies and demands, including the possible effects of climate changes; utilize a collaborative workgroup in formulating possible strategies that would address supply and management challenges and improve water supply reliability in the future; analyze the alternatives; and present them back to the State, with feedback from the a workgroup made up of Federal, State, regional, and local stakeholders (Workgroup), to assist with decision-making processes at the State and local levels. The most potentially viable alternatives were found to be for surface storage, managed recharge, water marketing, and water conservation.

The discussions and process used during the Basin Study is reflected in the table of contents presented below:

- **Section 1.0 - Introduction**: summary of Federal and State study authorities; collaboration and outreach; relevant previous and current studies; and interrelated programs and activities.

- **Section 2.0 - Overview of the Henrys Fork Basin**: summary description of the study area and its resources.

- **Section 3.0 - Water Supplies and Demands**: current and projected water supplies and demands and the potential effects of climate change.

- **Section 4.0 - Screening & Selection of Alternatives**: determination of which alternatives for surface storage, groundwater recharge, water markets, and conservation, water management, and demand reduction warranted more detailed investigation.

- **Section 5.0 - Evaluation of Alternatives**: evaluation of alternatives that emerged from the screening process.

- **Section 6.0 – Comparisons of Alternatives**: comparative assessment of the alternatives in terms of water supply, cost, environmental effects, and the perspectives of involved agencies, organizations and stakeholders.

- **Section 7.0 - Conclusions and Next Steps**: summary of basic study conclusions and steps to pursue the alternatives described in the evaluation and comparison sections.

1.2 Federal and State Study Authorities

The Basin Study Program, part of the U.S. Department of the Interior's WaterSMART Program, addresses 21st century water supply challenges such as increased competition for limited water supplies and climate change. The Federal SECURE Water Act of 2009 and Secretarial Order 3297 established the WaterSMART Program that authorizes Federal water and science agencies to work with State and local water managers to pursue and protect sustainable water supplies and plan for future climate change by providing leadership and technical assistance on the efficient use of water.

The 2008 Idaho State Legislature recognized that the need for additional water supplies and found that it was in the interest of the State to invest in short-term and long-term water projects that provide a balance between water use and water supply for both surface water and groundwater. State Senate Bill 1511, passed and approved by the 2008 Idaho State Legislature, authorized appropriation the of $400,000 for IWRB to study replacing Teton Dam and $1.4 million to determine the feasibility of enlarging the Minidoka Dam.

Reclamation and IWRB entered into a partnership under the auspices of Reclamation's WaterSMART Basin Study program. The $400,000 appropriation was used as the State's contribution to the Basin Study which included the replacement of Teton Dam as an alternative. Under this partnership, the Henrys Fork Basin Study was conducted. The results of the Basin Study are presented in this Final Report.

1.3 Collaboration and Outreach

Reclamation and IWRB collaborated with the Henry's Fork Watershed Council (Watershed Council) to form a Workgroup that included members of the Watershed Council and other interested stakeholders. The Workgroup helped develop and provide input and feedback on a set of alternatives for developing new water supplies and improving water supply reliability for instream flows, irrigation water, municipal and industrial water supplies, groundwater recharge, and fish habitat. In June 2010, the Watershed Council hosted the first session for the Basin Study. For more than 3 years, Reclamation and representatives from the IWRB met with the Watershed Council, Workgroup, and other stakeholder groups collectively and individually to develop alternatives and discuss the analyses and evaluation processes. Interests represented through this process included conservation groups, irrigators, other interested organizations, and Federal, State, and local agencies.

Reclamation created a Basin Study website[1] containing the meeting notes, presentations, research materials, and reports generated during the Basin Study. Input and comments were

[1] See http://www.usbr.gov/pn/programs/studies/idaho/henrysfork/index.html.

solicited from the Workgroup, the Watershed Council, and the general public before reports were finalized and published. Comments and responses to the comments were also included on the Basin Study website.

1.4 Relevant Previous and Current Studies

At the start of the Basin Study, an extensive literature search was conducted for previous studies in the Basin Study area, many of which are posted on Reclamation's website.[2] A list of documents produced during the course of this Basin Study can be found in Section 8.0. The following studies and programs were not part of the Basin Study, but were crucial in the analyses conducted during the study.

ESPA Managed Aquifer Recharge Program

As mandated by the Idaho Legislature, the IWRB operates a managed aquifer recharge program consistent with the goals set forth in the ESPA CAMP and State Water Plan. Several criteria are used to prioritize the location of the IWRB's recharge activities on the ESPA:

- Stabilization of the ESPA through long-term aquifer storage.
- In compliance with the Swan Falls Agreement, maintain minimum flows in the Snake River at the Murphy gage in a reach of the river largely fed by spring discharge from the ESPA through the Thousand Springs.
- Surface water availability for recharge within the water administration system (i.e., spill over Milner Dam, senior water rights at American Falls Reservoir, and senior water rights of 2,700 cubic feet per second (cfs) for hydropower at Minidoka Dam; all limit availability of water for recharge at specific locations in the system).
- Noninterference with optimal capture of water in the surface water reservoirs (ensure no impacts to reservoir fill due to managed recharge operations up-basin).
- Availability of willing partners with water delivery systems in priority areas.
- Avoidance of significant environmental impacts.

The ESPA CAMP, approved by the State Legislature in 2009, identifies an annual average target of 100,000 acre-feet in Phase 1 (through 2017) and 250,000 acre-feet in Phase 2. The IWRB has invested over $1 million since 2009 in recharge activities which include recharge water delivery contracts and development of additional capacity and new recharge

[2] See http://www.usbr.gov/pn/programs/studies/idaho/henrysfork/index.html.

infrastructure. From 2009 through 2012, an average of 117,111 acre-feet per year was recharged across the ESPA by the IWRB. The Fremont-Madison Irrigation District (FMID) has participated in this effort, delivering water under the IWRB's recharge water right to the aquifer through various unlined canals and making use of the existing recharge facilities at the Egin Bench.

Managed aquifer recharge is accomplished both through unlined irrigation canals and in dedicated constructed recharge sites. Recharge in existing unlined canals takes place both before and after the irrigation season. Constructed recharge sites further increase recharge capacity and provide a delivery location if recharge water is available after the irrigation season begins. Several dedicated recharge sites have been constructed on the ESPA, including the Egin Bench site inside the Basin Study area. Additional sites are being evaluated and prioritized based on the State's goals. The IWRB and FMID have a cost-sharing agreement in place to conduct an investigation of expansion of the Egin Bench site.

IWRB and the Idaho Department of Water Resources (IDWR) are continuing to refine IWRB's managed recharge program with cooperation from key leadership, stakeholders, water users, and the public throughout the ESPA and with participation from the State Legislature and Governor's Office. A fundamental component of the program is the continual evaluation, revision, and application of the ESPA groundwater model (ESPAM 2.1) to ensure that the IWRB's recharge activities are implemented in a manner that maximizes stabilization of the ESPA while minimizing water use conflict

Humboldt University Water Budget Study

Humboldt State University developed a computer model to estimate the water budget for the Henrys Fork watershed's surface irrigation system. Field research was conducted by graduate students supervised by university faculty and additional data were compiled from existing water resources and land use databases under a grant from the U.S. Department of Agriculture, Cooperative State Research, Education and Extension Service. Groundwater and surface water flows were modeled under historic, current, and future land and water use scenarios. The study resulted in a water budget and analysis of water supplies and use in the watershed which was shared with decision makers and stakeholders via University masters theses so that they could develop strategies to increase water availability while enhancing ecological benefits in key stream reaches. Reclamation used the modeling and study results during this Basin Study to evaluate potential water management alternatives.

1.5 Interrelated Programs and Activities

Federal, State, and local entities are currently overseeing a number of programs and ongoing activities related to water management in the in the Henrys Fork River basin. Most of these programs are expected to continue into the foreseeable future with the exception of the Agricultural Water Enhancement Program (AWEP) which expires in 2014. In this section, Federal, State, and local activities and programs being utilized in the basin are discussed.

1.5.1 Federal

Minidoka Project

The U.S. Geological Survey investigated the irrigation possibilities of the Minidoka Project in the early 1890s and the project was already under consideration when the Reclamation Act of 1902 was passed. One of Reclamation's earliest projects, the Minidoka Project provides irrigation water across the upper Snake River basin, including the Henrys Fork River basin. The project is discussed in more detail in Section 3.1.1.

Cooperative Watershed Management Program (CWMP)

A U.S. Department of the Interior program, CWMP was implemented in 2009 as part of the SECURE Water Act. The program supports local watershed groups and facilitates multi-stakeholder watershed management projects. Through WaterSMART grants, Reclamation provides 50/50 cost-share funding to water or power delivery entities for programs or actions that seek to conserve and use water more efficiently, increase the use of renewable energy, protect endangered species, or facilitate water markets.

Conservation Innovation Grant Program (CIG)

Natural Resources Conservation Service (NRCS) administers this voluntary program which is intended to stimulate the development and adoption of innovative conservation practices and natural resource protection approaches and technologies for agriculture.

Conservation Reserve Program (CRP)

The goal of CRP, administered by the Farm Service Agency, is to re-establish valuable land cover, and thereby help improve water quality, prevent soil erosion, and reduce loss of wildlife habitat. In exchange for yearly payments over 10- to 15-year contracts, farmers enrolled in the program agree to remove environmentally sensitive land from agricultural production and sow species that will improve environmental health and quality.

Targhee National Forest Plan

Parts of the Basin Study area are included in the Caribou-Targhee National Forest which is managed by the U.S. Forest Service. The Forest Service developed a Forest Plan for the conservation, protection, management, and utilization of the lands and resources in the Caribou-Targhee National Forest. During the course of the Basin Study, the Moose Creek Dam alternative was eliminated from consideration based in part on that Forest Plan which designated the site as a Research Natural Area and suitable for a National Wild and Scenic Rivers System designation.

National Wild and Scenic River System (NWSRS)

The NWSRS, instituted under the Wild and Scenic Rivers Act, protects rivers based upon three classifications: wild, scenic, or recreational. The Bureau of Land Management has determined that four streams in the Henrys Fork River basin meet the eligibility criteria for designation as a wild and scenic river: Teton River (split into four segments), Badger Creek, Bitch Creek, and Canyon Creek. The river segments determined to be eligible are granted interim protective management until a suitability study can be completed (BLM 2009).

Teton River Canyon Resource Management Plan (RMP)

Reclamation released the Teton River Canyon RMP in 2006. This plan guides the future use and management of Reclamation lands along 22 miles of the Teton River above the original Teton Dam site. The RMP provides balance between public demand for multiple uses of the river and natural resource protection and enhancement.

1.5.2 State

Eastern Snake Plain Aquifer Comprehensive Aquifer Management Plan (ESPA CAMP)

ESPA CAMP was developed to address water use conflicts that were threatening to severely disrupt the economy of the ESPA. The plan identifies actions to stabilize spring flows, aquifer levels, and river flows across the ESPA. The long-term objective of the ESPA CAMP is to incrementally achieve a net ESPA water budget change of 600,000 acre-feet annually by implementing a mix of management strategies over a 20-year period. The plan approaches the 600,000-acre-foot target in phases. The hydrologic target for Phase I (years 1 to 10) is a water budget change of between 200,000 and 300,000 acre-feet through groundwater-to-surface-water conversion projects, managed aquifer recharge, demand reductions, and a pilot weather modification program. The hydrologic target for aquifer recharge during Phase I is 100,000 acre-feet on an average annual basis. The long-term target at the end of Phase II (years 11 to 20) for aquifer recharge is 150,000-250,000 acre-feet on an average annual basis.

Agricultural Water Enhancement Program (AWEP)

AWEP is a voluntary conservation initiative administered by NRCS. It provides financial and technical assistance to agricultural producers to implement agricultural water enhancement activities on agricultural land for the purposes of conserving surface water and groundwater and improving water quality.

IWRB's AWEP Project to support stabilization of the ESPA was first approved in 2009. Projects eligible for consideration include 1) ground water to surface water conversions which allow for the delivery of additional surface water in order to reduce groundwater pumping; 2) improvements to water delivery systems in the Thousand Springs area; 3) regulating reservoirs; and 4) demand reduction projects such as end gun removal and conversion to dryland farming.

Idaho Conservation Reserve Enhancement Program (Idaho CREP)

Since 2006, the Idaho CREP agreement between the State, U.S. Department of Agriculture, and Commodity Credit Corporation has promoted the improvement of water quantity and quality in Idaho by enhancing wildlife habitat through establishment of vegetative cover to reduce irrigation water consumptive use and reducing agricultural chemical and sediment runoff to surface water and groundwater. The Idaho CREP is a part of the CRP operated by the Farm Service Agency (see Section 1.5.1). Other agencies involved with this program include Idaho Soil and Water Conservation Commission, IDWR, Idaho Department of Fish and Game (IDFG), local Soil and Water Conservation Districts, Pheasants Forever, and the Idaho Ground Water Appropriators.

The Idaho CREP was established with the goal of retiring up to 100,000 acres of groundwater-irrigated land which is expected to provide water savings of up to 200,000 acre-feet annually to assist in stabilizing the ESPA (ISWCC 2013). The Idaho CREP also addresses issues related to water shortages in the ESPA due to increased use of groundwater, drought, and changing irrigation practices that have resulted in decreased spring flows of tributaries to the Snake River.

Water Supply Bank (Water Bank) and Water District 01 Rental Pool

The Idaho Water Supply Bank (Water Bank), administered by IWRB, provides a centralized mechanism to promote trading and leasing of valid, but temporarily unused water rights. The Water Bank encourages the highest beneficial use of water and provides a source of adequate water supplies to benefit new and supplemental water uses. It also provides a source of funding for infrastructure, improvements to water user facilities and efficiencies across the state.

There are two types of exchange markets: 1) the Water Bank which generally refers to transactions executed across the state using natural flow groundwater and surface water rights and 2) local rental pools which manage exchanges of reservoir storage water primarily within a specific water district. Both the Water Bank and the local rental pools allow water exchanges for all beneficial uses recognized under State law. Any valid water right can be leased to the Water Bank during which time the right is protected from forfeiture. IDWR administers transactions through the Water Bank while local rental pools are administered by individual rental pool committees approved by the IWRB. Six rental pools are currently operated in Idaho, four of which are authorized by the IWRB. The upper Snake River rental pool is represented by the Upper Snake/Water District 01 (upstream of Milner Dam) and the Shoshone-Bannock rental pool is operated independently by the Tribes. The Upper Snake rental pool includes the Henrys Fork River basin area.

The Water District 01 Rental Pool is the largest in the state, exchanging 311,430 acre-feet of water and providing over $290,000 of revenue to the IWRB in 2012. Rental prices range from $6 to $22 per acre-foot depending on annual water availability. Participation in the IWRB's bank has increased in the last decade particularly in areas of limited supply, such as the ESPA. As a result of increased transaction activity and application fees approved by the State Legislature in 2011, the Water Bank rented a total volume of 57,306.9 acre-feet of water in 2012, an increase from 28,816 acre-feet in 2011. The total revenue generated from rental applications was over $540,000, of which approximately $95,000 was retained by the IWRB for administrative costs. The total rental revenue increased from over $190,000 in 2011 (IDWR 2012a).

Idaho Water Transactions Program (IWTP)

In 2003, IWRB became a Qualified Local Entity of the Columbia Basin Water Transaction Program and initiated activities through the IWTP. The purpose of this program is to help restore water to streams and rivers and improve habitat for imperiled fish species and populations while maintaining the agricultural economic base of the area. Mechanisms used include water right leases (partial or full-season), minimum flow agreements, negotiated changes in points of diversion, and water right acquisitions and conservation easements. All of these actions are accomplished using existing administrative programs or processes.

This program has been focused in the upper Salmon River basin. Based on program success in the Salmon River basin, the Friends of the Teton River entered into a partnership with IWRB in 2011 to expand the IWTP to the Teton River basin to enhance flows and improve resident fish habitat. Efforts in the Teton Valley are focused on the Yellowstone cutthroat trout, currently listed as a Species of Greatest Conservation Need by IDFG.

Comprehensive State Water Plan (Plan)

This Comprehensive State Water Plan (Plan), approved by the State Legislature, represents the State's position on water development, management, conservation, and optimum use of all unappropriated water resources and waterways (IDWR 2012b). The Plan seeks to ensure that through cooperation, conservation, and good management, future conflicts will be minimized and the optimum use of the State's water resources will benefit the citizens of Idaho.

In 1992, the IWRB prepared the Plan for the Henrys Fork River basin, including the Fall River and Teton River drainage basins. Each resource element is addressed in the Plan with seventeen recommendations that cover a wide range of water resource issues, including promotion of water conservation, groundwater recharge, and minimum streamflows for aquatic life. Approximately 200 miles of the basin's 3,000 miles of streams were designated for State recreational or natural river protection (IDWR 1992 and IDWR 2014).

Managed Recharge Program

The interaction between surface water and groundwater in the Basin Study area and the ESPA are discussed in Section 3.2 and demands on ESPA water supply resulting from declining aquifer levels is discussed in Section 3.3.2. The Recharge Program provides for development of managed recharge as part of the program to stabilize the ESPA, consistent with in the ESPA CAMP. While the focus of the IWRB's recharge activities is currently being prioritized based on available funding, water supplies, hydrogeologic characteristics, and technical information regarding the most effective locations for long-term aquifer storage, significant amount of managed recharge has occurred in the eastern part of the aquifer. From 2009 through 2012, a total of nearly 150,000 acre-feet of water has been delivered by FMID to the Egin Lakes as part of IWRB's ESPA recharge program.

Relationship to State Law

State government agencies with authority over water resource related activities generally include the Idaho Water Resource Board and the Idaho Departments of Water Resources, Environmental Quality, Parks and Recreation, Fish and Game, Lands, and Agriculture. Title 42, Idaho Code, vests authority over the appropriation and use of public surface water and groundwater of the state is vested in the IDWR. IDWR programs include water rights administration, dam safety, water distribution (measurement and enforcement), ground water protection (including well drilling licensing and permitting), stream channel protection, flood plain management, planning and technical services.

The IWRB is responsible for formulating and implementing the State Water Plan and basin-specific plans, including comprehensive aquifer management plans, subject to legislative approval (Title 42-1732 through 42-1734, Idaho Code; Idaho Constitution Article XV,

Section 7). All state agencies must exercise their duties in a manner consistent with these plans (Idaho Code § 42-1734B [4]). Additional programs operated by the IWRB include the Water Bank, water project development and funding, minimum stream flows, natural and recreational designations, as well as objective specific programs such as the managed aquifer recharge program on the ESPA, the Idaho Water Transactions program, Idaho AWEP, and Idaho CREP.

1.5.3 Local

Henrys Fork Drought Management Plan

In 2003, the Fremont-Madison Conveyance Act (P.L. 108-85) transferred title of the Cross Cut Diversion Dam, Cross Cut Canal, and Teton Exchange Wells to FMID. This legislation also established an advisory board to initiate a drought management plan to address all water uses in the Henrys Fork River basin. The purpose of the Henrys Fork Drought Management Plan is to maintain or enhance watershed health and ecology in below-average water years and to balance agricultural and environmental needs through flexible and adaptive water management within the context of State water law. Advisory members represent FMID, Reclamation, IDFG, Henry's Fork Foundation, The Nature Conservancy, Trout Unlimited, and the North Fork Reservoir Company, with technical support from Idaho State University. Meetings with the advisory members occur at regular intervals to determine the best management actions.

2.0 Overview of Study Area

2.1 Setting

The Henrys Fork River flows for 120 miles in the eastern part of Idaho, joining the upper Snake River from the north near Rexburg, Idaho (Figure 4). The Basin Study area encompasses the watershed, approximately 3,300 square miles bound by high desert areas of the Eastern Snake River Plain on the west and by the Continental Divide along the Centennial and Henry's Lake mountains on the north. The Yellowstone Plateau and Teton Mountains form the eastern boundary and the southern boundary is marked by the Snake River. Elevations in the Basin Study area range from over 10,000 feet along the Centennial Mountains on the north side of the basin to approximately 4800 feet near the Henrys Fork River's confluence with the Snake River on the south.

The Basin Study area includes most of Fremont, Madison, and Teton counties. Cities and towns within the basin include Rexburg, St. Anthony, Teton, Ashton, Island Park, Drummond, and Driggs (Figure 2 and Figure 7).

Figure 4. Aerial photo of the landscape and geologic features of the Henrys Fork River basin.

2.2 Climate

The climate in the Basin Study area varies with elevation and proximity to the mountain ranges on the north and east. Historically, the minimum annual average temperatures have ranged from 22° F near the headwaters of the Henrys Fork River to 30° F at its confluence with the Snake River. The maximum annual average temperatures have ranged from 52° F in the headwaters area to 57° F at the confluence. Precipitation varies with elevation, with an average of over 43 inches of precipitation in the headwaters area and about 14 inches near the confluence. Over 70 percent of the precipitation occurs between November and May, mainly in the form of snow (Reclamation 1980).

The effects of climate change in the upper Snake River basin have been studied by Reclamation, Bonneville Power Administration, and U.S. Army Corps of Engineers. In general, results of these studies suggest a shift in the annual precipitation to earlier in the year, with more falling as rain. This shift reflects the probability of a longer warm/growing season with less precipitation in the latter part of the season. More detailed discussion of climate change parameters and effects is provided in Section 3.5. Climate change studies by Federal agencies, universities, and researchers are ongoing and when new science and results become available, they will likely be incorporated into future analyses.

2.3 Geology

The geology in the Basin Study area was formed by volcanic cycles and flows that left the northern portion of the area, namely the Island Park basin, layered with primarily rhyolitic magma which fractured and allowed basaltic magma to erupt and flood the floor of the basin. The rhyolite formations are highly permeable, particularly in the upper 100 feet or in highly fractured zones. Rainfall and snowmelt appear to rapidly infiltrate the formation so that little runoff or evapotranspiration occurs (IDWR 1978).

Outwash from glaciers during the Pleistocene Epoch scoured the highlands at the same time as basalt flows from vents south and west of the caldera covered some of the rhyolite flows. Flows from vents on the north and east of the caldera covered much of the eastern part of the study area (Figure 4). The alluvium fill that covers most of the basin is derived from volcanic and sedimentary rocks in the adjacent highlands. In general, the alluvium fill is thickest in the area of Henrys Lake and thins toward the south (Bayrd 2006).

2.4 Hydrology

Originating at Big Springs in the northern part of the basin, the mainstem of the Henrys Fork River flows generally southward, supplemented by water from tributaries flowing from the mountains to the east. The Henrys Fork watershed has four major subbasins: upper Henrys Fork, lower Henrys Fork, Fall River, and Teton River. The United States Geological Survey (USGS) identifies the upper Henrys Fork River watershed as hydrologic unit code (HUC) 17040202; the lower Henrys Fork River watershed as HUC 17040203; and the Teton River watershed as HUC 17040204.

Flows in the basin are influenced by snowmelt and groundwater. The predominately permeable geology of the basin generates a strong connection between surface water and groundwater, especially in the northern parts of the basin. Consequently, much of the lower Henrys Fork River and many of its tributaries are dominated by groundwater flows. The upper Henrys Fork River and Teton River are dominated more by snowmelt, while the lower Teton River has a strong connection to groundwater.

Streamflows are altered by the operation of Henrys Lake Dam, Grassy Lake, Island Park Dam, and Ashton Dam. In general, the dams are operated so that high flows during the spring are captured. Dam operations lower the annual peak flows and increase the low flows of summer and early fall to be increased. Winter flows may be lower than under natural conditions. Under the Drought Management Plan, winter flows are set to serve the best interest of the agricultural community while giving consideration to downstream fisheries and aquatic habitat.

The water supply of the Henrys Fork River basin is discussed in more detail in Section 3.0 and in the baseline conditions of some of the alternatives discussed in Section 5.0.

2.5 Fish and Wildlife

The Henrys Fork River basin is part of the Greater Yellowstone Ecosystem. This ecosystem is one of the largest intact temperate zone ecosystems on earth, covering 28,000 square miles in Idaho, Montana, and Wyoming. It has become an important sanctuary of the largest concentration of wildlife in the lower 48 states (NPS 2014).

The Henrys Fork River basin supports wild populations of native Yellowstone cutthroat trout (Figure 5) and nonnative rainbow trout and brown trout. IDFG operated the Henrys Lake Hatchery near the town of Island Park part of the year for egg collections from Yellowstone cutthroat trout for later release into Henrys Lake. The hatchery was closed in 2013.

Figure 5. Yellowstone cutthroat trout.[3]

Migratory Yellowstone cutthroat trout can be found in Henrys Lake, the Teton River, and the lower Henrys Fork River (DeRito 2012). Rainbow trout have largely displaced cutthroat trout throughout most of the mainstem Henrys Fork River and the Fall River drainages, but have not displaced cutthroat trout in the Teton River drainage. The reason for the difference is likely due to hydrology. The Henrys Fork River hydrograph is representative of groundwater-dominated streams in the Henrys Fork River basin, while the Teton River at South Leigh Creek and Snake River at Heise (just outside the Henrys Fork River basin) hydrographs are representative of snowmelt-dominated streams in the Henrys Fork River basin.

Nonnative rainbow trout have difficulty reproducing in streams that have a high peak flow immediately before and during fry emergence in the spring months because the peak flow displaces eggs and fry. The Yellowstone cutthroat trout fry generally emerge in late summer and early fall when they are not displaced by high flows. In the Henrys Fork River drainage, peak flows are low during rainbow trout egg incubation and fry emergence; consequently, rainbow trout have displaced cutthroat trout throughout most of the Henrys Fork watershed (Van Kirk and Jenkins 2005). In the Teton River drainage, peak flows are high during rainbow trout egg incubation and fry emergence in the spring which may be one reason why rainbow trout have been less successful in the Teton River basin.

As a result of the Yellowstone cutthroat trout population status, IDFG has designated the Yellowstone cutthroat trout as a Species of Greatest Conservation Need (IDFG 2005). IDFG's *Management Plan for Conservation of Yellowstone Cutthroat Trout in Idaho* provides

[3] Photo catalog of yellowstone cutthroat trout can be found at http://www.nps.gov/yell/naturescience/fishid_yct.htm, accessed on September 27, 2013.

details on Yellowstone cutthroat trout population status, distribution, habitat, history of ESA actions, threats, and management actions (IDFG 2007).

As part of the Greater Yellowstone Ecosystem, the Basin Study area provides habitat for a variety of large and small mammals and birds. Over 50 IDFG Species of Greatest Conservation Need are found throughout the watershed. Grizzly bears and lynx, both listed under ESA, are found in the Henrys Fork River basin. Black bears, deer, moose, elk, and pronghorn also inhabit the forested uplands, grassland steppe, and canyons. Small mammals such as beaver, river otters, raccoons, marmots, bats, and a large variety of rodents are year-round residents across the entire Study Basin area. Species such as fisher, wolverine, and lynx use the watershed as transitional habitat. Low elevation areas of the Henrys Fork River basin that are located in the Sand Creek desert provide wintering grounds for thousands of mule deer, elk, and moose.

Fish in the rivers and creeks draw hawks, osprey, owls, kestrels, and eagles to nest in the area during the summers. Columbian sharp-tailed grouse are found throughout the watershed in suitable grassland steppe and agricultural habitats and are considered a Species of Concern by the U.S. Fish and Wildlife Service and a Sensitive Species by the U.S. Forest Service and Bureau of Land Management. Sage grouse are found in intact sagebrush habitats of the watershed and are a candidate species for ESA listing by the U.S Fish and Wildlife Service. Northern goshawks have been seen in the Basin Study area and are considered a Sensitive Species by the U.S. Forest Service (Reclamation 2006).

Figure 6. Sage grouse.[4]

[4] See http://fishandgame.idaho.gov/public/wildlife/sageGrouse/ for Sage-grouse Conservation and Management information.

The Henrys Fork River basin is located along a portion of the Pacific waterfowl flyway. Over a million waterfowl migrate through the area in spring and in fall, with large concentrations of ducks and geese found around Island Park Reservoir and Henrys Lake and along most of the river systems. Trumpeter swans utilize the open waters of the Henrys Fork River basin, which is the primary wintering area for most of Canada's trumpeter swan population (IWRB 1992). Open waters of the Henrys Fork River basin provide wintering habitat for the nearly 5,000 trumpeter swans of the Rocky Mountain population that nest in Canada and the Greater Yellowstone ecosystem area.

2.6 Land Use

Land use in the Henrys Fork River basin is comprised of forestland, rangeland, irrigated cropland, dryland agriculture, and other uses such as urban and housing development areas. The forest land and much of the rangeland are located mostly in the mountainous northern and eastern parts of the basin. Most of the forested lands are owned by the United States and managed by the Forest Service or the National Park Service. The majority of the agricultural land is concentrated in the western, central, and southern areas of the basin, especially on both sides of the lower Henrys Fork River and the lower Teton River (Figure 7).

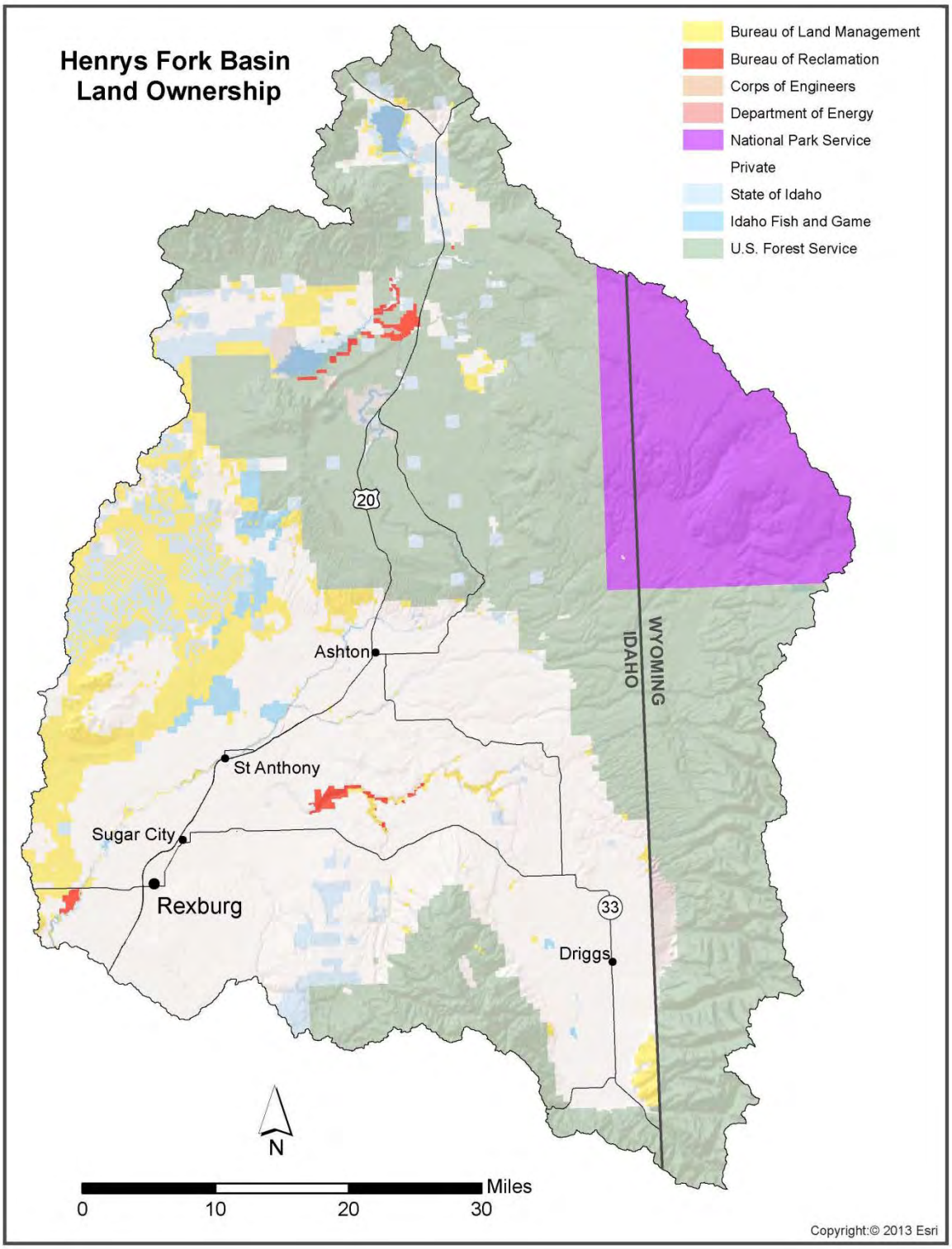

Figure 7. Map showing land ownership in the Henrys Fork River basin.

2.7 Socioeconomics

The 2010 Census recorded 13,242 people in Fremont County, 37,536 people in Madison County, and 10,170 people in Teton County (IDOL 2012). The average county population of the Basin Study area has increased by about 34 percent since 2000, with Fremont County population increasing 7.4 percent, Madison County increasing 39.9 percent, and Teton County increasing 55.7 percent (Census 2011). To meet the needs of the growing population, farms and ranches have been subdivided into housing developments, many of which were platted on lands formerly irrigated for agriculture.

Irrigated agriculture and its related food processing are the main economic activities in the Henrys Fork River basin (IWRB 1992), with the FMID lands generating over $100 million annually in crop sales (Reclamation 2004). Water for the majority of irrigated lands comes from Reclamation's Minidoka Project (see Section 3.1.1). The irrigated lands consist of highly productive soils which primarily produce grain, alfalfa, and potato crops and support dairy and beef operations (Table 2 and Table 3). Livestock water supplies come from irrigation canals or from livestock access to streams and springs.

Table 2. Estimated acreages of major crops in 2010 (NASS 2012).

Crop	Fremont County (acres)	Madison County (acres)	Teton County (acres)	Total Acres
Alfalfa	25,900	20,100	16,800	62,800
Barley	42,800	38,100	28,300	109,200
Potatoes	22,500	28,000	5,300	55,800
Winter Wheat	0	2,600	2,000	4,600

Table 3. Estimated number of cattle during 2010 (NASS 2012).

	Fremont County	Madison County	Teton County
Head of Cattle	13,100	11,100	8,200

Tourists come to the upper Henrys Fork River basin area to visit the nearby Yellowstone and Grand Teton National Parks and to participate in a variety of outdoor recreational activities on National Forest system lands. The Henrys Fork River's world-class fly fishing and the National Forest system lands provide summer and winter outdoor recreational opportunities, drawing tourists from all over the world, and sustaining the tourism/recreation businesses in the area. On the Henrys Fork River alone (Fremont and Madison Counties), angling contributed $29 million and 851 jobs to eastern Idaho's economy. Improved stream conditions could lead to higher catch rates and larger fish, resulting in larger benefits to the rural communities of perhaps as much as $49 million annually (Loomis 2005).

2.8 Hydropower Facilities

Hydropower generation facilities in the basin are located on the Henrys Fork River (Island Park Dam, Chester Dam, and Ashton Dam), the Teton River (Felt Hydro [Figure 8]), the Fall River (Marysville Hydro), and the Buffalo River (Buffalo River Dam).

Figure 8. Felt hydro powerplant on the Teton River.

3.0 WATER SUPPLY AND DEMAND

The hydrology and associated water supplies and demands in the Henrys Fork River basin are complex. Water supply and demand involves a variety of activities and users. In the *Henrys Fork Watershed Basin Study Water Needs Assessment* (Appendix A of Reclamation 2012), the Basin Study area's water needs were discussed in detail for agriculture; hydropower; domestic, commercial, municipal, and industrial water; fish and wildlife habitat; and stabilization of the ESPA. While all water needs are acknowledged as important to the Basin Study area, IWRB, Reclamation, and the Workgroup prioritized three water needs above the others for study: agriculture; fish and wildlife habitat; and groundwater supply for the ESPA.

The following sections describe the current surface water and groundwater supplies and water demands as related to the three prioritized needs in the basin as they currently exist. The climate change projections that may come about in the next 40 years are discussed, as well as how climate change may affect future water supplies and demands.

3.1 Surface Water Supplies

The Henrys Fork River is the largest tributary of the Snake River which in turn, is the largest tributary to the Columbia River. Under natural, unregulated conditions, the total watershed discharge would be around 2.5 million acre-feet per year, with the largest tributaries, Fall River and Teton River, collectively contributing about 1.3 million acre-feet per year (Table 4; Van Kirk 2011).

Table 4. Mean annual natural flows for Henrys Fork River basin (Van Kirk 2011).

Source	Segment	30-Year Mean Annual Natural Flow (acre-feet)	30-Year Mean Annual Flow (acre-feet)	Percent of Total
Upper Henrys Fork River			1,225,356	48.2%
	Henrys Lake	41,768		1.6%
	Henrys Lake to Island Park	439,072		17.3%
	Island Park to Ashton	744,516		29.3%
Fall River			699,914	27.5%
Teton River			618,863	24.3%
	Teton Above S. Leigh	304,084		12.0%
	Teton S. Leigh to St. Anthony	314,779		12.4%
Total Henrys Fork watershed			**2,544,133**	**100.0%**

The natural flow regime of the Henrys Fork River has been altered by irrigation diversions, increased evapotranspiration of irrigation, water storage, and canal conveyances. This alteration is highest during low water years and in the upper portion of the basin (Reclamation 2004).

The mean annual basin outflow over the past 30 years is about 1.6 million acre-feet (Figure 9; Van Kirk 2012a). Much of the water lost to reservoir, stream, and conveyance system seepage and irrigation is recaptured as recharge to the aquifers (Appendix A of Reclamation 2013a). Computer modeling has shown that the lower Henrys Fork River would be a losing reach in the absence of irrigation return flow so that under natural conditions, the basin outflow would still be somewhat less than the supply of 2.5 million acre-feet, due to river seepage to the ESPA (Van Kirk 2012a).

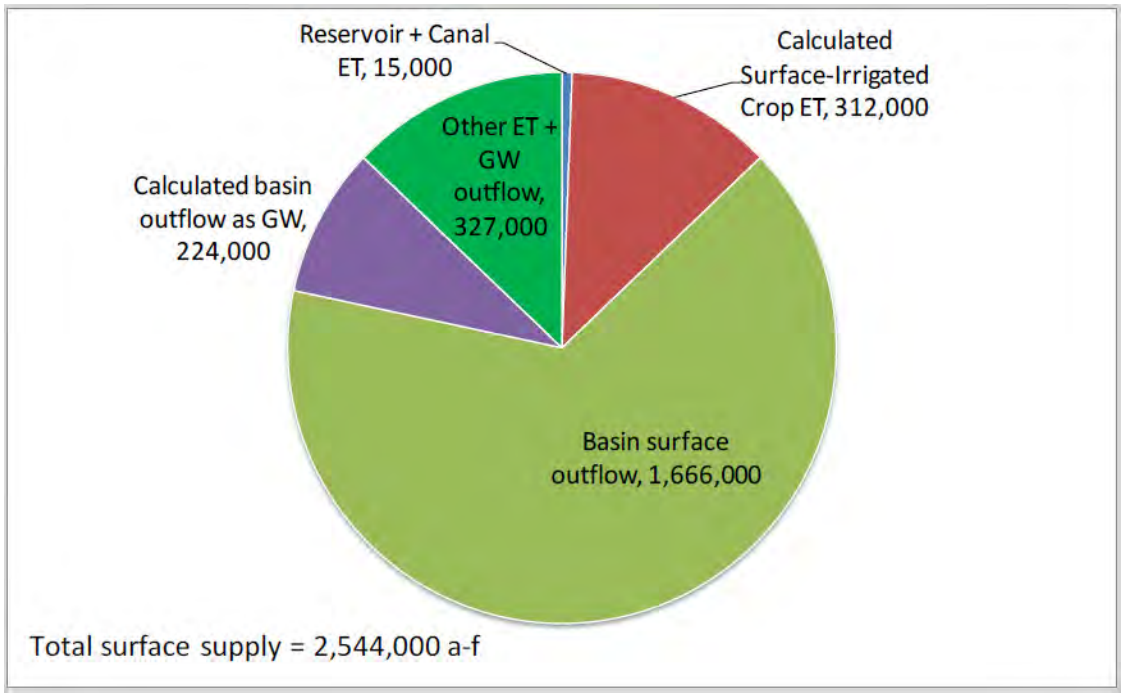

Figure 9. Water budget for Henrys Fork River basin surface supply (Van Kirk 2011). ET denotes evapotranspiration and GW denotes groundwater.

Much of the surface water is tapped for agricultural uses. Water in the Henrys Fork River basin is stored in Henrys Lake, Grassy Lake, and Island Park Reservoir for delivery to irrigated lands across the basin. Private interests developed Henrys Lake Dam and many canals and laterals serving the irrigation lands in the basin were privately developed prior to Reclamation's Minidoka Project. Reclamation's Minidoka Project extends into parts of the Henrys Fork River basin and includes Island Park Reservoir and Grassy Lake and some of the irrigation systems.

3.1.1 Minidoka Project

Reclamation's Minidoka Project is comprised of many dams, reservoirs, hydroelectric facilities, and associated irrigation systems throughout the upper Snake River system (Figure 10). Facilities of the Project include the Minidoka Dam and Reservoir, Jackson Lake Dam and Reservoir, American Dam and Reservoir, Island Park Dam and Reservoir, Grassy Lake Dam and Reservoir, and the Cross Cut, North Side, South Side, and Milner-Gooding canals. The Project provides a full or supplemental irrigation water supply to about 1.1 million acres. Project lands extend discontinuously from the town of Ashton on the Henrys Fork River, to the confluence of the Henrys Fork River with the Snake River and then continue for a total of about 300 miles downstream to the town of Bliss in south-central Idaho. Island Park Dam and Reservoir, Grassy Lake Dam and Reservoir, and the Cross Cut Canal are the only Project facilities present in the Basin Study area.

Most of the water in the Henrys Fork River basin is appropriated; however, new junior water rights may possibly be stored in reservoirs during high flows for short durations of time. Much of the water stored in Island Park Reservoir must be passed through the basin to out-of-basin senior water rights holders. In accordance with spaceholder contracts for reservoir storage, water is stored in a manner that will maximize reservoir storage by keeping storage in the most upstream reservoirs. Water may be passed downstream from Island Park Reservoir to American Falls Reservoir to increase late winter flows below the Island Park Dam; consequently, water physically stored in one reservoir may actually belong to another reservoir.

In 1935, FMID was formed to unite the many irrigation and canal companies spread across Fremont, Madison, and Teton Counties in eastern Idaho. FMID distributes a supplemental water supply to about 1,500 water users irrigating over 285,000 acres associated with the original Upper Snake River Storage Division of the Minidoka Project and the Lower Teton Division of the Teton Project (Reclamation 2004). Irrigated acreage and irrigation methods have changed through the years, increasing the efficiency of water use. FMID estimates that over 70 percent of the acreage is sprinkler irrigated; the remaining lands are flood or subirrigated.

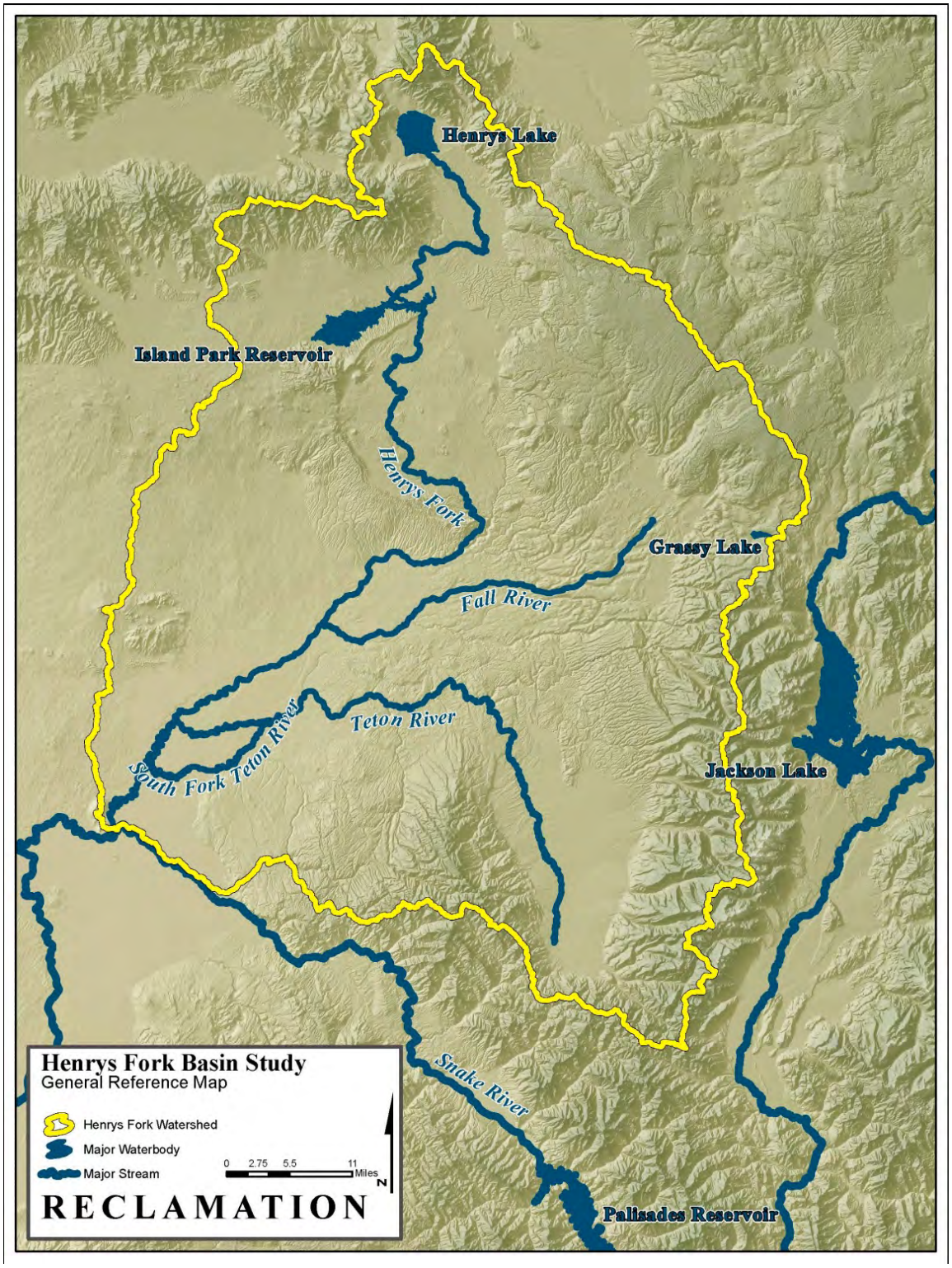

Figure 10. Map of the Minidoka Project facilities in or adjacent to the Henrys Fork Basin Study area. Only Island Park Dam and Reservoir and Grassy Lake are inside the Basin Study area. Henrys Lake is privately owned.

Island Park Dam and Reservoir

Island Park Reservoir, operated by Reclamation, has a total storage capacity of 135,500 acre-feet (Figure 11). The water surface elevation in the reservoir reaches its highest level in late spring and its lowest level in October. Releases from the reservoir are made in consultation with FMID based on water supply, reservoir carryover, and irrigation demand. Releases during irrigation season are generally maintained at 1,200 cfs at the St. Anthony gage, but during years of low runoff, an operating target of 1,000 cfs is maintained downstream at the Rexburg gage.

Figure 11. Island Park Dam and Reservoir on the Henrys Fork River, Idaho.

In the winters, Island Park Dam and Reservoir are owned by Reclamation and operated by FMID. In coordination with Reclamation and other State and Federal agencies, FMID sets the timing and quantity of winter flows in the Henrys Fork River below the dam, based on reservoir carryover and current and projected precipitation. Winter flows may be passed out of Island Park Dam and stored in American Falls Dam without shorting irrigation needs for the next irrigation season, allowing higher late winter flows below the dam which are critical to juvenile fish survival. Ramping rates and schedules are in accordance with the project's Federal Energy Regulatory Commission (FERC) license.

Hydropower is generated at Island Park Dam. The Fall River Rural Electric Cooperative owns the Island Park Hydroelectric Project.

Grassy Lake Dam and Reservoir

Constructed and operated by Reclamation, Grassy Lake Dam is located on Grassy Creek in Wyoming near the southern edge of Yellowstone National Park on Reclamation-withdrawn National Forest system lands (Figure 12). Its storage capacity of 15,500 acre-feet provides supplemental water for FMID. No releases are made during the winter, and summer releases are based on demand, usually in July and August. Additional releases may be made in late summer, if needed, to draft Grassy Lake to its winter operation level of 12,200 acre-feet.

Figure 12. Grassy Lake Dam and Reservoir, Grassy Creek, Wyoming.

Cross Cut Diversion Dam and Canal

Reclamation built the Cross Cut Diversion Dam and Cross Cut Canal in 1938 as part of the Minidoka Project. The Cross Cut Diversion Dam, later renamed Chester Dam, diverts water from the Henrys Fork River between Ashton and St. Anthony, immediately below the confluence with the Fall River. The dam is a concrete weir that raises the water level 10 feet above the streambed (Figure 13). The Cross Cut Canal travels approximately 6.6 miles in a south-southwesterly direction before flowing into the Teton River near Newdale, Idaho. It has a capacity of 591 cfs at the headworks and 759 cfs where the Fall River discharge water enters the canal. The canal conveys irrigation water to 112,000 acres in Fremont and Madison counties, in part via the Teton River.

Under the Fremont-Madison Conveyance Act (P.L. 108-85), Reclamation transferred all right, title, and interest of the United States in and to the Cross Cut Diversion Dam and Reservoir, the Cross Cut Canal, and the canals, laterals, drains, and other components of the water distribution system to FMID.

Figure 13. Cross Cut Diversion Dam and radial headgate on the Henrys Fork River.

3.1.2 Teton Exchange Wells

In the early 1970s, Reclamation drilled five wells to serve the Lower Teton Division of the Teton Basin Project. In 1977, FMID and Reclamation entered into a contract to allow use of the wells as a supplemental water supply in exchange for the water that would have been stored behind the failed Teton Dam. During low water years, FMID pumps up to 30,000 acre-feet of water from the wells into the lower Henrys Fork River, the lower Teton River, and the North Branch Independent Canal to increase the water supply. Although the well permit allows for additional well developments, FMID has agreed to limit well expansion to supply a maximum of 80,000 acre-feet per year during low water years. Although the well water is discharged directly into the Henrys Fork River, it does not provide a net benefit to the instream flows, but instead replaces storage water released from Island Park Reservoir for irrigators downstream of FMID. Exchange well pumping and additional exchange well development may impact the Henrys Fork River and Snake River by slightly decreasing river flows.

3.1.3 Henrys Lake and Dam

In the early 1920s, the North Fork Reservoir Company (NFRC) constructed a dam across the outlet of the natural Henrys Lake to increase the storage capacity of the lake and supply irrigation water to the St. Anthony area (Figure 14). NFRC owns the dam and reservoir, and operates the 90,000 acre-feet of storage in conjunction with the Minidoka Project.

Figure 14. Henrys Lake.[5]

3.2 Groundwater Supplies

Aquifer recharge from irrigation system seepage is a major component of the Henrys Fork River watershed hydrology. The Henrys Fork River watershed exhibits a high degree of surface water and groundwater interaction, both spatially and temporally. Almost 25 percent of the flows diverted from rivers in the Basin Study area enter the aquifers as seepage from reservoirs, rivers, conveyance systems, and irrigation. (Van Kirk 2011). Using the large aquifers of the region as underground reservoirs has been extensively studied, but mostly in regard to recharging of the ESPA (IDWR 1999). Increased irrigation efficiencies, increased groundwater pumping, and a series of drought years have lowered groundwater levels in the Basin Study area and in the ESPA. The total diversions in the basin have decreased about 20 percent since 1978 and recharge has decreased by approximately the same amount (Van Kirk 2011).

There are three main aquifers in the Basin Study area which influence the flows in the Henrys Fork watershed, as well as a localized shallow aquifer. The Yellowstone Plateau Aquifer, formed of rhyolite, covers hundreds of square miles and is recharged by snowmelt. It discharges hundreds of thousands of acre-feet annually to the headwaters of the Henrys Fork River. The Teton Valley Aquifer covers 90 square miles and is recharged by stream channel,

[5] From Idaho Parks and Recreation website at http://parksandrecreation.idaho.gov/parks/henrys-lake.

irrigation canal, and irrigation seepages (Bayrd 2006). The southwestern portion of the Basin Study area lies above the highest point of the ESPA, upstream of most points of ESPA use. The Henrys Fork River basin is an important source of recharge to the ESPA. FMID participates in IWRB's Recharge Program and since 2008, has provided nearly 150,000 acre-feet of water for recharge to the ESPA.

The ESPA covers more than 10,800 square miles of southern Idaho, extending from the town of Ashton in the Basin Study area for 170 miles to the southwest and 60 miles across at its greatest width (Figure 15). The capacity of the ESPA is estimated to be as much as a billion acre-feet of water. It discharges about 8 million acre-feet of flow each year past King Hill at the western-most point of the aquifer (IDEQ 2005). Recharge to the ESPA comes from stream channel and irrigation seepage, and discharge is primarily at Thousand Springs on the Snake River. Its discharge is higher now than it was before irrigation due to the increased seepage from irrigation systems above it; however, the total recharge to the ESPA has decreased since the mid-1900s due to more efficient irrigation delivery systems (Bayrd 2006). More than 10 percent of the ESPA is recharged from irrigation activity in the Basin Study area (Reclamation 1991).

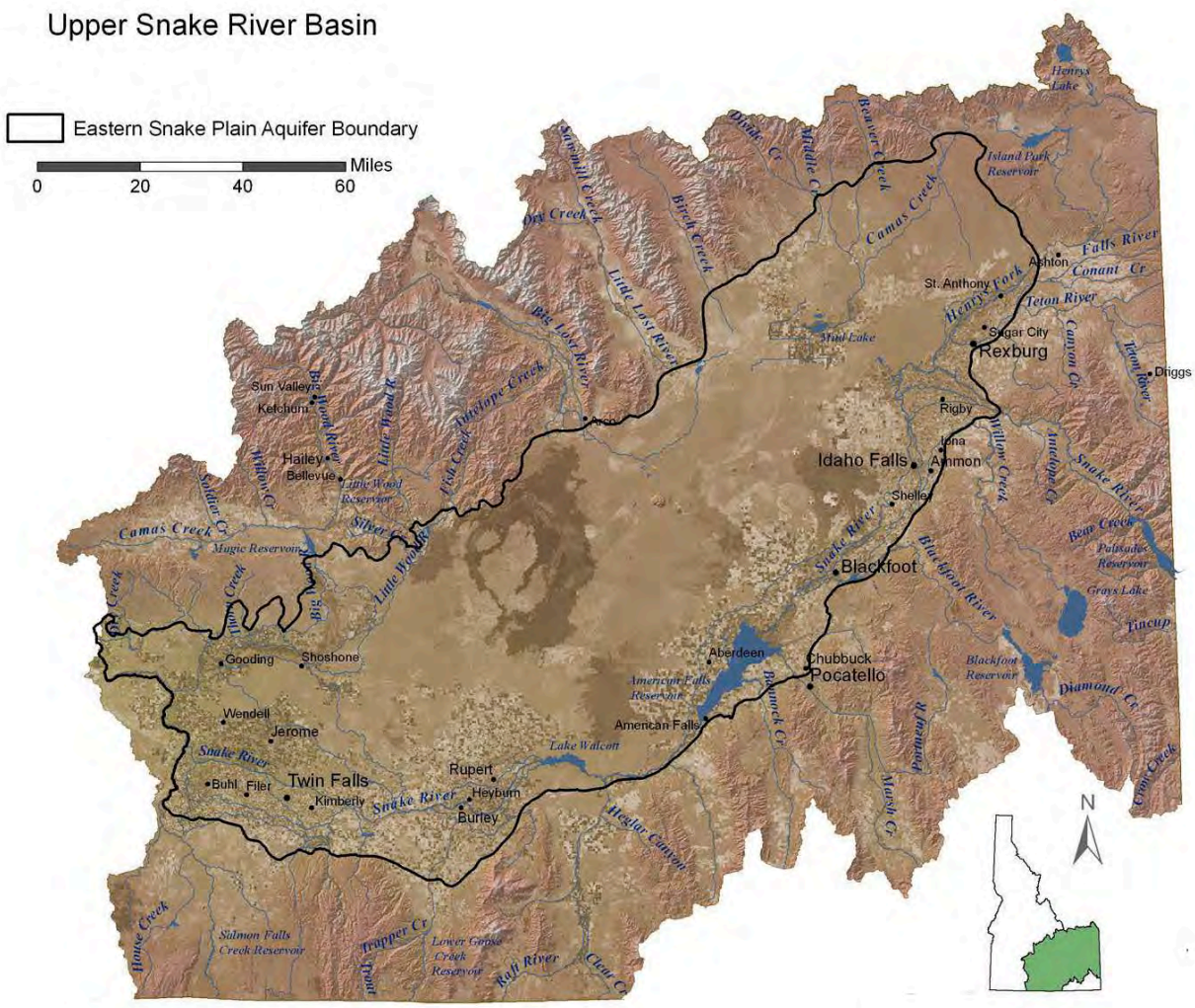

Figure 15. Map of the Eastern Snake River Plain (ESPA). The northeastern-most part of the ESPA stretches into the western side of the Basin Study area.

The IWRB operates a Managed Recharge Program in the ESPA, together with other measures as laid out in the ESPA CAMP (see Section 1.5.2). From 2009 through 2012, IWRB-sponsored managed recharge in the ESPA totaled almost 468,444 acre-feet, or 117,111 acre-feet per year on average. FMID and its member canals participate in the Recharge Program by delivering recharge water prior to and after the irrigation season. FMID's recharge occurs as a result of canal seepage and by direct delivery to the Egin Lake recharge site. In both situations, water passively infiltrates into the ESPA; however, the proportion of water from the Egin Bench canals that goes into the ESPA is still unknown. Since 2008, FMID has delivered an estimated 148,831 acre-feet for recharge (IWRB 2010, IWRB 2012b).

3.3 Water Demands

From the beginning of the Basin Study in 2010, the Workgroup, Reclamation, and IWRB collaborated to identify alternatives that addressed the Henrys Fork River basin water needs. As a result of input from meetings and from public comments received on Basin Study documents, the three water needs of agriculture, fisheries, and ESPA were determined to be the priorities in the Basin Study area and became the focus of the Basin Study.

Existing water demands vary from year to year with varying annual precipitation amounts; future water needs will vary with climate change impacts, population growth, changes in farming methods, water conservation, and other factors that may not be fully understood at this point in time. Table 5 summarizes the current demands and projected future water demands in the basin without consideration of climate change impacts. These totals may vary as climate change impacts become more evident in the future.

Table 5. Summary of average annual water demands in the Henrys Fork River basin (Appendix A of Reclamation 2012).

Water Needs	Current Water Use (acre-feet)	Projected Future Use (acre-feet)	Future Unmet Water Demands (acre-feet)
Agriculture (based on the four canal-irrigated regions)[1]	282,905 in average years 234,421 in drought years	366,235 in average years 366,235 in drought years	83,331 in average years 131,814 in drought years
Fisheries			200,000
ESPA (long-term target to be met through a mix of regional strategies)			600,000
Domestic, commercial, municipal, and industrial needs[2]	18,361	36,722	18,361
Environmental needs	Various Recommendations	Various Recommendations	Various Recommendations

[1] Agricultural current and future use refers to crop consumptive requirements. To meet these crop requirements, additional water must be diverted to account for canal and on-farm inefficiencies.

[2] 2 percent annual increase over 40 years based past population growth and current water use.

3.3.1 Surface Water Demand

Agriculture

Reclamation defines a water shortage as a maximum of 50 percent of a full water supply in a single year or a 10 percent average shortage in any 10 consecutive years. Based on these criteria, three of the four irrigated regions in the Basin Study area have varying degrees of water shortages that range from 20 to 80 percent for individual canal companies (Figure 16):

- Lower Watershed – adequate supply in average water years; deficit in a drought year following a drought year.
- North Fremont – always significantly deficit.
- Teton Valley – always significantly deficit.
- Egin Bench – has a surplus in average water years and a balance in drought year following a drought year.

The average annual irrigation water supply shortage in all four canal-irrigated regions is 83,331 acre-feet (Appendix A of Reclamation 2012). The Teton Exchange wells are located at the lower end of the basin; consequently, supplemental water from the wells cannot be directly delivered to the Fremont and Teton areas that have the greatest unmet irrigation needs. Local irrigators indicate that several management strategies are used during drought periods, particularly in regions like the Fremont and Teton irrigated regions where water shortages are greatest, to minimize the economic consequences of agricultural water shortages.

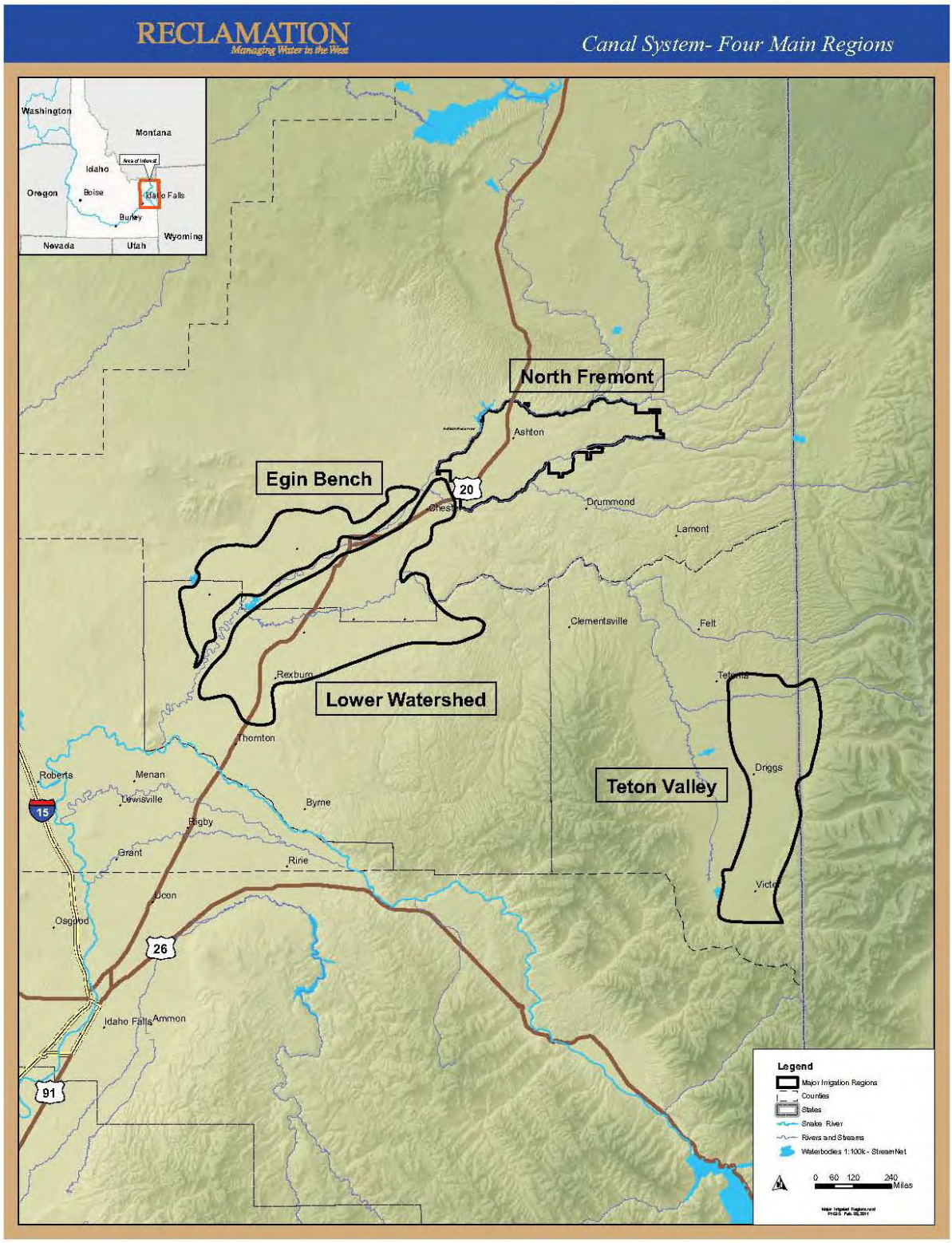

Figure 16. The four irrigated regions in the Henrys Fork Basin Study area.

Fish and Wildlife

The minimum streamflow is defined as the minimum flow necessary to protect desired stream values such as fish and wildlife habitat, aquatic life, recreation, aesthetic beauty, navigation, transportation, or water quality (Idaho Code § 42-1502(f)). Various recommended minimum flow targets to preserve stream values have been planned by the IDFG (IDFG 1999 and IDFG 1978), the Snake River Resources Review panel (SR3 2001), and other entities. Under the Henrys Fork River Drought Management Plan, Reclamation cooperates with IDFG and FMID to minimize impacts from reservoir drawdowns and meet fish habitat needs while still considering irrigation needs.

Current water management practices allow Teton Valley irrigators to purchase water from storage facilities outside of the Teton River basin (most commonly out of Island Park Reservoir) to provide water for downstream senior users when IWRB curtails surface water usage. This practice results in out-of-basin water exchanges and tends to exacerbate tributary dewatering issues. While groundwater recharge from irrigation activities helps replenish downstream flows, diversions often have a negative impact on fish and fish habitat.

The timing and magnitude of peak and seasonal flows in the Henrys Fork River and its tributaries are important to sustain its fisheries (see Section 2.5). The current alteration of flows below storage and power facilities on the rivers in the basin is offset to a small extent by inflows from the tributaries and groundwater recharge from irrigation activities. Additional water to reduce the impacts to fisheries is most needed in the tributary basins where there is less inflow and recharge and the water shortages are the greatest (Van Kirk et al. 2011).

3.3.2 Groundwater Demand

The ESPA was designated as a sole source aquifer by the U.S. Environmental Protection Agency because it supplies at least 50 percent of the drinking water to the population living above the aquifer and there is no other source of drinking water that can be physically, legally, or economically used to supply that population (IDEQ 2005). A large part of Idaho's agricultural product, valued at approximately $10 billion annually, is dependent on water from the ESPA (IDWR 2009). Fish farms fed by the ESPA provide about three-fourths of the nation's farm-raised trout (IDEQ 2005).

In the ESPA, more water is being used than is being recharged. Declining aquifer levels and spring discharges (e.g., Thousand Springs area), changing flows in the Snake River, and other actions (e.g., flow augmentation for anadromous fish survival) have resulted in insufficient supplies to satisfy existing beneficial uses across the upper Snake River basin. As described in Section 1.5.2, the ESPA CAMP outlines a long-term objective of incrementally achieving a net ESPA water budget increase of 600,000 acre-feet annually through implementation of a

mix of management actions including, but not limited to, aquifer recharge, groundwater-to-surface water conversions, and demand reduction strategies (IWRB 2009).

3.4 Characterization of Future Conditions

Looking 40 years into the future, economic issues relating to irrigation, recreation, and associated businesses will continue to require dependable water supplies. Future water needs may fluctuate with varying annual precipitation amounts, climate change impacts, population growth, changes in farming methods, water conservation, and other factors that may not be fully understood at this point in time. While the quantity of available water is not expected to change in the future, the timing of peak flows and an extended warm-weather season could increase future demands across all areas and needs (see Section 3.5).

For the Basin Study, no increase in the number of irrigated acres is expected; however, fewer acres may be irrigated as farms and ranches are subdivided into housing developments to meet the growing population needs. Future irrigation water demands could be affected by the continued conversion of agriculture lands to urban areas; changes in crop types in response to the market or climate conditions; and the employment of new conservation measures in agricultural practices or irrigation delivery systems. Whether these impacts will increase or decrease future demands is unclear at this time.

The Henrys Fork River is expected to maintain its reputation for world-class fly fishing and the adjacent National Forest system and National Park lands will likely continue to draw tourists from all over the world.

The river is expected to continue to support wild populations of native Yellowstone cutthroat trout and nonnative rainbow trout and brown trout. The Basin Study area is expected to continue to provide habitat for a variety of large and small mammals and birds; however, recharge from irrigation has decreased with the installation of more efficient irrigation systems, which in turn has decreased groundwater inflows to the rivers. Over time, this could potentially impact wildlife and fisheries and their habitats (Van Kirk 2011).

IWRB expects to continue the managed recharge program and manage and improve the ESPA water supply consistent with the ESPA CAMP and State Water Plan.

3.5 Potential Effects of Climate Change on Supply and Demand

The impacts of climate change in the Henrys Fork River basin are uncertain. Ongoing research indicates that the basin may experience warmer air temperatures and varied precipitation amounts. There may be a shift in the timing of peak flows to earlier in the year

and a decrease of summer flows during the warmer months. The projected warmer air temperatures could extend the irrigation season to later in the year than is currently experienced.

Reclamation, the Bonneville Power Administration, and the U.S. Army Corps of Engineers collaborated to adopt climate change and hydrologic datasets to better understand how potential changes in water supply due to climate change may affect reservoir operations in the Columbia River Basin. Output (e.g., temperatures, precipitation) from Global Circulation Models (GCMs) was spatially downscaled and bias corrected, then used in a hydrologic model that generated supply or flow values at various locations in the Columbia River Basin. Two future time periods called Hybrid-Delta were defined as the 30-year period surrounding the 2020s (2010 to 2039) and the 30-year period surrounding the 2040s (2030 to 2059). Those supply data were provided to stakeholders for use in their long-term planning models for several basins, including the upper Snake River basin which included the Henrys Fork watershed. For the analyses of the Basin Study alternatives, the 2040s period was used in the computer modeling activities.

3.5.1 Potential Effects on Agricultural Water

Using hydrologic models, Reclamation generated projected inflows influenced by climate change. Those data were used in existing water management models for the upper Snake River above Brownlee Reservoir. The modeling results indicated a shift in the timing of the peak flow to a month earlier. Flow volume increased above historical flows earlier in the cool season (October or November to April) and decreased in the summer and fall seasons (May through September or October).

This shift in peak flow timing and increased cool season inflow occurred when reservoirs would be at or near capacity or constrained by a flood control rule curve that may increase the probability of passing floodwaters downstream. The lower flows that are projected in future summer months may result in less water in the rivers and creeks to fulfill natural flow water rights, subsequent increased use of stored water by those that hold contracted storage space, and potential impacts to reservoir carryover during particularly long-term drier periods.

Given the modeled warming global temperatures and changes in precipitation, the growing season for agriculture is expected to begin earlier in the season and end later in the season than it currently does, depending on geography. While the shift of peak flow timing to earlier in the year may be counterbalanced by the shift in the volume of flow, the extension of the growing season will likely exacerbate any drought conditions currently experienced by instream flow users and create a greater reliance on storage water rights.

These shifts may also affect the operations of dams and management of irrigation systems, increasing the need to release more water from the reservoirs and divert more water for

irrigation later in the summer months (Reclamation 2011). A decrease in natural streamflow in the late summer to early fall months could result in less water available for natural flow diversions thus increasing stored water usage.

3.5.2 Potential Effects on Fish and Wildlife Habitat

Environmental objectives for both anadromous and resident fish species were evaluated in the climate change study. Climate-induced changes in the hydrologic regime of the Henrys Fork River could impact early life stages of fish (i.e., Yellowstone cutthroat trout and rainbow trout). Earlier peak flows due to climate changes in the Basin Study area could potentially impact the timing of spawning and fry emergence (see Section 2.1). Warmer air temperatures may increase water temperatures enough that fish will move to higher elevations in search of cold water (Gresswell 2011).

Since 1992, consultations between Reclamation and NOAA Fisheries Service under Section 7(a)(2) of the ESA have included the consideration of flow augmentation from Reclamation's upper Snake Projects (including Island Park Reservoir) to augment flows in the lower Snake and Columbia rivers through acquisitions from willing sellers. In the reservoirs that require minimum pools or flows, it was found that in some cases, it may be more difficult to meet these augmentation objectives in some of the reservoirs in the driest conditions (Reclamation 2011).

3.5.3 Potential Effects on Groundwater and the ESPA

Climate change in the Henrys Fork River basin has the potential to impact the quantity of groundwater recharge and the quantity of water pumped from the shallow aquifer. Three climate change scenarios were used to evaluate potential impacts to streamflow in the Henrys Fork River basin (see Section 5.1.2). The modeling results indicated an increase in precipitation from historical norms in the winter months and a decrease in the summer months (Reclamation 2013b). These changes in precipitation patterns would result in increased base streamflows in the winter months and a decrease in the summer months.

Based on the climate change projections, recharge that occurs directly from precipitation has the potential to increase during the winter months and decrease during the summer months. Since a large portion of the groundwater recharge in the Henrys Fork River basin occurs due to canal losses and on-farm inefficiencies, changes in farming practices and methods in response to climate change have the potential to impact the aquifer more than climate change alone. Irrigators may be more likely to implement conservation measures, such as converting to sprinkler irrigation or lining/piping canals, to improve the efficiencies of their systems if late summer flows are limited. These activities could result in decreased recharge to the aquifers.

The Teton exchange wells are operated by FMID in years when FMID's full water allotment from Island Park Reservoir storage is not available. This type of operation may occur less often under the projections evaluated. Island Park Reservoir fills more often under the climate change projections that were used in this study. Because these projected future climates increase inflow to the reservoir during the winter and thereby increases the reliability of filling the reservoir, the operation of the exchange wells would be required less often, resulting in less water pumped from the aquifer.

The changes to aquifer storage as a result of changes in recharge would impact groundwater returns to streams, though the extent of the impact would depend on the quantity of increased or decreased recharge.

3.6 Future Challenges and Considerations

The Henrys Fork River basin and ESPA are in a non-trust water area as designated by the IDWR. The trust/non-trust areas were established as a result of 1984 Swan Falls Agreement between the State and Idaho Power Company which defined minimum streamflows in the Snake River for Idaho Power Company's water rights at Swan Falls above Milner. Water rights from the Snake River in the non-trust area are not fully satisfied at certain times.

In general, for any new consumptive use of water, applicants must demonstrate to the State that their new diversion and consumptive use of water will not injure senior water rights or that mitigation can be done during times in which injury would otherwise occur. The interconnection between surface and groundwater in the area must be considered and addressed in any new proposal. Meeting these criteria may limit new water uses in the future for municipalities and industries.

4.0 SCREENING AND SELECTION OF ALTERNATIVES

As a first step in the planning process, Reclamation, IDWR, and the Workgroup met to discuss the issues, opportunities, and constraints to be considered in formulating alternatives for the Basin Study. Through these discussions, the following process was defined to both identify the full range of alternatives and determine which ones held the most promise and warranted more detailed investigations as the focus of this study:

1. Identify a full range of potentially viable alternatives for augmenting water storage and for optimizing and conserving water supply in the Henrys Fork River basin. In the case of storage, alternatives needed to provide additional water supply for both the Henrys Fork Basin and the ESPA. For water supply optimization and conservation, the focus would be on in-basin needs.

2. Conduct initial opportunities and constraints screening of the full list of potential alternatives by using available information and a straightforward scoring system to determine which alternatives warranted more detailed consideration or should be eliminated early due to a high level of constraint ("fatal flaws") or fundamental absence of meaningful opportunities.

3. Review results of initial screening to verify accuracy and credibility; refine results based on (Step A) professional judgment of the study team and (Step B) preliminary analysis, including field reconnaissance, to define the final short list of the most promising alternatives that would become the focus of this Basin Study.

4.1 Identification of Potential Alternatives

The full range of potential alternatives to provide additional water storage and to optimize and conserve water resources in the Henrys Fork River basin was identified through a review of existing sources[6] and through discussions with the Workgroup. Four general categories emerged from the 51 alternatives put forward by the Workgroup: 1) surface storage; 2) groundwater recharge; 3) water markets; and 4) conservation water management and demand reduction in agricultural and municipal uses.

4.1.1 Combination of Alternatives

Reclamation, IDWR, and the Workgroup recognized that the potential to combine alternatives aimed at increasing storage and improving management of water resources held significant promise for meeting local and regional/State needs. At this early stage of planning, too little

[6] Many of these published sources may be found at http://www.usbr.gov/pn/programs/studies/idaho/henrysfork/reference/index.html.

was known about the characteristics of the individual elements, how viable they would be, and how they may synchronize with each other. Consequently, the study of potential combination options or water supply and management programs was deferred until sufficient study of individual categories of action was completed.

4.2 Preliminary Screening – Opportunities and Constraints Assessment

All of the alternatives put forward by the Workgroup were assigned scores based on the evaluation categories and factors listed in Table 6. The scores provided a ranking of the alternatives that emphasized constraints and impacts of each alternative for comparative purposes.

Table 6. Evaluation categories, factors, and scoring (rating) system.

	Score of 1	Score of 2	Score of 3
Water Supply			
Hydrologic potential (average annual in acre-feet)	High potential: greater than 100,000 acre-feet	Moderate potential: 30,000-100,000 acre-feet	Low to no potential: less than 30,000 acre-feet
Restrictions on hydropower development (i.e., IWRB or Northeast Power Coordinating Council (NPCC) designation)	No restrictions	Moderate: NPCC restrictions	IWRB or both IWRB & NPCC restrictions
Flood control potential	High potential	Moderate potential	Low to no potential
Natural Environment			
Wildlife habitat (i.e., big game winter range and big game migration corridors)	Low to no constraints	Moderate constraints: e.g., adverse but not significant or significant but mitigable adverse impact	High constraints: e.g., significant impact not subject to mitigation
ESA-listed species, including At-Risk (U.S. Forest Service and Bureau of Land Management Sensitive Species and Idaho Species of Greatest Conservation Need), and threatened, endangered, candidate and experimental nonessential species			
Wetland/habitat values, including National Wetlands Inventory (NWI) wetlands			
State aquatic species of special concern (i.e., Yellowstone cutthroat trout, presence and conservation/management tier)			
Special designation (i.e., Bureau of Land Management/U.S. Forest Service eligible stream, State natural river, State recreational river, and designated wilderness)			
Socioeconomic Environment			
Land management (i.e., private, Federal or State landownership and presence of conservation easements)	Low to no constraints	Moderate constraints: e.g., adverse but not significant or significant but mitigable adverse impact	High constraints; e.g., significant impact not subject to mitigation
Recreation/economic value (i.e., boating, fishing, hunting, Yellowstone National Park, guiding/outfitting, scenic/natural features, cultural/historic resources, and developed recreation facilities such as campgrounds and trails)			
Infrastructure (i.e., roads, utility lines, structures, habitation)			

From the screening results, the following top-rated alternatives were carried forward into the next level of assessment:

- Surface Storage Site Alternatives
  - Lane Lake
  - Moody Creek (Webster Dam)
  - Teton Creek (Alta Project)
  - Ashton Dam enlargement
  - Horseshoe Creek
  - Island Park Enlargement
  - Grassy Lake
  - Squirrel Meadows (Wyoming)
  - Conant Creek
  - Moose Creek
  - Squirrel Creek (Idaho)
  - Driggs
  - Spring Creek (Canyon Creek)
  - Teton (rebuild or new site)
  - Upper Badger Creek
- Managed Groundwater Recharge Alternatives
  - Egin Lake enlargement
  - FMID Recharge Program (Egin Bench)
  - FMID Recharge Program (other)
  - Teton Valley Recharge Program
- Water Market
  - Credit system
  - Utilize and/or expand existing banking program
  - Economic valuation of water

- Conservation, Water Management, and Demand Reduction Alternatives
  - Teton Valley water conservation
  - North Fremont water conservation
  - Lower Bench water conservation
  - Egin Bench water conservation
  - Increase capacity of Cross Cut Canal
  - General demand reduction alternatives
  - Weather modification
  - Consolidation (e.g., Lemhi)
  - Domestic, commercial, municipal, and industrial supply and conservation
  - FMID system optimization

At this preliminary stage of the Basin Study, no analyses were done to estimate the volumes or locations of water; however, these options offered the potential for meeting at least part of local needs and generally did not have the potential for adverse environmental impacts. For these reasons, all identified options were carried forward for further discussion and analysis.

4.3 Final Screening of Alternatives

The results of the preliminary screening were reviewed by Reclamation, IDWR, and the Workgroup. For the candidate surface storage sites, the review focused on the relative severity of potential environmental impacts and the potential to mitigate those impacts. For the remaining alternatives (managed recharge; water markets; and conservation, water management, and demand reduction), the review centered on determining whether the most viable and productive options had been identified.

As a first step (Step A) in this final screening, Reclamation, IDWR, and the Workgroup checked the preliminary screening results based on available information and revised the results, where warranted, based on more in-depth review. In cases where substantial uncertainty still remained, a second step (Step B) of final inquiry was carried out. This step featured preliminary field work and/or more in-depth research.

The results of this final screening are summarized in the following subsections.

4.3.1 Surface Storage Site Alternatives

Fifteen candidate surface storage sites received a score of 1 through 6 in the preliminary screening process described in Table 6. A more in-depth review found that eight of these storage site alternatives had other constraints that were both significant and not subject to mitigation. Seven of these constrained sites were identified during Step A of the final review; the eighth, Moose Creek, was identified as a result of a more in-depth Step B assessment. As shown in Table 7, these eight sites were removed from further consideration and the remaining seven sites were carried forward into the full study.

Table 7. Final screening results (Steps A and B) for the surface storage alternatives

Preliminary Alternatives	Carried Forward for Further Study	Remove from Consideration	Rationale for Removal
Ashton Dam Enlargement	X		
Conant Creek		X	Impact on Yellowstone cutthroat trout
Driggs		X	Impact on community (infrastructure inundation)
Grassy Lake		X	Limited additional capacity; within National Park boundary
Horseshoe Creek		X	Undefined; Horseshoe Creek is on the west side of a bifurcation of Teton River near Bates Road. This would be a partial alternative of Driggs.
Island Park Enlargement	X		
Lane Lake	X		
Moody Creek (Webster Dam)	X		
Moose Creek		X	Further investigation revealed that this alternative would have severe impacts on wildlife habitat and protected landmark features.
Spring Creek (Canyon Creek)	X		
Squirrel Creek (Idaho)		X	Significant Endangered Species Act concerns; grizzly bear habitat; contiguous with National Forest and National Park boundaries.

Preliminary Alternatives	Carried Forward for Further Study	Remove from Consideration	Rationale for Removal
Squirrel Meadows (Wyoming)		X	Significant Endangered Species Act concerns; grizzly bear habitat; contiguous with National Forest and National Park boundaries.
Teton (rebuild or new site)	X		
Teton Creek (Alta Project)		X	Geologic fatal flaw
Upper Badger Creek	X		

4.3.2 Managed Groundwater Recharge Site Alternatives

A more in-depth review by Reclamation, IDWR, and the Workgroup resulted in (Step A) restating the alternatives to provide better focus on the most promising actions or sets of actions related to groundwater recharge, and (Step B) the elimination of all but the Egin Lake alternative based on more in-depth study. The overall review and selection process is shown in Table 8.

Table 8. Final screening results for the managed groundwater recharge alternatives.

Preliminary Alternatives	Step A Shortlist	Step B
Egin Lake enlargement	Expansion of managed recharge in Egin basin	Retain for further study by IWRB (see Section 5.3)
FMID Recharge Program (Egin Bench)		
FMID Recharge Program (all other FMID)	Evaluate recharge in the Lower Teton through development of new facilities	Retain for further study by IWRB (see Section 5.3)
Teton Valley Recharge Program		
Evaluation of the benefits of expanding Egin Lake groundwater recharge	Recharge using existing irrigation canals (moved to the agricultural water conservation category)	Eliminated due to low viability due to significant challenges in obtaining water rights, limited benefits, and potential environmental impact conflicts

4.3.3 Water Market Alternatives

The three alternatives related to water markets identified in the preliminary screening process represented different aspects of or approaches to a water marketing program. During the final screening, discussion of the potential for water markets resulted in the decision to consolidate these aspects and further consider the broad concept of water markets as a whole (Table 9).

Table 9. Final screening results for the water market alternatives.

Preliminary Alternatives	Final Screening (Steps A and B)
Credit system	Evaluate existing and potential market-based mechanisms
Utilize and/or expand existing banking program	
Economic valuation of water	

4.3.4 Conservation, Water Management and Demand Reduction Alternatives

As with the managed groundwater recharge and water market alternatives, Reclamation, IDWR, and the Workgroup discussions during Step A of the final screening process resulted in substantial restatements of candidate alternatives related to conservation, water management, and demand reduction. Some alternatives were grouped or restated; others were eliminated due to being too general or speculative. This restatement of the alternatives is shown in Table 10. Overall, the restatement was intended to more clearly describe potentially feasible options as more detailed analyses were initiated. Step B of the final screening process for conservation, water management, and demand reduction alternatives involved further assessment by Reclamation, IDWR, and the Workgroup. The results of this assessment are shown in Table 10.

It should also be noted that assessment of on-farm conservation practices was also originally considered as part of this study. This analysis would have evaluated the conversion of surface irrigation systems to sprinkler irrigation systems. However, due to the lack of extensive surface irrigation systems and the complexity of estimating the reduction in irrigation seepage, canal discharge, and increased crop consumptive use, this alternative was not evaluated.

Table 10. Step 1 final screening results for the conservation, water management, and demand reduction alternatives.

Preliminary Alternatives	Final Screening – Step 1 Restatement of Shortlist	Step B Final Screening Results
Teton Valley water conservation	Piping and lining	Carry forward into more detailed study
North Fremont water conservation		
Lower Bench water conservation	Demand reduction	Carry forward into more detailed study
Egin Bench water conservation		
Increase capacity of Cross Cut Canal (CCC)	Recharge using existing irrigation canals	Eliminated due to significant challenges related to obtaining additional water rights and the limited and/or conflicting benefits/impacts
General demand reduction alternatives		
Weather modification	Municipal and industrial conservation	This option is considered viable to help basin cities meet their population growth needs, but would not be a benefit to the Henrys Fork River basin water budget or the ESPA. The municipalities would be able to implement conservation on their own to meet their needs; therefore, this alternative was dropped from consideration.
Consolidation (e.g., Lemhi)		
Domestic, commercial, municipal, and industrial supply & conservation	Canal automation	Carry forward into more detailed study
FMID system optimization		

5.0 EVALUATION OF ALTERNATIVES

The screening process described in Section 4 resulted in 12 alternatives being carried forward for more detailed analysis. Care was taken to provide for the array of alternatives selected for further study to include the most promising actions in the four main categories: surface storage, managed recharge, water marketing, and conservation, management and demand reduction. The selected alternatives were:

- Surface Storage Alternatives
    - Lane Lake Dam
    - Spring Creek Dam
    - Moody Creek Dam
    - Upper Badger Creek Dam
    - Teton Dam
    - Island Park Dam storage increase
    - Ashton Dam raise
- Managed Recharge Alternative
- Water Marketing (common to all alternatives)
- Conservation Alternatives
    - Canal automation
    - Canal piping
    - Demand reduction

The reporting of study results begins in Section 5.1 with a discussion of characteristics and/or findings that are common to all or a significant subset of the alternatives. Study results for each alternative are organized according to the following general outline:

- Description
- Impact to Water Budget
- Benefits and Impacts
- Key Points from Evaluation and Feedback
- Additional Limitations of Analysis

Three alternatives, Lane Lake, Teton Dam, and Island Park Dam storage increase, were selected for in-depth hydrology and climate change analyses at the request of IWRB and the Workgroup (Reclamation 2013b). These three alternatives represented a storage alternative with pumped water as a source, a storage alternative with impoundment of a major river, and an alternative that would alter an existing facility. The results could be used to extrapolate information about the other alternatives. For the hydrologic analyses, ecological flow targets for the hydrologic modeling were determined after discussions with the Native Trout Subcommittee of the Henrys Fork Watershed Council. The ecological flow targets were modeled as 200 cfs from September to November, 400 cfs from December to February, and 300 cfs the rest of the year (Reclamation 2013b).

5.1 Findings Common to Majority of Alternatives

5.1.1 Capability of Alternatives to Meet Henrys Fork River Basin and/or ESPA Needs

A review of existing and projected water needs in the Henrys Fork River basin revealed that any of the candidate actions, either individually or in combination, would only represent a partial solution to meeting the basin's needs. Given these conditions, future actions in the basin would need to be defined and pursued based on the needs of specific areas and/or uses. Some combinations of the alternatives may provide significant progress toward meeting the needs.

Available in-basin storage is only a partial solution for changing the water budget in the ESPA. IWRB would need to develop delivery strategies downstream on the Eastern Snake River Plain to deliver the storage water into areas served by groundwater pumpers such as the A&B Irrigation District. With respect to the Egin Lakes recharge alternative, IWRB would continue to work with stakeholders to determine whether recharge activities at this site would stabilize the ESPA and meet recovery goals and objectives set out in the ESPA CAMP and State Water Plan.

5.1.2 Potential Climate Change Impacts

As noted in Section 3.4, climate change scenarios indicate a shift in the timing of peak precipitation and runoff and an increase in volume in most locations. The timing of peak runoff is generally projected to shift to a month earlier, with volumes increasing above historical levels earlier in the cool season (October or November to April) and decreasing in the summer and fall seasons (May through September or October). This shift in timing and increase in runoff volume to earlier in the year would mean an increase in reservoir storage earlier in the year and a greater need to provide irrigation water later in the summer months

(Reclamation 2011). A decrease in surface water delivery would be anticipated in the latter part of the irrigation season or warmer months (Reclamation 2011).

The baseline conditions in the Henrys Fork River basin were compared to these climate change scenarios:

- Less Warming and Drier (LW/D).
- Minor Change (MC).
- Less Warming and Wetter (LW/W).

Another probable effect of climate change was observed through the more in-depth studies of the Lane Lake, Teton Dam, and Island Park storage increase alternatives. Studies performed for these three potential reservoir actions all suggested an increase in precipitation in the spring, allowing increased reservoir accrual (see individual sections for more details). The percentage of years during which little or no precipitation would be available to fill the new reservoir space would be reduced from 15 to 20 percent of years to approximately 5 percent or less; however, all climate change simulations are based on current irrigation and operational practices. Under future changes in climate, irrigation activities could possibly begin earlier in the year and in that case, less water would accrue to the new reservoir space.

The findings from these climate change studies show the potential benefits of additional storage space in capturing and storing increased spring flows for use during the longer dry season during the late summer and fall seasons.

Implementation Options

Due to the relatively low prices for water and limitations on agricultural payment capacity in the Henrys Fork River basin and ESPA, development of water supply projects that can be funded solely by payments from direct beneficiaries may be challenging.

5.1.3 Elements Relevant to All Surface Storage Alternatives

Benefits and Impacts

The out-of-basin water budget would be temporarily reduced when water is diverted during the annual high flow period and stored in a reservoir, but some or all of that stored water may be available at a later time for numerous out-of-basin uses, including agricultural needs; domestic, commercial, municipal, and industrial needs; ecological needs; and as additional water supply to offset ground water pumping in the ESPA. The stored water may also alleviate some of the effects of climate change.

While any of the surface storage alternatives would be a barrier to fish migration, fish ladder facilities could facilitate migration around the structure. While on-stream dam structures would inhibit upstream and downstream movements of fluvial Yellowstone cutthroat trout, the greater impact would be from replacing free-flowing stream reaches with long stretches of slack water.

Limitations of Analysis

Geologic and geotechnical site analysis was based on available geologic literature, soil mapping, and review of geotechnical literature and reports. No field reconnaissance or geologic mapping was conducted as part of this investigation and analysis. No quantitative hazards analysis was performed.

A limited number of site and alignment alternatives were explored, and professional judgment was used to balance maximum storage potential with efficient embankment configurations. Embankment configurations were generalized and site-specific materials and material properties were not evaluated. No optimized dam approaches were proposed. Potential impacts along the canal and pipeline routes were not assessed during this evaluation and would require further investigation. Some of the canals needed for water delivery would be very long and may have high water losses due to seepage.

The hydrologic and environmental impacts on the supply sources would need to be investigated more thoroughly, as well as the impacts overall to the Henrys Fork River basin and ESPA system. Stream habitat changes in the affected tributaries and streams due to constructing the proposed dams and reservoirs were not evaluated in detail. Analysis would be needed to demonstrate how water storage in the proposed reservoirs meets the defined needs.

No accounting was done for direct precipitation on the reservoir and seepage and evaporation losses from the reservoir. Water balance considerations were not evaluated and would depend on the elevation-capacity relationship, reservoir operations, and drought conditions.

Cost estimates given in this Final Report are relative, comparative, and preliminary and are not intended for budgeting. Planning costs for designs, compliance with National Environmental Policy Act (NEPA) and the National Historical Preservation Act, land acquisitions, and other actions necessary for implementation were not included in the cost estimates. Some dam and canal sites may be prone to high seepage rates, and mitigation measures intended to ensure stability and limit seepage could lead to higher construction costs. Future concept refinements could potentially change the ranking of alternatives by cost (see Section 6.0).

Water rights issues are not known and water availability was approximated. Actual runoff was not measured and firm yield was not evaluated. All water supply issues and balances and refined operations would need to be evaluated.

Implementation Options

Analyses to fill in the data gaps as detailed in the Limitations of Analysis sections would need to be conducted. For example, some of the alternatives would require more geologic analyses for spillway designs or tunneling. Alternatives that have pump-back systems would need analyses for their impacts on fish and wildlife. Hydrologic impacts would need to be further investigated. Some canals may be prone to high rates of seepage and additional evaluations would need to be completed.

Construction of any surface storage alternative would require a Corps of Engineers 404 permit under the Clean Water Act, with the attendant requirements. The environmental, social, and economic analysis required to construct a dam would be extensive. The use of Federal funds (e.g., Reclamation Secure Water Act) would require meeting the funding agencies' environmental/policy requirements.

Due to the size and complexity of the surface storage alternatives, an environmental impact statement, including ESA Section 7 and National Historic Preservation Act Section 106 consultations, would likely be required as part of the 404 permit process. Compliance with these laws may cost upwards of $1 to $2 million and take 5 to 7 years.

Financing for the implementation of any of the surface storage alternatives may be difficult to obtain. Multiple Federal and State programs may be available for implementation for many of the alternatives, although some alternatives are more complex than others. IWRB is authorized to work with state-wide irrigation entities in securing State-backed bonds with a suitable irrigator payback schedule. Traditional sources for dam construction, such as Reclamation, may be limited in their ability to secure funding for a single-benefit project (i.e., irrigation). Funding may be more available for a water storage project which directly benefits the environment in addition to irrigation. Congressional authorization would be required for Federal financing.

If hydropower generation facilities are constructed with any of the alternatives, a FERC license would be required. In the Basin Study area, the Northwest Power and Conservation Council have designated protected areas where hydroelectric power development may incur unacceptable risks to fish and wildlife. Protected area status would need to be considered in any hydroelectric development.

If any surface storage alternative is implemented, a management plan would need to be developed for operation of the facilities with consideration to timing of storage and release

with respect to ecological flow targets. The purpose of the management plan would be to provide the greatest benefit to irrigation and ecological flows.

5.2 Surface Storage Alternatives

The alternative reservoir sites discussed in this section emerged from the screening process described in Section 4.0. Each alternative was analyzed to determine potentially viable reservoir configurations, including water sources and dam configurations. The locations of these potential reservoir sites are shown on Figure 17. The configuration described for each site is the option that emerged from these studies as most potentially viable and most responsive to site opportunities and environmental resources. For all of the alternatives except the Island Park storage increase alternative, the estimated water storage volumes are based on normal reservoir levels, typically 14 feet below the crest of the dam. The full process of alternatives analysis and decision making related to the selected alternative for each site is documented in the technical reports listed in Section 8.0.

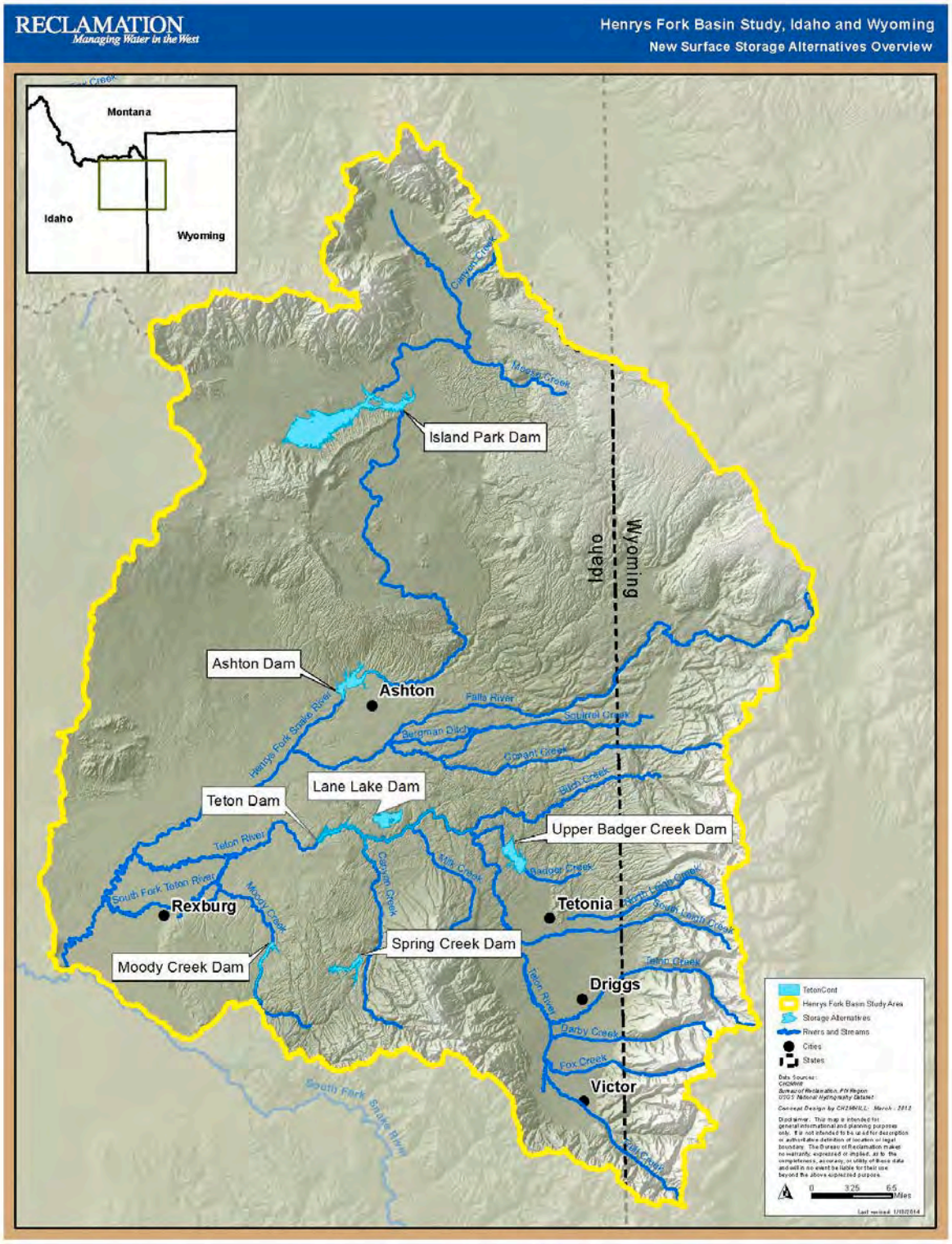

Figure 17. Map of the Henrys Fork River basin and the proposed locations of the seven surface storage alternatives.

5.2.1 Lane Lake Dam

Description

The Lane Lake Dam alternative features a proposed off-channel 101,000-acre-foot reservoir contained by a 160-foot-tall main dam and a smaller saddle dam (Figure 18). The dam site is located on a generally dry drainage that is situated about 1 mile north of the Teton River and 5 miles downstream of the Bitch Creek confluence (Figure 17). When full, Lane Lake could provide a roughly 145-foot drop to a proposed new hydropower facility at the base of the dam (CH2M HILL 2013); however, this addition was not considered as part of this cost estimate.

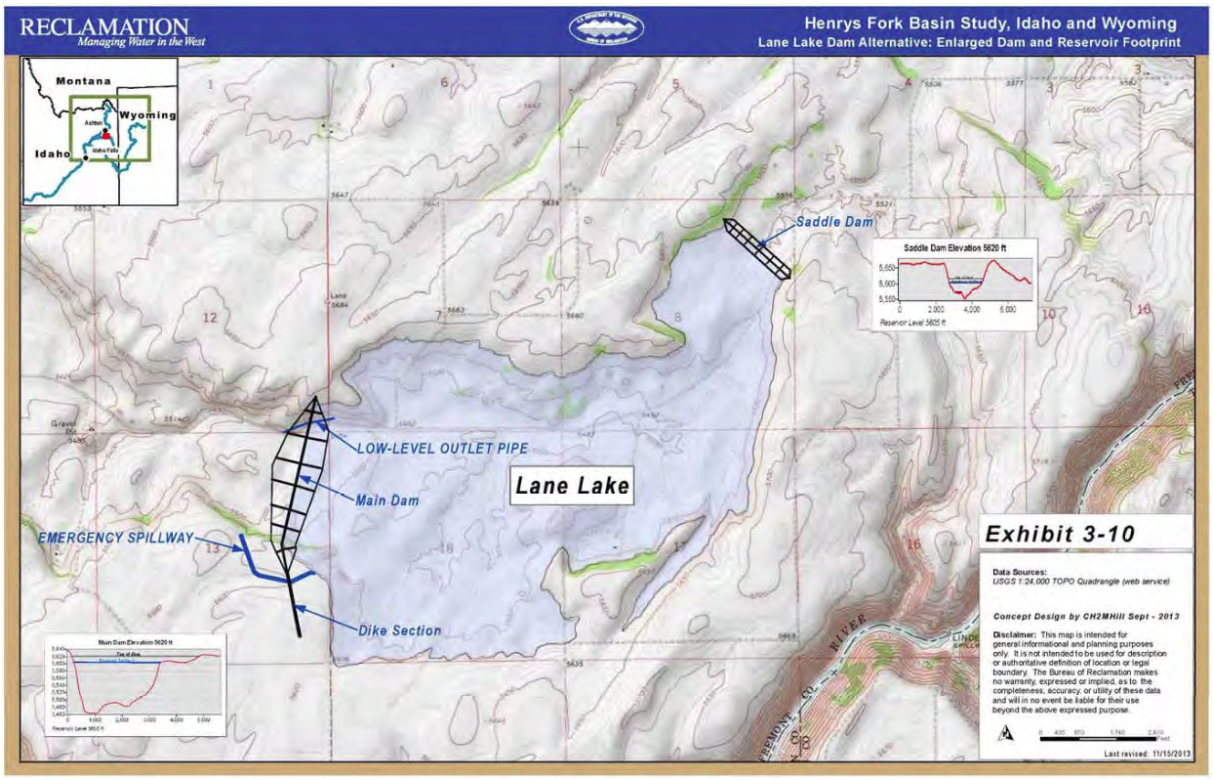

Figure 18. Map showing the proposed dam and reservoir of the Lane Lake Alternative (from CH2M HILL 2013).[7]

Since the natural watershed is only slightly larger than the reservoir itself, natural runoff from the watershed would be very low. Water for the reservoir could be supplied from several sources, including the Teton River and Fall River. The supply from the Teton River would require pumping. Bitch Creek is very important to Yellowstone cutthroat trout so it was not considered as a water source.

[7] A more detailed map may be found in CH2MHILL 2013.

In average water years (50 percent exceedence), the reservoir would capture 98,000 acre-feet or more, based on runoff availability with consideration to existing water rights. In the hydrology analysis for Lane Lake, Reclamation assumed a storage volume of 120,000 acre-feet; however, an expanded engineering analysis of Lane Lake concluded that only 101,000 acre-feet of storage would be available at this site. This report presents the data as related to the storage volume of 101,000 acre-feet.

The estimated construction cost for Lane Lake, without hydropower facilities, is about $462,000,000 ($4,600 per acre-foot). A lined concrete spillway was assumed for cost estimation purposes.

Impact to Water Budget

Lane Lake would provide additional storage water for the Teton River basin, effectively enhancing water supply by capturing peak flows and redistributing that water during periods of higher demand. The available storage would enhance the in-basin water budget by diverting up to 101,000 acre-feet (if the reservoir was initially empty) during the annual high flow period and storing that water until more critical, higher demand periods. This storage water could help satisfy unmet irrigation demands in the Lower Watershed irrigated region.

For the Lane Lake alternative, new ecological flow targets were modeled to minimize impacts on the Fall River and Teton River due to Lane Lake storage and in consideration of existing water rights. This analysis provided a more accurate reflection of the storage in Lane Lake. The same ecological flow targets s were applied to both the Fall River and the Teton River: 200 cfs from September to November, 400 cfs from December to February, and 300 cfs the rest of the year (Reclamation 2013b).

The modeling results showed that about 75 percent of the time, approximately 90,000 acre-feet or more would be available for storage. Approximately 15 percent of the time, no water would be available (Figure 19). Using the modeled period of record (water years 1928 to 2008), the model showed approximately 47,000 acre-feet from the Fall River would be stored in Lane Lake on average as compared to 41,000 acre-feet from the Teton River.

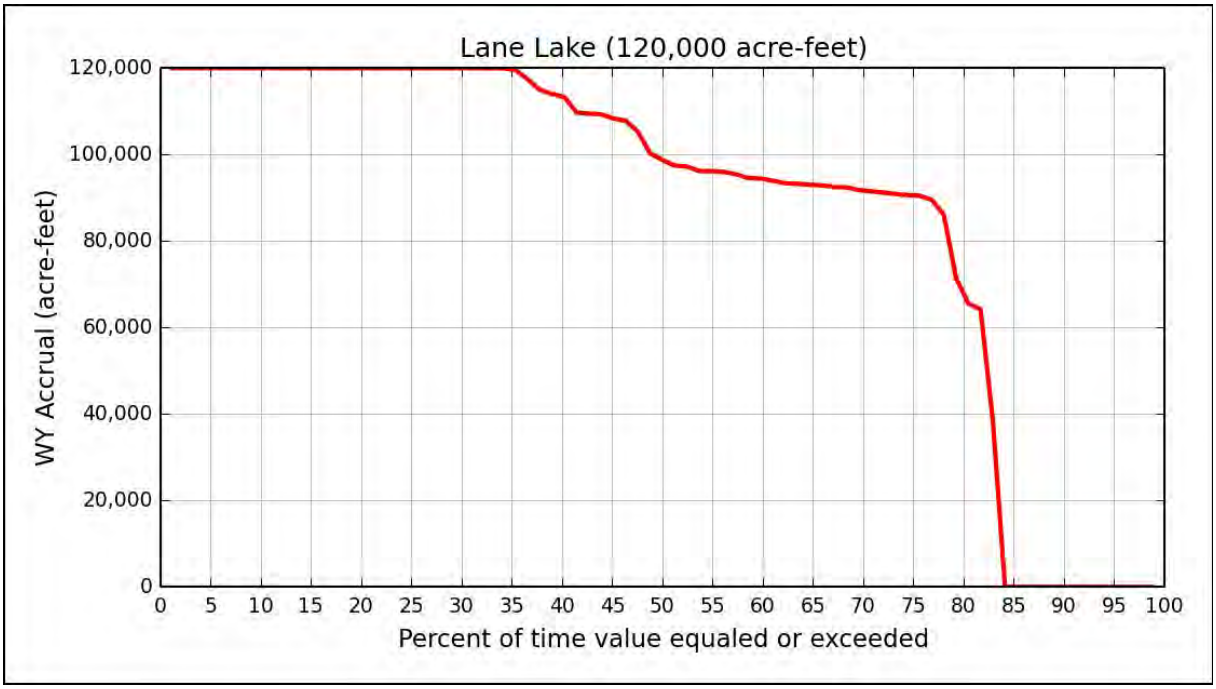

Figure 19. Volume stored in the new reservoir from the Fall River and Teton River per water year. This represents the volume of water that would be available for use.

Related to changes in flows of the Teton and Fall Rivers due to operation of Lane Lake, the analysis revealed the following:

- Projected change in flows on the Teton River at St. Anthony, ID: under mean conditions, there would be a decrease in the Teton River flow from February through April when excess flow would be captured in the reservoir and an increase in flow from May through August when stored water would likely be released. However, the water stored and released during those times may actually belong to other water users (see Section 3.1.1). Under low flow conditions from December through February, flows are higher because the flows would meet ecological flow targets.

- Projected change in flows on the Fall River near Chester, ID: due to the Lane Lake diversion, mean conditions would show a decrease in flow year-round as flows are diverted from Fall River and stored in Lane Lake. During low flow periods, ecological flow targets described above would be met.

Potential Climate Change Impacts

In the hydrologic models,[8] additional water would be stored more reliably in Lane Lake (Figure 20). This additional water would enter the reservoir during the winter and by April or May, the reservoir would be full or nearly full in up to 95 percent of years.

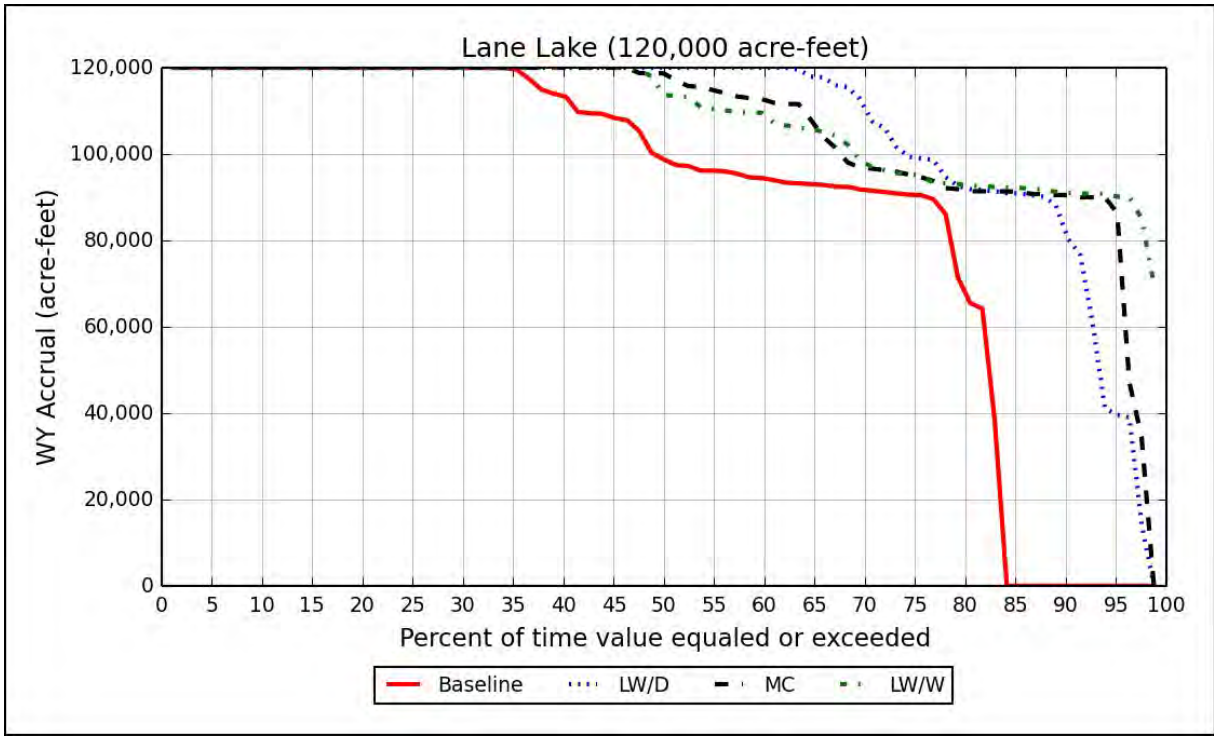

Figure 20. Volume stored by the new reservoir per water year for the Lane Lake alternative. This represents the volume of water that would be available for use. An increase in water year storage was seen for all climate change scenarios.

This increase in the reliability of the reservoir filling would not improve the extent to which ecological flow targets or other demands will be met in the late summer and fall months when compared with the baseline condition. Further, analysis indicates that ecological flow targets in the Fall River would not be satisfied from December through March in dry years because either downstream demand has priority for the water or natural flow would be insufficient.

Benefits and Impacts

Reservoir releases during low flow periods would improve fish habitat in downstream river segments, including the North Fork Teton River and South Fork Teton River, which have been identified as having additional ecological streamflow needs. Pumping for water storage

[8] A hydrologic model run for "climate change" is simply run with precipitation, temperature, and other inputs from a GCM rather than historical inputs. The hydrologic model itself is not changed.

in the reservoir would typically occur during periods of high flows; nonetheless, withdrawals may be expected to impact conservation populations of Yellowstone cutthroat trout in the Fall River and Teton River.

This alternative could also involve impacts to lands designated as eligible for Federal wilderness status and ESA-listed terrestrial species (grizzly bear [designated as threatened] and wolverine [designated as a candidate for listing]).

Key Points from Evaluation and Feedback

Local conservation stakeholders generally support further study of this alternative, due largely to its off-stream location and potential to enhance steam connectivity. Those stakeholders, however, remain focused on the imperative of no impacts to the aquatic ecosystem at the proposed Fall and Teton river diversion points. As long as that concern can be addressed, conservation stakeholders remain willing to explore this alternative further.

Lane Lake has the advantage of being off-stream; however, the proposed site is on private irrigated farmland and includes residences and numerous farm-related structures. Negotiations for acquiring the site could potentially be difficult.

Local water users in the Teton River drainage support this alternative as one of few that would enhance their water supplies. The substantial cost of the Lane Lake alternative would not be affordable to these users; however, they are willing to explore possibilities for investment only if costs can be reduced or shared by other parties.

While the IWRB remains interested in retaining this alternative for long-term consideration because of its large volume and potential to address statewide water supply issues, the high cost of Lane Lake, combined with the existence of other less expensive options to mitigate local water shortfalls, make short-term action on it unlikely.

Similarly, Reclamation is interested in retaining this alternative since it potentially has multi-purpose benefits to address statewide supply issues, provide more operational flexibility in the upper Snake River system, and increase the reliability for flow augmentation for ESA responsibilities. Given these potential benefits, Reclamation would be interested in participating if other parties wish to explore this option further.

Study participants suggested the investigation of a pump-back power system using a Lane Lake reservoir with the Teton River as a water source. Such a system would pump when power is abundant in the early spring and generate power when the power supply is constrained in the late summer or early fall; however, the costs to operate such a system could potentially be high or even prohibitive.

Additional Limitations of Analysis

Excavation for an open spillway would likely be in colluvial soils and/or rock and possibly in soft erodible materials. If an open channel spillway is used, it may require concrete or rock linings that are suitable to match the intended spillway flows. Alternative spillway approaches should also be investigated once the design flow has been established and local site conditions are better understood.

Fish and wildlife impacts from a pump-back system are likely to be significant and would need to be analyzed.

5.2.2 Spring Creek Dam

Description

The Spring Creek Dam alternative features a proposed 20,000 acre-foot reservoir, impounded by a new dam that would be 180 feet tall and 120 feet long (Figure 21). The maximum surface area of the reservoir would be 540 acres. On average, the reservoir would capture 10,800 acre-feet each year, based on runoff availability with no consideration of existing water rights. The dam site would be located on State and private lands in the Teton River watershed on the Spring Creek headwater tributary where it joins Canyon Creek (Figure 17). The water sources for Spring Creek Dam would be Spring Creek and Canyon Creek.

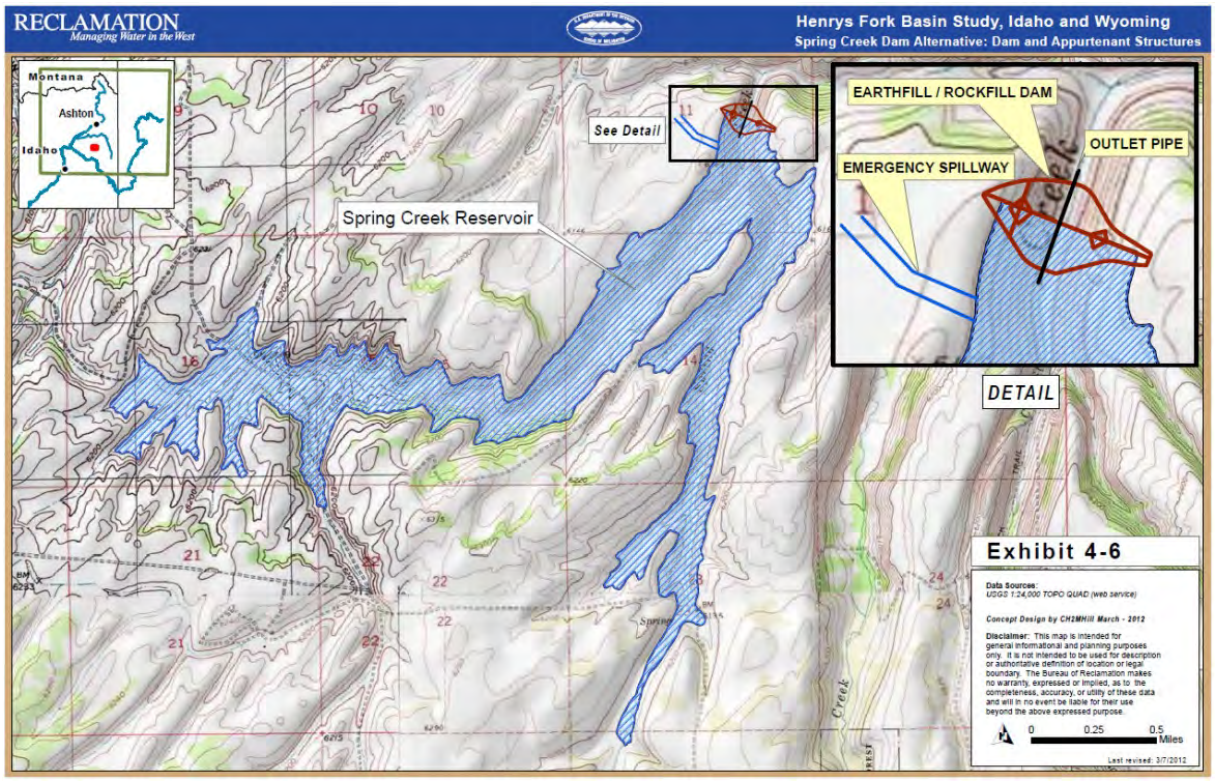

Figure 21. Map showing the proposed dam and reservoir of the Spring Creek Dam Alternative (Appendix B of Reclamation 2013a).[9]

The estimated cost for Spring Creek Dam is $41,760,000 ($3,900 per acre-foot). These costs may be reduced by constructing a smaller reservoir which only stores the 10,800 acre-feet of estimated annual runoff. The more costly options (each of which would have had a 20,000 acre-foot capacity) would require expensive conveyance systems and were eliminated from consideration, including pumping from the Teton River.

Impact to Water Budget

Water stored in Spring Creek Reservoir could be used to satisfy unmet irrigation needs in the Lower Watershed irrigated area by diverting and storing 10,800 acre-feet of water during the high flow period until needed in more critical, higher demand periods in the summer and early fall. Water withdrawal from Spring Creek Reservoir could be coordinated with irrigation use to augment late summer streamflows in Spring Creek.

[9] A more detailed map may be found in CH2MHILL 2012.

Benefits and Impacts

The increase in Spring Creek streamflows with reservoir releases during the irrigation season may benefit both irrigators and fish populations in Spring Creek and Teton River, or augment the ESPA. Yellowstone cutthroat trout are present in the proposed reservoir inundation area; consequently, the alternative would impact Spring Creek and Teton River's conservation population (Reclamation 2013a, Appendix B). The hydrology of Canyon Creek and the Teton River would be modified and possibly impact conservation populations as well. In Spring and Canyon creeks, potential impacts to river connectivity would be decreased flows where and when water is diverted; however, these diversions would occur during high spring flows, and releases from the reservoir would be made during low flow periods. Downstream segments of Spring Creek and Canyon Creek were identified as needing additional ecological streamflows and would benefit from augmented late summer flows.

Impacts may occur on big game migration corridors of one ESA-listed threatened species (grizzly bear) and one candidate species (wolverine).

Key Points from Evaluation and Feedback

Conservation stakeholders, consistent with their philosophy, oppose further investigation of the Spring Creek alternative, which they regard as a new in-stream dam.

Though they recognize this alternative would provide water to users in the Teton River drainage, where the need is greatest, local water users are deterred from supporting this alternative due to its comparatively small water yield, high cost and small contribution to local needs or State needs in the larger upper Snake River basin. Water users would be interested in investing in this option only if the costs could be reduced or shared by other parties.

While they recognize the contribution to local water needs with this alternative, both the IWRB and Reclamation see little opportunity for this small project with its minimal contribution to meeting regional/Federal needs to compete with other alternatives.

5.2.3 Moody Creek Dam

Description

The Moody Creek Dam alternative features a proposed 37,000 acre-foot reservoir contained by a new dam that would be 220 feet tall and 1,300 feet long (Figure 22). The maximum surface area of the reservoir would be 520 acres. On average, the reservoir would capture 34,400 acre-feet each year, based on runoff availability with no consideration of existing water rights. The proposed dam site would be located on State and private lands on Moody

Creek, just downstream of the Dry Canyon Creek confluence (Figure 17). The water sources for the Moody Creek Dam would be Moody Creek and Canyon Creek.

The estimated cost for Moody Creek Dam would be $123,920,000 ($3,600 per acre-foot). A lined concrete spillway was assumed for costing purposes. More costly options requiring expensive conveyance systems, including pumping from the Teton River, were eliminated from consideration.

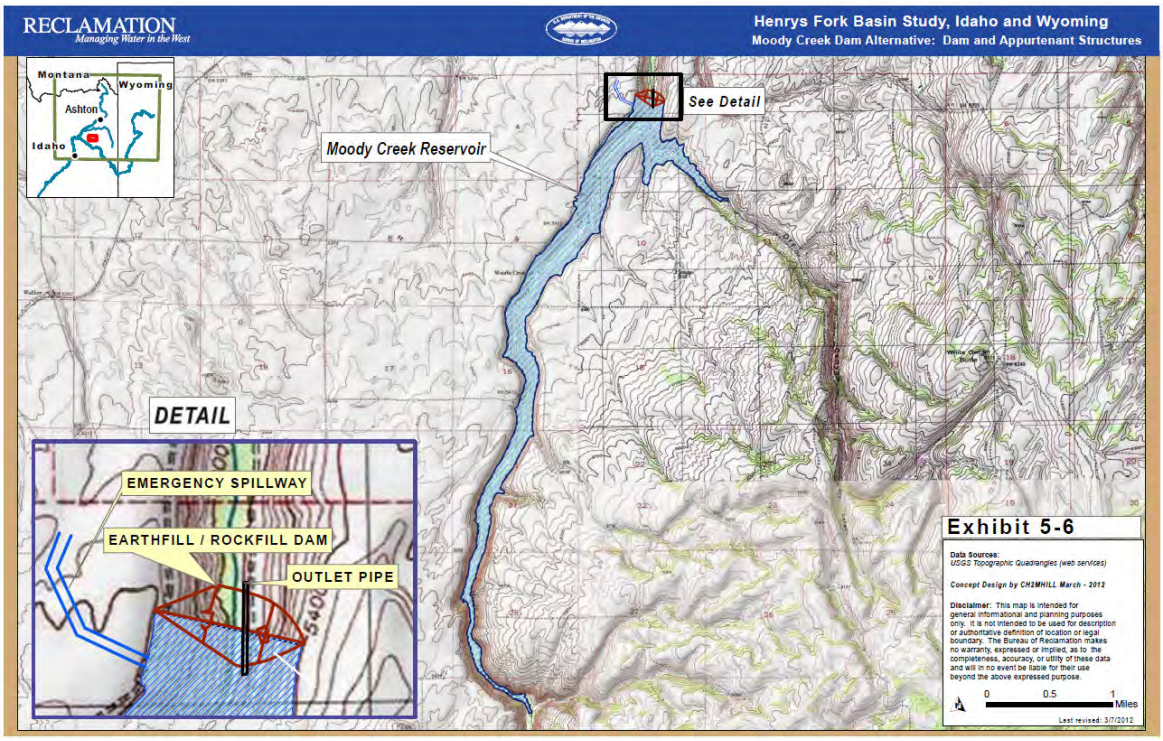

Figure 22. Map showing the proposed dam and reservoir of the Moody Creek Dam Alternative (Appendix B of Reclamation 2013a,).[10]

Impact to Water Budget

Water stored in Moody Creek could be used to satisfy unmet irrigation needs in the Lower Watershed irrigated area by diverting and storing 34,400 acre-feet during the high flow period until needed in more critical, higher demand periods in the summer and early fall. Reservoir releases would be managed for ecological instream targets. The out-of-basin water budget would be affected temporarily by diversion of 34,400 acre-feet, but the water could also be used to meet out-of-basin needs such as agricultural needs, M&I needs, ecological needs, or groundwater recharge. Water withdrawal from Spring Creek Reservoir may be coordinated with irrigation use to augment late summer streamflows in Spring Creek.

[10] A more detailed map may be found in CH2MHILL 2012.

Benefits and Impacts

The increase in storage volume related to Moody Creek Dam would help to alleviate problems associated with the shift in the timing of streamflows with climate change. By providing water storage, some of the additional water runoff expected from wetter years may be captured in the early spring and released later during the irrigation season. The reservoir may provide some increase to late season flows in Moody Creek. This increase in flows may benefit both irrigators and fish populations in Moody Creek and the Teton River and may augment the ESPA.

Yellowstone cutthroat trout are present in the proposed reservoir inundation area; consequently, the alternative would impact Moody Creek's conservation population. The hydrology of Moody and Canyon creeks and the Teton River would be modified and possibly impact conservation populations as well. Potential impacts to river connectivity would be decreased flow in Moody and Canyon creeks where and when water is diverted. These diversions would occur during high spring flows and releases from the reservoir would be made during low flow periods. Downstream segments of Moody Creek were identified as needing additional ecological streamflows and would benefit from augmented late summer flows.

Impacts may occur on big game winter range and migration corridors of one ESA-listed threatened species (grizzly bear) and one candidate species (wolverine).

Key Points from Evaluation and Feedback

Stakeholders see the same limitations for the Moody Creek alternative as for the Spring Creek alternative and, as such, have the same reservations about its utility and feasibility.

Additional Limitations of Analysis

Excavation for the open spillway would likely be in colluvial soils and/or rock and possibly in soft erodible materials. If an open channel spillway is used, it may require concrete or rock linings that are suitable to match the intended spillway flows. Alternative spillway approaches should also be investigated once the design flow has been established and local site conditions are better understood.

Some of the canals needed for water delivery are very long and may have high water loss due to seepage. Methods for reducing seepage may increase the estimated construction costs. Stream habitat changes in Moody and Canyon creeks due to constructing the Moody Creek Dam were not evaluated in detail.

5.2.4 Upper Badger Creek Dam

Description

The Upper Badger Creek Dam alternative features a proposed 47,000 acre-foot reservoir contained by a new dam that would be 290 feet tall and 2,400 feet long (Figure 23). The maximum surface area of the reservoir would be 520 acres. On average, the reservoir would capture 47,000 acre-feet each year, based on runoff availability with no consideration of existing water rights. Water for the reservoir would be supplied from Badger Creek and the Teton River. The conveyance system from the Teton River would be pressurized pipelines and a pump-back system which would pump when power is abundant in the early spring and generate power when the power supply is constrained in the late summer or early fall. The dam site would be located in the Teton River watershed on Badger Creek approximately 5 miles upstream of the Teton River (Figure 17). Stream diversions, intake and fish screen structures, pump stations, and siphons were also assessed during the evaluation.

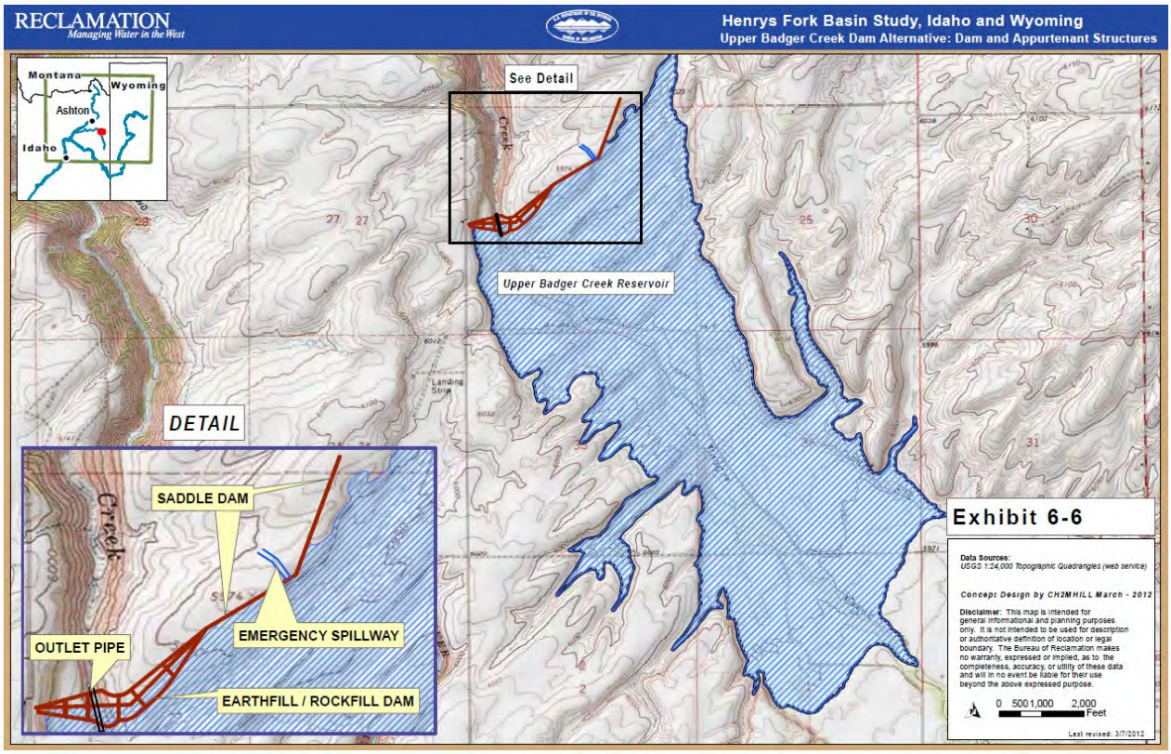

Figure 23. Map showing the proposed dam and reservoir of the Upper Badger Creek Dam Alternative (Appendix B of Reclamation 2013a,).[11]

[11] A more detailed map may be found in CH2MHILL 2012.

The cost estimates for Upper Badger Creek Dam would be $128,940,000 for 47,000 acre-feet of storage volume ($2,700 per acre-foot). Operating a pump-back system using the Teton River as a water source may be very costly. A lined concrete spillway was assumed for costing purposes.

Impact to Water Budget

Water stored in Upper Badger Creek Reservoir could be used to satisfy unmet irrigation needs in the Lower Watershed irrigated area by diverting and storing 47,000 acre-feet during the high flow period until needed in more critical, higher demand periods in the summer and early fall. Reservoir releases could also enhance ecological instream flows. The out-of-basin water budget would be affected temporarily by the diversion of 47,000 acre-feet, but water could also be used to meet out-of-basin needs such as agricultural needs, M&I needs, ecological needs, or groundwater recharge.

Benefits and Impacts

The increase in storage volume related to Upper Badger Creek Reservoir would help to alleviate problems associated with the shift in the timing of streamflows with climate change. By providing water storage, some of the additional water runoff expected from wetter years may be captured in the early spring and released later during the irrigation season. This increase in Badger Creek flows during the irrigation season may benefit both irrigators and fish populations in Badger Creek and Teton River or augment the ESPA. Water stored may be released and diverted much farther downstream on the Snake River. This surface water supply may replace groundwater supplies which would have a direct positive impact on the ESPA.

Potential impacts to river connectivity would be decreased flow in Badger Creek and Teton River where and when water is diverted. These diversions would occur during high spring flows and releases from the reservoir would be made during low flow periods.

Upper Badger Creek was identified as containing a core conservation population of Yellowstone cutthroat trout. The proposed location of Upper Badger Creek Dam currently goes dry during the summer, isolating a local Yellowstone cutthroat trout population in creek segments above the proposed site. The construction of Upper Badger Creek Dam may result in a change in behavior for this population which may be detrimental. Furthermore, the presence of a reservoir may increase the likelihood of a nonnative fish population being introduced into the reservoir and increase competition for the local Yellowstone cutthroat trout population.

Impacts may occur on big game winter range and migration corridors of one ESA-listed threatened species (grizzly bear) and one candidate species (wolverine).

Key Points from Evaluation and Feedback

Stakeholders view this option as having the same limitations as the Spring Creek and Moody Creek alternatives. IWRB remains interested in retaining the Badger Creek alternative because it could address local water user needs and have a cost estimate in the range of possible State investment. At the same time, IWRB acknowledges that the Badger Creek alternative has serious environmental impacts that would provide challenges not inherent in other alternatives.

Additional Limitations of Analysis

Excavation for the open spillway would likely be in colluvial soils and/or rock and possibly in soft erodible materials. If an open channel spillway is used, it may require concrete or rock linings that are suitable to match the intended spillway flows. Alternative spillway approaches should also be investigated once the design flow has been established and local site conditions are better understood.

Fish and wildlife impacts from a pump-back system are likely to be significant and would need to be analyzed.

5.2.5 Teton Dam

Description

The Teton Dam alternative features a proposed 265,000-acre-foot reservoir impounded by a new dam 300 feet tall and 2,300 feet long (Figure 24). In 50 percent of years, the reservoir would capture 202,000 acre-feet or more, based on runoff availability with consideration of existing water rights. The dam site is located on the Teton River approximately 16 miles upstream of the City of Rexburg at the site of the old Teton Dam and would require no secondary water sources (Figure 17). When full, Teton Reservoir could provide a roughly 285-foot drop to a proposed new hydropower facility at the base of the dam, but that option is not included in the cost estimate.

The estimated cost of Teton Dam construction, without fish passage or hydropower costs included in the total, is $492,210,000 ($1,900 per acre-foot). The site may be prone to high seepage rates, and measures intended to maintain stability and limit seepage may lead to increased construction costs (CH2MHILL 2013).

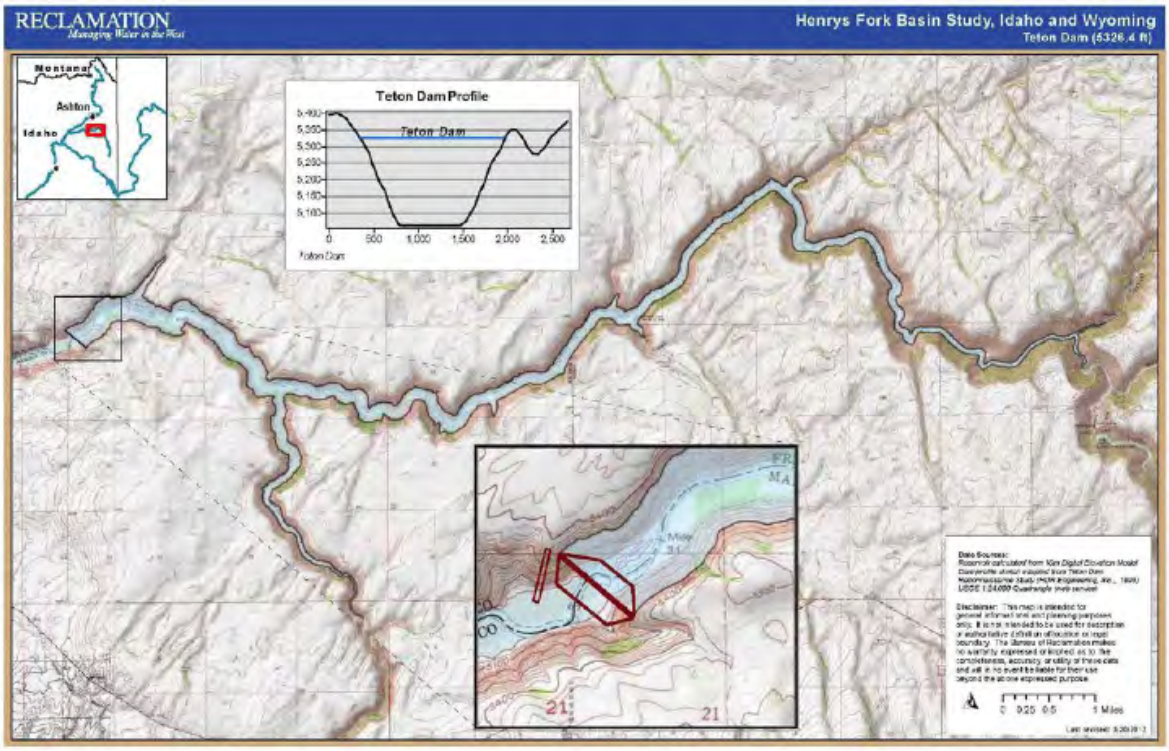

Figure 24. Map showing the proposed dam and reservoir of the Teton Dam Alternative (Appendix B of Reclamation 2013a).

Impact to Water Budget

Teton Dam would provide additional storage water for the Teton River basin, effectively enhancing water supply by capturing excess peak flows and redistributing that water during periods of higher demand. The available storage would enhance the in-basin water budget by storing 202,000 acre-feet (in 50 percent of the time, if the reservoir was initially empty) during the annual high flow period and storing that water until more critical, higher demand periods. This storage water could help satisfy unmet irrigation demands in the Lower Watershed irrigated region.

New ecological flow targets were modeled to minimize impacts on the Teton River due to Teton Dam storage. This analysis provided a more accurate reflection of the storage in Teton Reservoir since reservoir diversions cannot negatively affect instream flows. The ecological flow targets were modeled as 200 cfs from September to November, 400 cfs from December to February, and 300 cfs the rest of the year.

The modeling results showed that about 50 percent of years approximately 200,000 acre-feet would be available for storage and 75 percent of the time, approximately 85,000 acre-feet or more would be available. However, in approximately 15 percent of the time, no water would be available (Figure 25).

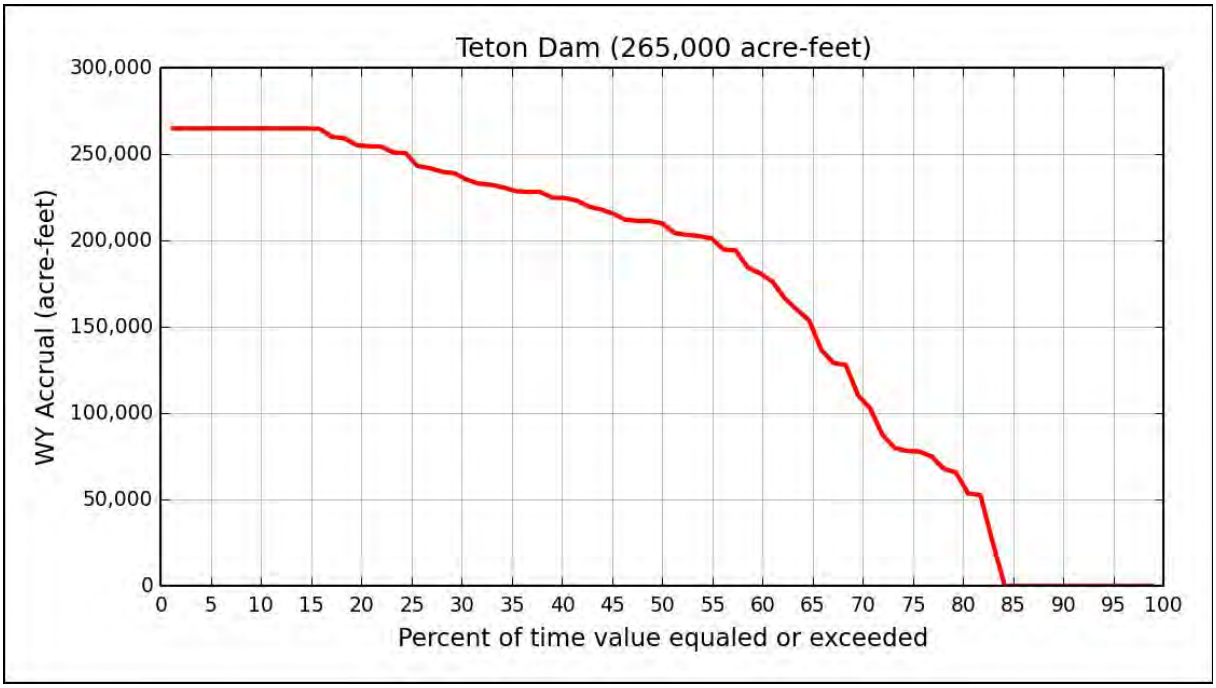

Figure 25. Volume stored in the new reservoir from the Teton River per water year. This represents the volume of water that would be available for use.

Regarding changes in flow of the Teton River, calculations for the Teton at St. Anthony stream gage show a median condition decrease in flow from March through mid-May (when excess flow would be captured in the reservoir) and an increase in flow from mid-May through July (when stored water would be released); however, the water stored and released during those times may actually belong to water users outside of the basin. Under low flow conditions, from December through February, the flows are higher because the flows would meet the ecological flow targets.

Potential Climate Change Impacts

In the hydrologic models, additional water would be stored more reliably in the reservoir during the winter. The reservoir would achieve its maximum storage for the year by April or May (Figure 26).

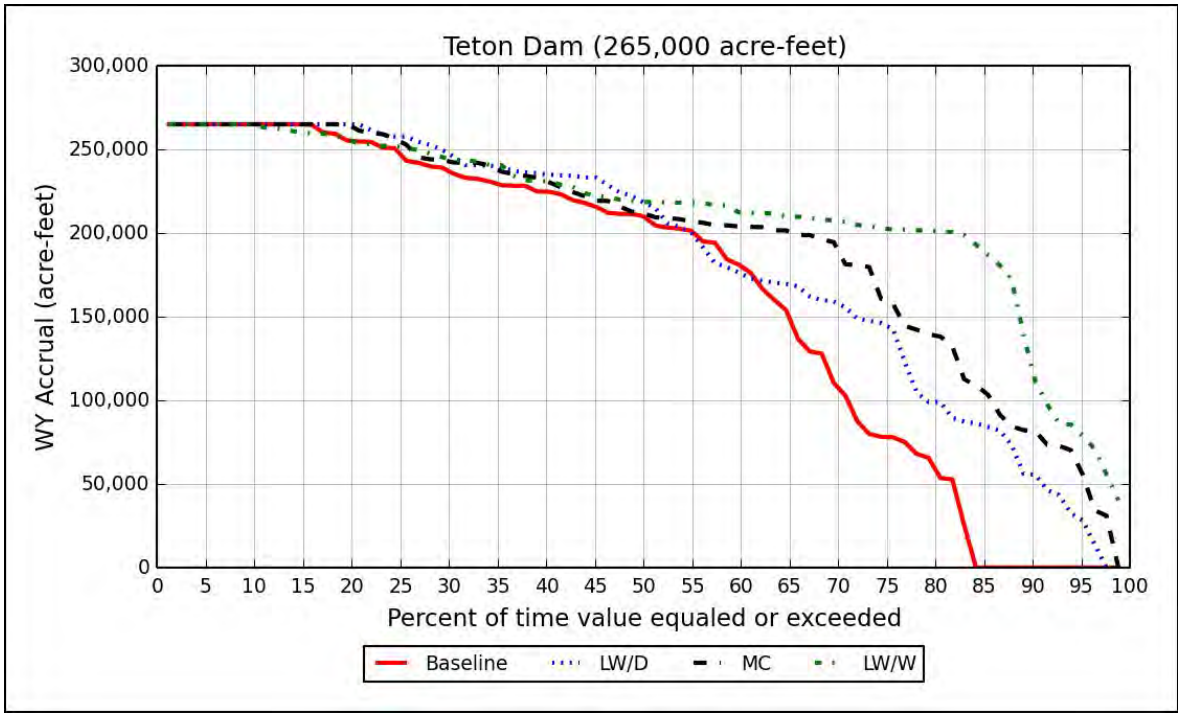

Figure 26. Volume stored by the new reservoir per water year. This represents the volume of water that would be available for use. An increase in water year storage was seen for all climate change scenarios.

Regarding changes in flows in the Teton River from climate change, additional water would be delivered downstream in the wet season, but due to the projected reduction in flows from July through September, the delivery of the additional water would not be apparent when compared to the baseline.

In wet and average water years, similar flows would occur through the spring until April when it would be likely that Teton Dam would be full and all flows would bypass the reservoir. The natural flow peaks in May would recede more quickly than the baseline.

Benefits and Impacts

Reservoir releases during low flow periods would improve flows in downstream river segments, including the North Fork Teton River and South Fork Teton River which have been identified as having additional ecological streamflow needs. Storage would typically occur during periods of high flows; nonetheless, water storage would impact conservation populations of Yellowstone cutthroat trout in the Teton River and Bitch Creek.

Teton Dam would have a major impact on fish populations by blocking migration in Teton River and eliminating riverine habitat needed by Yellowstone cutthroat trout. Free flowing river miles would be converted to slack water which would negatively impact fisheries.

Yellowstone cutthroat trout are present in the proposed reservoir inundation area and is a State aquatic Species of Greatest Conservation Need. Fluvial Yellowstone cutthroat trout are found above and below the proposed dam site. Rainbow trout are present upstream of the Teton Dam site so the migration barrier created by the dam would not isolate the Yellowstone cutthroat trout from the effects of nonnative fish; however, the dam would prevent additional up-migration of nonnative fish in the future. The reservoir would impact the Teton River's conservation population, which is defined as having less than 10 percent genetic introgression from other species.

The proposed Teton Reservoir inundation area contains important winter range and migration corridors for big game. The U.S. Fish and Wildlife Service tracks one candidate species in the area, the wolverine. The bald eagle, trumpeter swan, and Wyoming ground squirrel make their homes here and are considered at risk by the Bureau of Land Management and the U.S. Forest Service. Data from the National Wetlands Inventory indicate construction at this site would have an extensive impact on mapped wetlands, affecting an area greater than 200 acres. Hydrologic changes to the water source brought about by the proposed construction would also have direct impacts on a stretch of Teton River that is eligible for Wild and Scenic River status designation (CH2M HILL 2013).

Recreational benefits related to whitewater rafting, hunting, wildlife viewing, fishing, and fly fishing may be reduced which would impact the local economy; however, these impacts may be moderated by the advent of slack water recreation such as boating and swimming.

One of the purposes of the original Teton Dam was flood control and could be included in the purposes of this alternative.

Key Points from Evaluation and Feedback

Teton Reservoir, formed by water impounded by a new dam at the site of the Teton Dam that failed in 1976,[12] would provide additional storage water for the Teton River basin, effectively enhancing water supply by capturing excess peak flows and redistributing the water during periods of higher demand. The available storage would enhance the in-basin water budget by impounding up to 265,000 acre-feet (if the reservoir was initially empty) during the annual high flow period and storing that water until more critical, higher demand periods. This storage water could help satisfy unmet irrigation demands in the Lower Watershed irrigated region.

[12] Reclamation conducted a stringent investigation of the reasons for the Teton Dam failure and found the failure was due to poor grouting of the highly fractured rock abutments and foundation of the dam. Given the depth of knowledge of the Teton Dam site, a safe, reliable dam can be constructed.

Reservoir releases during low flow periods would improve connectivity in downstream river segments, including the North Fork Teton River and South Fork Teton River which were identified as having additional ecological streamflow needs. Storage of flows would typically occur during periods when connectivity is not an issue, but nonetheless, withdrawals may be expected to impact conservation populations of Yellowstone cutthroat trout in the Teton River.

Teton Dam presents a cost-effective alternative for the purpose of storing water, but may be environmentally unacceptable. The impact to Yellowstone cutthroat trout may be the most significant environmental impact, but loss of wildlife habitat, including important mule deer and elk winter range, and free-flowing river miles will also be significant.

Public acceptance of any new dam at or near the site of the original Teton dam would be problematic given the history of the dam's failure. A large reservoir on the mainstem of the Teton River would be strongly opposed by a number of groups. Several nongovernmental organizations have stated they would sue to stop the construction of Teton Dam. This would require extensive legal costs and judgments in those lawsuits may prevent the construction of Teton Dam. Environmental interests do not want to see Teton Dam replaced and would like it eliminated from future consideration. Conservation stakeholders are particularly opposed to this alternative because it creates an on-stream dam on a free-flowing river.

Reclamation has serious reservations about the environmental consequences and public acceptability of the Teton Dam alternative. Reclamation is not prepared to support Teton Dam due to national and international commitments with other Federal agencies, State agencies, and nongovernmental organizations which are focused on improved water management and environmental benefits. Construction of Teton Dam may impede meeting these commitments. In the current atmosphere of Federal budgeting, Congressional authorization may be difficult to obtain absent Reclamation's support.

The Teton Dam site is owned by Reclamation. Congressional authorization would be required to allow this site to be used for reconstructing Teton Dam or to be transferred to another party, such as the State. The original repayment contractors still have a repayment obligation to the Federal government for the original Teton Dam. This may prove to be a substantial obstacle to gaining congressional authorization.

While local water users recognize there are significant environmental issues with the Teton Dam alternative that may prove insurmountable, they also note that the development of this reservoir would be cost-effective, addressing the possibility that a critical water supply shortage would have severe impacts on the economy of the region. The water users support retaining this option, despite its drawbacks, until another option is available to mitigate local water shortages. IWRB shares the perspective of the water users.

Additional Limitations of Analysis

The hydrologic and environmental impacts on the Teton River should be reinvestigated thoroughly, as well as in the impacts overall to the Henrys Fork River basin and ESPA system. Neither stream habitat changes to the Teton River nor impacts to Yellowstone cutthroat trout due to constructing the Teton Dam were evaluated in detail. Additional analysis would be needed to demonstrate how water storage in Teton Reservoir would meet hydrologic and environmental needs.

The dam site alignment and feature configurations were the same as the original designs. Updated materials and material properties were not re-evaluated. Cost estimates were derived from past estimates and adjusted to reflect current dollars.

5.2.6 Island Park Storage Increase

Description

The Island Park Reservoir storage increase alternative consists of raising the normal reservoir water surface elevation by 4 feet which would increase reservoir storage by 26,700 acre-feet. In average water years, the reservoir would capture 26,700 acre-feet, based on runoff availability with consideration of existing water rights. The storage increase would also require expanding the spillway capacity of Island Park Dam to maintain or negligibly increase the same level of dam safety risk. Additional storage in Island Park Reservoir would be managed with consideration of the Henrys Fork Drought Management Plan.

Alternative Analysis

Due to preliminary findings and Workgroup interest, the Island Park Reservoir storage increase alternative was evaluated in more depth than most other storage alternatives. Eight floodwater routing scenarios were evaluated for four options for increasing Island Park Reservoir storage and raising the normal reservoir water surface elevation of 6303 feet (Reclamation 2013c).

The cost estimate for adding a 5-foot bladder to the service spillway and enlarging the existing emergency spillway would be approximately $6,400,000 for 26,700 acre-feet of storage volume ($240 per acre-foot). Power-generating costs were not included in the cost; however, the existing power facilities would generate additional power, due to an increase in water surface elevations, with only minor modification. Shoreline protection costs due to raising the normal water surface were not considered.

The purpose of the flood routing analysis was to evaluate various bladder heights on the service spillway and their impacts on Island Park Dam. Flood routings were performed

through both Henrys Lake Dam and Island Park to determine the potential flood frequency return periods which could induce overtopping at Island Park Dam, as well as the discharge through Island Park Dam during a large flood event.

A 5-foot bladder with an increase in emergency spillway width to 1,130 feet is currently considered the preferred option. This option would raise the normal pool by 4 feet to increase reservoir storage by 26,700 acre-feet. Flood routing studies also revealed that this increase in reservoir capacity would potentially affect two buildings adjacent to the reservoir.

Impact to Water Budget

Water stored in Island Park Reservoir could be used to satisfy unmet irrigation needs in the Lower Watershed irrigated area by storing up to 26,700 acre-feet more during the high flow period and releasing it in more critical, higher demand periods in the summer and early fall. Reservoir releases from Island Park Dam would also enhance ecological instream flows. However, more detailed modeling of local hydrology indicates that this additional water storage would not be available in all years. As shown in Figure 27, the additional 26,700 acre-feet of storage would be available only approximately 78 percent of the time. In contrast, no additional water would be stored in approximately 20 percent of the time.

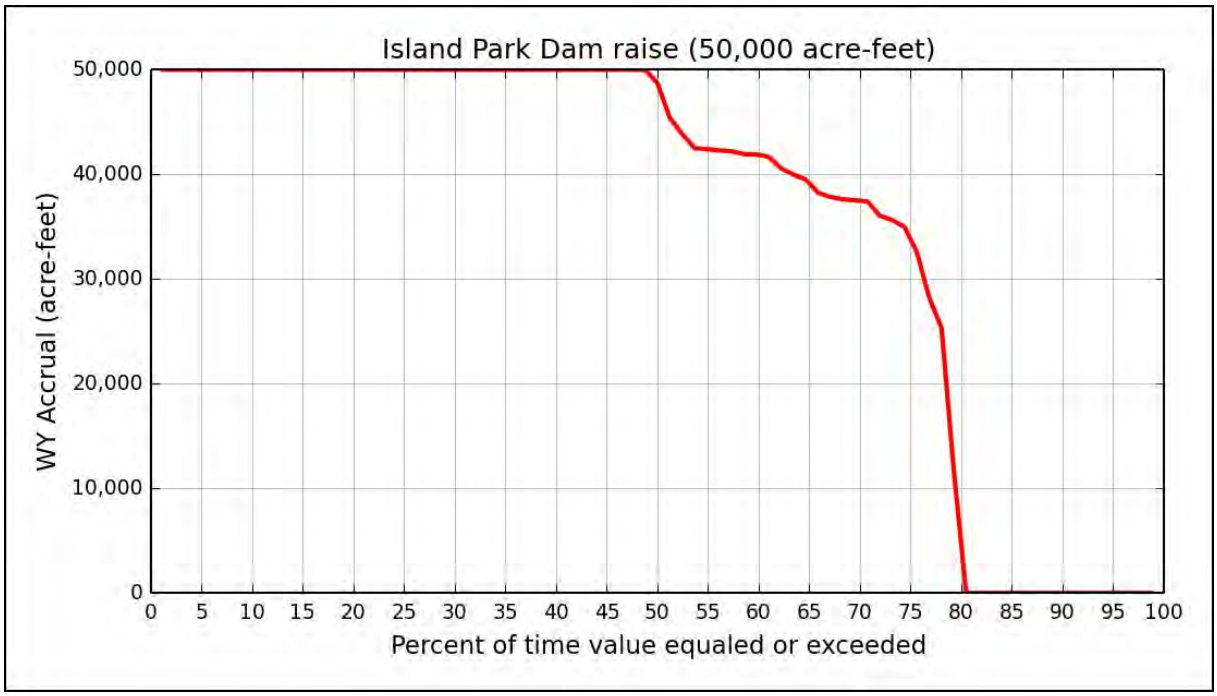

Figure 27. Additional water volume stored per water year with the Island Park storage increase alternative. This represents the volume of water that would be available; that is, about 70 percent of the time there would be approximately 37,000 acre-feet or more available and about 20 percent of the time no water would be available as additional storage.

The additional storage would also affect flows downstream of the reservoir. Under median conditions there would be a decrease in flows in the spring when excess flows would be stored in the reservoir and an increase in flows in July as the stored water would be released. In wet years, the full 26,700 acre-feet would be stored and delivered; hence, flows would increase from June through September. In dry years, less water would be stored in the spring and less would be delivered in the late summer.

Potential Climate Change Impacts

The baseline conditions described in Section 5.1.2 were compared to the same climate change scenarios specified for Lane Lake. In the hydrologic models, additional water would be stored more reliably in Island Park reservoir (Figure 28). This additional water would enter the reservoir during the winter and by April or May, the reservoir would be full or nearly full in most years.

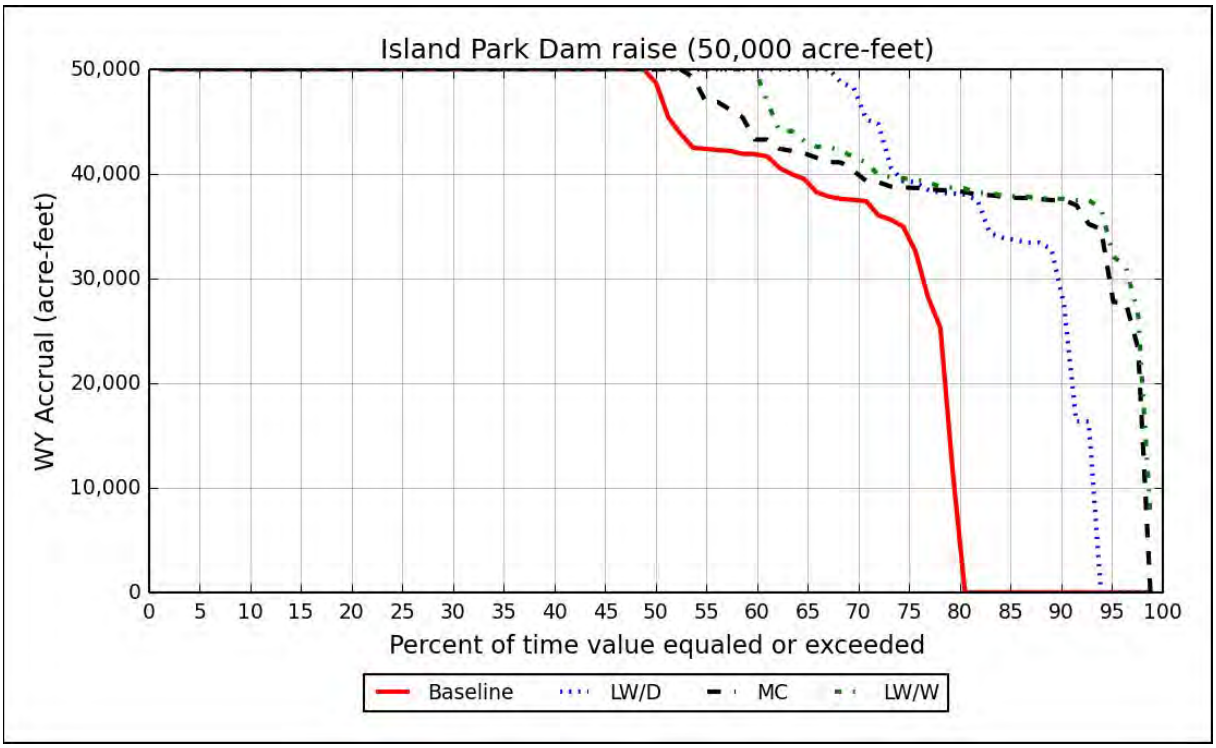

Figure 28. Volume accrued by the new reservoir water right per water year. This represents the volume of water that would be available for any new use. An increase in storage (water year accrual) was seen for all climate change projects.

In terms of changes in flow below Island Park reservoir, average and wet conditions would show increased storage or reduced downstream flows from October through December when the reservoir would fill. From January through May, inflows would be passed downstream. Because more water would be stored, additional water would be released downstream from

July through September to satisfy new demand. Even in the drier years, enough additional water would be captured to increase July flows to new demand.

Benefits and Impacts

The increase in storage volume in Island Park Reservoir would help alleviate problems associated with the shift in the timing of flows from climate change. By providing additional water storage, some of the additional water runoff expected from wetter years may be stored in the early spring and released under the Island Park Dam management plan. This increase in Henrys Fork River flows during the irrigation season may benefit irrigators and fish populations in the river or be used to augment ESPA recharge.

Bird habitat in the fringe wetlands and on Trude Island may also be inundated with an increased storage pool.

Key Points from Evaluation and Feedback

Conservation stakeholders support retention and further exploration of this alternative because environmental impacts would be less significant than with any alternative calling for construction of a new dam. They further recognize the potential for Island Park to provide additional water in winter droughts and improve stream connectivity.

Local water users and IWRB are greatly interested in the Island Park alternative, given its relative low cost. They note that, in addition to this alternative enhancing a structure currently operating, this alternative has the potential to address state-wide as well as local water supply issues.

Similarly, Reclamation supports further exploration of increasing storage in Island Park Reservoir, especially when additional storage has the potential to enhance the operational flexibility of the Minidoka Project in the Upper Snake River system.

Homeowners adjacent to the Island Parks Reservoir would be very involved in a pool raise due to concerns over the impacts to their properties.

Additional Limitations of Analysis

Cost estimates are preliminary and a more detailed analysis of the cost of tunneling and expanding the emergency spillway would be needed. Depending on the configuration of the tunnel, the site analysis could lead to increased estimated construction costs which could potentially change the ranking of alternatives by cost (see Section 6.0).

Hydrologic impacts on the supply sources and the downstream Henrys Fork River would need to be further evaluated, as well as impacts on the overall Henrys Fork River basin and ESPA

system. Analyses to demonstrate how additional water storage in Island Park Reservoir would meet defined needs would also need to be conducted.

5.2.7 Ashton Dam Raise

Description

Ashton Dam is owned by PacifiCorp Energy and operated as a run-of-river project that generates hydropower (LIHI 2010). The Ashton Dam Raise alternative would involve increasing the height of Ashton Dam by approximately 43 feet to a total height of 100 feet. This increase in height would increase the reservoir storage by 20,400 acre-feet to a total of 30,200 acre-feet which would inundate additional areas around the existing reservoir (Figure 29). Ashton Reservoir is located on the Henrys Fork River adjacent to the Town of Ashton and would require no secondary water sources. In average water years, the reservoir would capture 24,000 acre-feet, based on runoff availability with consideration to existing water rights.

The cost estimate for enlarging Ashton Dam would be approximately $28,210,000 for 20,400 acre-feet of storage volume ($1,382 per acre-foot). When full, Ashton Reservoir could provide about 80 feet of drop to a new hydropower facility at the base of the dam, but that option was not included in the cost estimate.

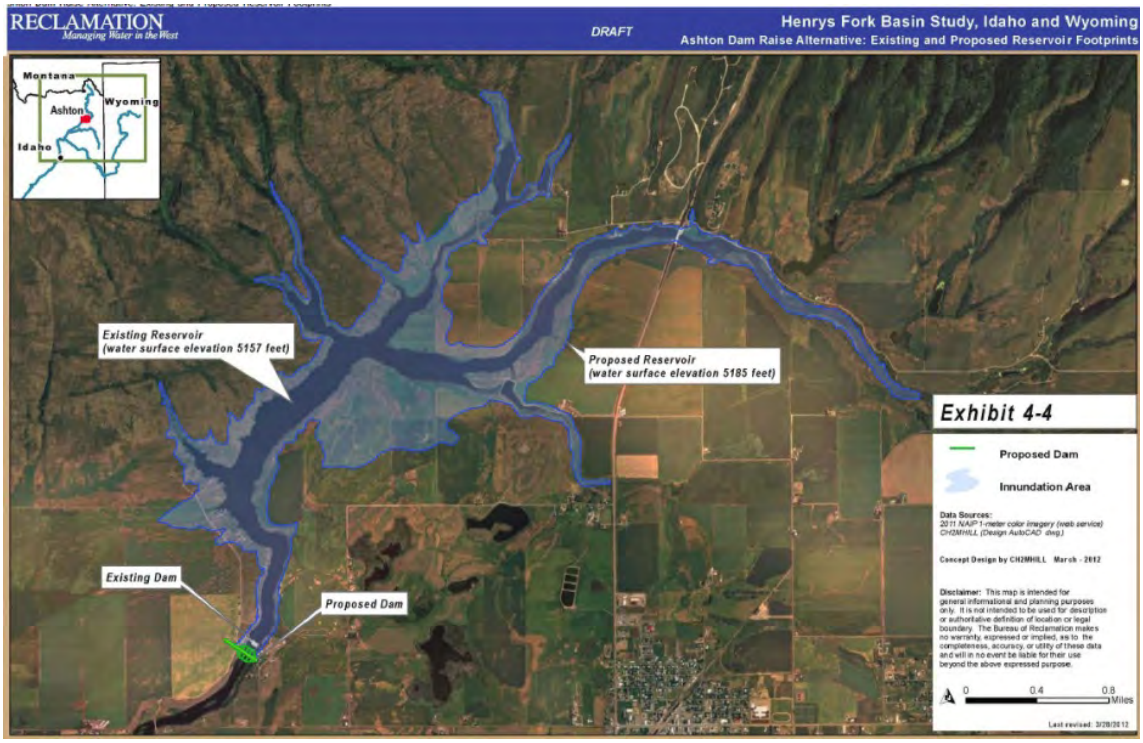

Figure 29. Aerial photo with the projected inundation area associated with the Ashton Dam raise alternative.

Impact to Water Budget

Water stored in Ashton Dam could be used to reduce demand for irrigation withdrawals from Island Park Reservoir to meet irrigation needs in the Lower Watershed irrigated area by storing an additional 20,400 acre-feet during the high flow period until needed in more critical, higher demand periods in the summer and early fall. Reservoir releases would also enhance ecological instream flows in the Henrys Fork River downstream of St. Anthony. The out-of-basin water budget would be affected temporarily by storage of 20,400 acre-feet, but the water could also be used to meet out-of-basin needs such as agricultural needs, municipal and industrial needs, ecological needs, or groundwater recharge.

Benefits and Impacts

The Henrys Fork River flows would be changed both during storage and releases at Ashton Dam. Streamflows could potentially be impacted from decreased flows in downstream river segments when water is being stored and increased flow for river segments when water is released from the reservoir. The water storage increase would likely occur during the excess spring runoff period and reservoir releases would likely occur during more critical low flow periods. Releases from Ashton Dam would need to be closely coordinated with those at Island Park Dam to improve ecological flows in the Henrys Fork River while delivering water supplies for irrigation or augmentation of the ESPA.

Key Points from Evaluation and Feedback

Similar to the Island Park storage increase alternative, conservation stakeholders support the Ashton Dam alternative for further study. Given the existing dam structure, modification of the structure would translate to less significant environmental impacts than construction of a new dam.

Local water users remain interested in this alternative, given its cost relative to other alternatives, but note the cost remains too high for local funding.

Though acknowledging recent rebuilding and license renewal for Ashton Dam, IWRB supports continuing to study this alternative for several reasons. The alternative is relatively inexpensive. Downstream water supply issues, including mitigation for wells within the ESPA, could also be addressed by this alternative.

Reclamation noted that Ashton Dam is privately owned and the identified storage volume of this alternative is relatively modest. Ashton Dam is a run-of-river operation which is not expected to change. Only incremental water stored would be used and there would be no impact to hydropower generation.

Additional Limitations of Analysis

Embankment configurations were generalized and site-specific materials and material properties were not evaluated. No optimized dam approaches were proposed. A detailed evaluation of dam-raise design considerations would need to be performed in future phases to assess feasibility.

5.3 Managed Recharge Alternative

5.3.1 Introduction

Managed recharge in the Henrys Fork River basin must be evaluated as a potential source of water supply for the basin as well as for stabilization and recovery of the ESPA. The importance of groundwater and its close integration with the basin's surface hydrology is widely recognized. Enhancement of managed recharge activities may improve in-basin storage as well as instream flow conditions downstream of the recharge sites.

Recent studies by IDWR related to the ESPA stabilization objectives indicate that recharge in the Henrys Fork River basin for the purpose of improving the condition of the ESPA is not as effective as focused recharge in locations downstream of American Falls Reservoir. Nonetheless, these studies have also highlighted the importance of recharge in the Henrys Fork River basin during above average water years to contribute to system-wide recharge capacity when water is available in excess of that needed to recharge in the downstream locations. Historically, the IWRB has partnered with FMID in the managed recharge program, recharging a total of nearly 150,000 acre-feet from 2008 to 2012.

Three locations in the Henrys Fork River basin were identified by Basin Study participants: 1) Egin Lake recharge site expansion, 2) lower Teton River, and 3) Teton Valley tributaries. Of these, only the expansion of the existing Egin Lake recharge site was assessed as part of this Basin Study; however, the other two sites may hold potential for future assessment and action.

Lower Teton River

Managed recharge near the lower Teton River has been identified for its potential to support unmet irrigation demands in the lower Teton Valley in the late summer and to enhance ecological flows in adjacent river reaches. A candidate site between the North and South Forks of the Teton River was evaluated in the early phases of the Basin Study. Initial modeling suggested that a portion of the water recharged in this area would be retained in the ESPA and the remaining volume would be discharged to the Teton and South Fork Teton rivers. This water could help satisfy both late season irrigation and fisheries needs. However,

while this area was included in the ESPAM, it remains an area of uncertainty even in the newer version of the model (ESPAM 2.1). The surface and groundwater hydrology in the area is known to be complex. The contribution of surface water from the Henrys Fork and Fall rivers through the Crosscut Canal and the corresponding canal seepage complicates the system hydrology even further.

Teton Valley Tributaries

Groundwater recharge in the upper Teton River Valley was also identified during the Basin Study process. Most of the Teton River tributaries contain Yellowstone cutthroat trout while nonnative trout are located primarily in valley-bottom spring creeks throughout the Teton River (Van Kirk et. al. 2011). Surface water flow dries up in the alluvial fan reaches of the Teton Valley in the late summer of most years. While many of the stream channels would dry naturally, irrigation diversions have likely extended the period of desiccation. The purpose of managed recharge activities in the area, as proposed by conservation groups, would primarily be to increase the period of hydraulic connectivity between spawning and rearing areas and the mainstem river by increasing return flows to the tributary reaches later in the summer. This may improve late season flows for irrigation in the lower Teton as well (Van Kirk et. al. 2011).

Given the complexity of the hydrology, ecology, and water use in the Teton Valley, the effects of new management practices may have consequences throughout the watershed. Administrators, water users, and advocates for ecological streamflows acknowledge that thorough consideration and evaluation should be given to any proposed changes in water management practices.

Future Program and Actions

The potential effects of managed recharge at all of the identified sites must be considered within a legal, scientific, and social framework and taken into account with IWRB's goals for managed recharge as an aquifer stabilization tool. To refine recharge proposals at specific locations, future actions could include collection of additional data related to flow, trout, and aquatic life, and allowing water uses to better quantify the effects of low and modified flows in a specific reach as well as the watershed. Continued development and integration of watershed and basin-wide hydrologic models is also a critical component for identifying practical and effective changes in water management practices.

Any appropriation of water for managed recharge must be consistent with the State Water Plan and the ESPA CAMP. Projects involving the diversion of natural flow water appropriated pursuant to Idaho Code § 42-234 for managed recharge in excess of 10,000 acre-feet on an average annual basis must be submitted to the IWRB for approval prior to construction (Idaho Code § 42-1737).

The IWRB holds recharge water right permits (1980 priority dates) which authorize diversion of water from the Snake and Big/Little Wood rivers. IWRB resubmitted its 1998 applications on behalf of the State for groundwater recharge permits throughout the ESPA, including locations within the Basin Study area. The applications state that the IWRB will establish an environmental consultation committee to review potential impacts of recharge activities on fish and wildlife resources within the Henrys Fork and South Fork of the Snake Rivers, and the mainstem Snake River above American Falls Dam. The IWRB also intends to consult with IDFG to develop a protocol for evaluating and minimizing potential adverse impacts on these resources. This information will assist the IWRB and stakeholders in determining whether recharge activities in the Henrys Fork and Teton watersheds can address some of the water needs in the basin.

5.3.2 Egin Lake Recharge Site Expansion

Description

Expansion of the Egin Lake recharge site has the potential to enhance water supplies in the Henrys Fork River basin by improving groundwater table levels and increasing ecological flows in the river and to contribute to stabilization of the ESPA. Expansion of the site was initially evaluated during the Basin Study process using the ESPAM1.1 and by estimating costs associated with enlargement of the recharge facilities. An updated version of the model, ESPAM2.1, was released later in the study process and was used by IDWR in a broader analysis intended to prioritize aquifer recharge sites across the ESPA based on hydrogeologic characteristics and recharge water availability. The studies were initiated to help clarify where recharge activities would be most effective in achieving ESPA stabilization and recovery.

The hydrogeologic analysis compared the potential effectiveness of recharge locations across the ESPA relative to the retention time of water in the aquifer and capacity to receive recharge water (acre-feet per month). To evaluate potential retention time, IDWR modeled a recharge event of 100 cfs over one month in the spring and a second event in the fall at 13 recharge locations across the ESPA, including the Egin Lake site. The sites were first ranked based on the percentage of water retained in the aquifer after 5 years. They were ranked further based on recharge limitations corresponding to potential physical capacity (i.e., diversion, infiltration and groundwater capabilities). Evaluating recharge in the spring and fall was an important consideration given that increased water table elevations in the fall limit additional recharge capacity at some sites and in some cases, may result in infrastructure flooding/damage, or water wasted by returning to the river via drains.

Results of the hydrogeologic analysis indicated that the Egin Lake recharge site had highest 5-year retention potential relative to other sites across the ESPA. However, the total volume of

recharge was limited by the site capacity. The analysis showed that of the 13 sites evaluated, the top 5 were located below American Falls Reservoir.

In addition to hydrogeologic considerations, the amount and frequency of water available for recharge upstream of Milner Dam at different locations across the ESPA was determined to be an important factor in prioritizing recharge activities. Several fundamental assumptions were applied in the water availability analysis: 1) recharge should be an opportunistic use of available natural flow; 2) recharge should not interfere with optimal capture of water in the storage system; 3) recharge must be in priority at the point of diversion; 4) Reclamation's hydropower water right at Minidoka Dam must be fully satisfied (2,700 cfs); 5) volume of water available for recharge was limited to water spilling past Milner or water at the recharge point of diversion less an assumed minimum streamflow (minimum stream flows were assumed as 0 cfs at Milner, 2,700 cfs at Minidoka, 200 cfs at Blackfoot, 900 cfs at South Fork, and 200 cfs at Henrys Fork).

Water District 01's water right uses accounting data for a period of record from 2000 through 2012 from five significant gage locations to represent all of the recharge points of diversion: Milner, Minidoka, Snake River near Blackfoot, the Snake River near Heise (South Fork of the Snake River), and the Henrys Fork near Saint Anthony. Results indicated that upstream of American Falls Reservoir, there is sufficient annual volume of water available for recharge in nearly half of the water years and zero water available for recharge in the other half. The volume of water for which there was at least a 50 percent likelihood of availability (exceedance) for recharge was also calculated and combined with the retention and capacity characteristics of each site. Sites with the best available supply were generally located below American Falls Reservoir. This was in part due to the fact that flows are not in priority for recharge during nearly half of the years evaluated.

Conclusions drawn from the analyses were that the best ranked sites were located below American Falls Reservoir, between the Minidoka-to-Milner reach of the Snake River, and that significant additional recharge capacity would be needed in this area of the aquifer. Recharge above American Falls Reservoir was determined to have value, but water supply was more limited (50 percent of years recharge water is not likely to be available). These sites, which included two locations in the Henrys Fork River basin, were generally ranked lower than sites downstream of American Falls, but would provide important additional recharge capacity in above-average water years. In addition, existing sites above American Falls have large canal capacities so minimal infrastructure investment would be required. The Egin Lake site was identified as an exception which may warrant enlargement of the conveyance capacity.

The hydrogeologic and water availability analyses indicated that recharge in the Henrys Fork basin for the purpose of improving the condition of the ESPA would not be as effective as focused recharge in locations downstream of American Falls Reservoir. The studies also underscored the importance of recharge in the Henrys Fork during above average water years

to contribute to system-wide recharge capacity. While an expansion of Egin Lakes recharge site was not evaluated using the ESPAM2.1 as part of the Basin Study, IWRB, through its managed recharge program, is actively considering how to proceed with further development of infrastructure in critical locations across the ESPA that will provide for system-wide recharge capacity.

Impact to Water Budget

Impacts to the water budget would be minimized if diversions for recharge occurred during high spring runoff when water is being passed downriver for flood control purpose and when there is an adequate water supply for diversion at high-priority recharge sites that have been shown to increase long-term aquifer storage. Some of that water may be recovered when subsurface flow returns to the river, at which time it may be available for numerous out-of-basin uses, including needs resulting from climate change; agricultural needs; domestic, municipal, and industrial needs; ecological needs; and for recharge of the ESPA (CH2M HILL 2012).

Benefits and Impacts

Diversions to the recharge site would typically occur during periods when low flows are not an issue and would not adversely affect substantial populations of Yellowstone cutthroat trout. Diversions would need fish screens to prevent trout entrainment. Return flows to the river resulting from increased diversion to the recharge site may benefit a priority rainbow trout fishery in the Henrys Fork River by improving flows in downstream river segments and temperature conditions in the lower Henrys Fork River. Specifically, increased groundwater return flows would likely help mitigate temperature conditions associated with surface water diversions below the St. Anthony gage

The recharge site is located within the Nine Mile Knoll Area of Critical Environmental Concern, the St. Anthony Sand Dunes Special Recreation Management Area, and is directly adjacent to the Sand Mountain Wilderness Study Area. No ESA-listed threatened or at-risk species have been noted in the area, but the St. Anthony Sand Dunes host a Bureau of Land Management sensitive plant (St. Anthony Sand Dunes evening primrose) and the largest and most viable population of a rare tiger beetle. Expanding the volume of water recharged at the site should not result in adverse impact to these resources.

The National Wetland Inventory dataset indicates that further development of the site would have minimal impact on mapped wetlands, affecting an area less than 1 acre in size.

Key Points from Evaluation and Feedback

Recharge to support needs within the Henrys Fork River basin and the ESPA generally received wide support from involved agencies and the public. Expansion of these actions must be accompanied by the appropriate environmental impact analysis and assessment of benefits versus costs.

Conservation stakeholders recognize and support managed recharge for its local benefits of cooler/late season return flows as well as the contributions from the incidental recharge associated with irrigation delivery.

Local water users support continuation and expansion of the Egin Lakes recharge site to enhance the local economic benefit of the IWRB's managed recharge program. While IWRB will continue to prioritize recharge activities that result in long-term aquifer storage, it will continue to work with local water users and stakeholders to implement where feasible recharge activities within the study area that further the objectives of the ESPA CAMP and State Water Plan.

Reclamation also recognizes the value of incidental recharge within the basin resulting from irrigation deliveries. This would be considered when assessing or implementing water management actions in the future.

Limitations of Analysis

More detailed studies would be required to evaluate the optimal increase in volume of recharge at this site, including evaluation of the potential impact on instream flows and stream reconnection.

5.4 Water Markets

Description

The water marketing alternative consists of continued implementation of the State's water transactions programs as well as transactions among private entities. Such transactions can provide a source of adequate water supplies to facilitate all types of water use for improved economic returns, improved stream connection, and enhanced instream flows.

There is currently a significant amount of activity in the upper Snake River basin using existing administrative mechanisms such as the State's water supply bank, Upper Snake Water District 1 Rental Pool, and permanent water right transfers (see Section 1.5.2). Water marketing is often used to maximize the economic value of water by exchanging water rights that would have otherwise been unused and/or forfeited and to minimize the economic

consequences of water shortages. Typically water marketing involves a voluntary water transfer agreement for a temporary or permanent change in the type, period, or place of use of water and/or a water right. Water transfers can be local or in specific cases, regional; be in the form of a permanent sale, temporary lease, or donation; and can move water among agricultural, municipal, industrial, and in some cases, to environmental uses.

The recently published *Water Transfers in the West* documented the extent of water transfers in Idaho from 1988 to 2009 (Western 2012). During this period, approximately 6.6 million acre-feet of water was transferred within Idaho, primarily through lease programs. Idaho ranked third among 12 western states in the volume of water transfers and has a highly developed water marketing system.

The primary water exchange market in Idaho is the water bank operated by IWRB (see Section 1.5.2). The water bank has two distinct categories of water marketing: the state-wide water supply bank and basin-specific rental pools. The exchange of natural flow water rights (both surface water and groundwater) is processed through the water supply bank and is administered by IDWR. Rental pools are administered by the local water district advisory committee for a given river basin and primarily rent reservoir storage water rights.

In general, water prices are low in Idaho as compared to other more urban markets largely as a result of the limited payment capacity of agricultural producers. A portion of the fees assessed for the lease and rental of water through the water bank is retained by the IWRB to assist with water bank administrative costs. Similarly, a portion of the fees assessed for the lease and rental of water through the rental pools is retained by the IWRB as a source of funding for water infrastructure across the state, while a portion is also retained by the local water district advisory committee to assist with rental pool administrative costs.

The water supply bank provides a centralized mechanism to lease (deposit water to the bank) and rent (withdraw water from the bank) surface water and groundwater rights throughout Idaho. Water rights are traded and leased to the water supply bank and made available for rent by other water users. Several criteria must be met for IDWR to process a rental agreement through the water supply bank. IDWR must determine (among other criteria):

1. There is a hydrological connection between the water right leased and the proposed rental location.
2. The rental causes no injury to other water users from the rental.
3. The water will be put to beneficial use.
4. The rental does not require a permanent water right (unless the renter can demonstrate a reasonable effort is being made to provide a permanent source for the long-term water use).
5. The rental does not result in an enlargement of the water right.

The rental pools are a central component of IWRB's water marketing activities. They almost exclusively rent storage water allocations and allow reservoir spaceholders to make excess water available to those with limited water supplies in a given year.

Idaho is a leading state in leasing water between water users and the Water District 1 Rental Pool which serves the Basin Study area and is the most active in the state. The local water district advisory committee, under appointment by the IWRB, establishes the pricing and operating procedures that govern each rental pool. The procedures define the priority for rentals, the order of assignments and the rental prices which may vary depending on the type of use and water supply. Rental pools serve an important role in water transactions given the significant volume of water and efficiency with which transactions are processed. While the water supply bank is relatively active in the Henrys Fork River basin, the Water District 1 Rental Pool handles much larger volumes of water.

Facilitating Water Markets

Assessment of the successes and limitations of Idaho's water bank focused on increasing the economic, environmental, and social benefits resulting from water transfers. These opportunities were evaluated: 1) removing transaction costs, 2) having a better understanding of the marginal value of water, 3) improving market clearing mechanisms, and 4) developing region-specific solutions. Due to the complexity of water market transactions, developing region-specific solutions offers the greatest potential for facilitating an increase in water market transfers. The following provides examples of existing programs which attempt to address region-specific solutions and reflect IWRB's efforts to support and expand the existing market system.

Idaho Water Transaction Program

As discussed in Section 1.5.2, the IWRB is a Qualified Local Entity (QLE) of the Columbia Basin Water Transactions Program (CBWTP) and manages activities in the upper Salmon River basin through the IWTP. Funding for the CBWTP is used to support projects that provide flows necessary for ESA-listed fish species while maintaining the agricultural economic base of the upper Salmon River basin. These projects are carried out using mechanisms such as water right leases (partial or full-season), water right subordination agreements, negotiated changes in points of diversion, and conservation easements. All of these mechanisms exist independent of the IWTP and can be utilized by any entity independent of the IWTP. The IWTP and the IWRB's QLE status under the CBWTP provide funding from the Bonneville Power Administration to the IWRB to carry out these projects. The IWTP is a good example of successful implementation of a region-specific solution to address fisheries issues, and illustrates the importance of an established a funding mechanism in combination with the use of existing legal and administrative tools.

The recent partnership between IWRB and the Friends of the Teton River to evaluate the effectiveness of directing IWTP funds into the Teton River basin (see section 1.5.2) may provide a method, through existing administrative systems, to achieve certain conservation goals in the Teton River basin.

Potential Aquifer Recharge and Mitigation Credit Bank

The concept of an aquifer credit and mitigation bank is currently under consideration by the IWRB, the State Legislature, the Governor's Office, and water users across the state. If enacted it would authorize the IWRB to develop a program, initially focused on the ESPA, and perhaps extended to other areas as needed, which would allow local entities to conduct managed aquifer recharge within the framework of the IWRB's recharge program and receive marketable mitigation credits after a "cut to the aquifer." The credits may allow for some new water uses and economic development while incentivizing additional managed recharge within the framework of IWRB's overall managed recharge efforts consistent with the ESPA CAMP and State Water Plan.

Impact to Water Budget

The current water market programs provide a mechanism for improvement of the Henrys Fork River basin's water budget. Continued support of existing water market programs and development of expanded programs in the region can provide additional system flexibility and opportunities to assist in managing available water supplies to satisfy the goals of the ESPA CAMP as well as meeting water needs in the Henrys Fork River basin. While water markets are not capable of increasing water supply, localized improvements to water budgets and mitigation of the economic consequences of water shortages may benefit from market activities.

Benefits and Impacts

Water marketing will help mitigate the economic consequences of increased demand and of water shortages during drought cycles and due to the effects of climate change throughout the Henrys Fork River basin, and may improve stream connectivity associated with lower summer streamflows.

Key Points from Evaluation and Group Feedback

Market activity may increase if constraints to market participation were addressed (e.g., the current $17 per acre-foot Water Bank-suggested rental rate). Expansion of competitive water markets is likely to experience obstacles related to the costs of payments which could be more than the direct beneficiaries could bear. In order to expand the use of water markets in the region to improve aquifer conditions and meet projected future demands, some level of public funding or a broader funding base will likely be required.

A high degree of pressure is placed on the existing surface water storage system and rental pool in the upper Snake River basin to help provide water for a variety of needs, including in-basin agricultural and downstream ESA needs. IWRB passed a resolution on January 27, 2012, stating that its managed recharge efforts would not utilize storage water and would utilize only excess natural flows. This places a significant limitation on the use of the water marketing system to meet aquifer management goals.

All stakeholders accept and support the water management alternative, with conservation groups actively working with IWRB to explore methods for ecosystem restoration by improving markets. IWRB, recognizing that modifications to the State water markets program are ongoing, continues to work within the boundaries of the existing program and law to address challenges with interested stakeholders. Reclamation sees existing water markets as a valuable management tool and supports expanding and improving water markets through competitive grants from the WaterSMART program.

Some conservation groups believe the current institutional barriers prohibiting the real use of markets in the State include 1) the restriction or inability to transfer a consumptive use water right (such as an irrigation right) to an instream flow right and protect that water instream; 2) failure to apply conjunctive management principles throughout the state; and 3) incomplete accounting of water use, both by failing to include the Upper Teton Valley area in accounting for water delivery and for the failure to accurately and consistently regulate irrigation diversion in certain locations.

Limitations of Analysis

Stream reconnection through instream flows is of significant importance to stakeholders in the Basin Study area. Low winter season flows below Island Park Reservoir are a significant concern for the Henrys Fork River. Potential benefits of water transactions in the upper Teton Valley are currently being explored. While existing administrative mechanisms for leasing, transferring, subordinating and selling water rights are available, there are inherent challenges in applying those processes to a specific situation. For example, throughout Idaho, water rights for water delivered through a canal system are generally owned by the water entity. Individual landowners do not have the authority to lease or sell water shares without canal company approval. In the upper Teton Valley, some landowners have expressed interest in leasing water with canal company approval. These types of challenges are not unique to this basin, but do reflect the need for localized solutions. This level of evaluation did not provide recommendations about any new proposed market structure or recommendations to mitigate constraints to using existing water markets.

Water markets can be regulated in a variety of ways to satisfy water supply objectives, including regulatory constraints on certain types of market transfers or the development of

market demand through regulatory drivers that create incentives for trades. The existing regulatory environment for market-based mechanisms was not evaluated, but was considered.

The relationship between water pricing for water transfers and water needs is difficult to estimate due to insufficient (large enough) real time data. In many regions, water supplied to the water market is associated with surplus water supplies or obtained through fallowing irrigated land; however, the greatest demand for water transactions occur during periods of water shortages.

Implementation Options

IWRB has an advanced water market system and is coordinating efforts to enhance existing programs and advance new programs such as a potential aquifer recharge credit program. In combination with the necessary funding, existing programs may be used by all water users to address regional and local water demands.

5.5 Conservation Alternatives

5.5.1 Canal Automation Alternative

Description

The canal automation alternative consists of installing automated gates as primary diversion on high priority canals. The number and location of automated canals to be installed was not determined, but high priority canals were been identified. Primary diversions are the direct diversions from the Henrys Fork, Teton, or Fall rivers. Automated canals more accurately adjust and divert water than manual systems and are a useful tool that allows irrigators to match diversions with irrigation requirements. Flow measurement and data are transmitted to the operator and would reduce the demand for stored water, particularly late season storage withdrawals. Operation and maintenance costs may also be reduced.

Using information from another Reclamation project, estimated costs were developed for the installation of automated canal gates located at the principal stream diversion points and included costs for reworking of headgates, construction of concrete control sections, installation of the radial arm headgates with 200 cfs to 600 cfs capacities (Figure 30), and the installation of a telemetric data acquisition system. A regression equation was developed that directly estimated the cost of totally automated canal systems per cfs capacity: cost = $392/cfs x cfs capacity + $14,988. These cost estimates do not include fish screen costs.

Figure 30. Photo of an automated canal system with a Langemann gates structure.

Impact to Water Budget

Almost all of the canals in the Henrys Fork River basin divert both natural flows and flows from stored water. In general, the natural flows are diverted early in the irrigation season and stored water is withdrawn from reservoirs later in the irrigation season. Given the scarcity and/or options available via the Local Rental Pool, irrigators are more judicious in their water use when using stored water. Water not diverted during the later season remains in storage, giving irrigators more options. Water not diverted during the spring runoff season remains in the river.

The analysis of the conservation alternatives documented that reducing early season diversion would have a negative impact on later season recharge and subsequently a reduction in later season river flows (Reclamation 2012, Appendix E). For this reason, the preferred operation scenario would be for irrigators to continue their normal early season diversions, but to more precisely manage the diversion of stored water.

Automated canal costs were based on the maximum rate of diversion for a particular canal during the past 30 years. This maximum diversion was used as the basis for estimating the annual volume of water that may be saved by canal automation and estimating the cost of placing an automated canal at the head of the major canals (Table 11). The cost per acre-foot of water saved for the nine largest canals ranged from $399 to $2,843 per acre-foot.

The priority for installing automated canal systems would be on those canals which divert storage water when improved efficiencies would result in more water being left in storage. The priority rankings are shown in Table 11.

In terms of changes in streamflow in the Henrys Fork River near Rexburg, the canal automation alternative would result in a slight increase in flow in June due to the decreased diversion. A very slight decrease in winter flows would occur because the decreased summer diversions would result in a decrease in winter groundwater returns.

Table 11. Priority ranking of canal systems, estimated cost for automated canals at main diversion, and estimated storage volume saved.[1]

Canal	Island Park Storage (acre-feet)	Henrys Lake Storage (acre-feet)	American Fall Storage (acre-feet)	Total Storage (acre-feet)	Peak Diversion (cfs)[2]	Estimated Annual Water Saved (acre-feet)[3]	Cost Per Installation[3]	Cost Per Acre-foot Water Saved
Independent	9,147	24,120	0	33,267	522	333	$219,624	$660
Salem Union	7,752	22,374	0	30,126	339	301	$147,888	$491
Consolidated Farmers	4,857	18,459	0	23,316	612	233	$254,904	$1,093
Enterprise	10,233	0	10,024	20,257	168	203	$80,856	$399
Marysville (9A)	19,554	0	0	19,554	240	196	$109,080	$558
Last Chance	1,824	10,047	0	11,871	136	119	$68,312	$575
St. Anthony U (17A)	3,680	7,500	0	11,180	620	112	$258,040	$2,308
Egin	2,308	7,500	0	9,808	439	98	$187,088	$1,908
Teton Island FDR	9,229	0	0	9,229	631	92	$262,352	$2,843
Totals						**1687**	**$1,588,144.00**	**$941**

[1] In the hydrology analysis of automated canals, Reclamation simulated the automation of 44 canal headworks within the FMID in the Henrys Fork River basin and not just the canals listed here as high priority canals. Changes in diversions at the canal headworks were modeled using an analytical model developed by Dr. Rob Van Kirk as documented in *Conservation Alternatives Technical Series Report No. PN-HFS-006* in combination with the Reclamation's MODSIM model (Van Kirk 2013).

[2] Van Kirk 2013.

[3] Estimated amount of water saved is 1.00 percent of historic mean annual storage diverted. This is a conservative estimate.

Potential Climate Change Impacts

Using the best available datasets and data development methodologies, the modeling results showed little difference with canal automation in any of the climate change projections compared to the baseline conditions.

In the Henrys Fork near Rexburg, Idaho, a slight increase in flow was projected for June due to decreased diversion and a slight decrease in flow was projected in the winter as the decreased diversions cause a decrease in groundwater returns.

Benefits and Impacts

For all four of the irrigated regions shown in Figure 16, canal automation would increase both total annual and peak flow volumes and would have a positive impact on the overall water budget of the Henrys Fork River basin. Automated canals would reduce the demand for storage water withdrawal which would improve management options in both the Henrys Fork River basin and the ESPA. Installation of fish screens, in conjunction with construction of automated canal systems, would have a positive environmental impact, but are not considered part of this alternative.

For the North Fremont region, canal automation would increase nonpeak flows. The increase of nonpeak flows would be a positive effect during periods of normally low flows. While the benefit to low flows would be relatively small (less than a 2-percent nonpeak flows increase), the absolute quantity of improved nonpeak flows may make a positive impact.

For the Teton Valley, Lower Watershed, and Egin Bench regions, canal automation would decrease nonpeak flows and would have a negative environmental impact.

Key Points from Evaluation and Feedback

The analysis of automated canals in the Henrys Fork River basin only documented instream flows at existing USGS gaging stations. While model results show increased flows in the Henrys Fork River and Teton River, these increases would likely reduce recharge to the Snake River or the ESPA below Rexburg.

Automated canals appear to have a high degree of acceptance by irrigators, environmental interests, and State water managers. Automated canal projects could qualify for funding from the State's loan program.

Partial funding for this alternative could potentially come through Reclamation's WaterSMART program. Grants for the 50/50 cost share funding are awarded through a competitive process.

All stakeholders support canal automation, with Reclamation noting that WaterSMART grants may be available for this purpose. The support of environmental stakeholders is tempered by concerns that incidental canal recharge to rivers would be affected. At the same time, conservation stakeholders support the improved management of storage water, which could contribute to higher carry-over volumes and promotion of market activity. Similarly, conservation stakeholders recognize and support the benefit of automation to canal measurement and the positive impact that measurement could have in future market activity.

Limitations of Analysis

The amount of water remaining in storage was based on a practical estimate and not based on historical observations.

Existing data from previous projects using a limited number of factors and coupled with high-level assumptions were used to estimate the costs for canal automation. These costs were relative and meant to be used only for planning purposes. The cost analysis only considered the cost of installing an automated canal gate at the principal river or stream diversion point.

No detailed evaluations of stream habitat changes were made for the installation of automated canals.

Modeling estimates were used to determine potential impacts and benefits. Hydrologic and hydraulic modeling inherently contains assumptions, simplifications, and estimations. The modeling protocol allowed for impacts to be analyzed for many stream reaches in the Henrys Fork River basin, but the model was not linked to the ESPAM groundwater model. Consequently, the impacts of changes in diversions and subsequent changes in groundwater and surface water related to each conservation alternative were not calculated as to how they might meet out-of-basin needs (Reclamation 2013a, Appendix E).

Implementation Options

Given the relatively low cost, high social acceptance, and potential to reduce labor costs, automating canals would be a good candidate for early implementation. IWRB's Financial Program is available for developing and financially assisting in the development of the water resources of the State through the construction of water projects. Projects eligible for financing include new construction or rehabilitation of existing water projects. As such, automated canals to improve irrigation water management would be qualifying projects.

It is likely that local sponsors (e.g., a canal company or irrigation district) would be responsible for a portion of installation costs. Because of this, canals which serve a significant number of users or acres may best be able to manage these costs by distributing them to the project beneficiaries.

While the cost estimates for automated canals do not include fish screening, it would be practical to install fish screens when improving diversions. Conservation programs may be tapped to share the fish screen costs of proposed installations.

Installation of automated canals adjacent to waters of the United States with non-Federal dollars would require a Corps of Engineers' 404 permit under the Clean Water Act and its attendant requirements. The use of Federal funds (e.g., under Reclamation Secure Water Act) would also require meeting that particular agency's environmental/policy requirements.

5.5.2 Irrigation Canal Piping Alternative

Description

The irrigation canal piping alternative consists of IWRB continuing to provide financial assistance for the installation of gravity pressure pipelines in the North Fremont irrigated region. NRCS would continue to assist North Fremont irrigators with financial and technical support. In 2013, IWRB approved a loan application from the North Fremont irrigators for $2.5 million which would provide match money for about $6 million in Federal NRCS funds for Phase 4 of the North Fremont Gravity Pipeline Project. The project is being implemented in five phases. Both the IWRB and NRCS provided financial assistance for the previous phases of the project as well.

The installation of pipelines in irrigation canals to limit water loss due to canal seepage is a routine conservation practice. In the Henrys Fork River basin, pipelines and canal linings were determined to be of practical benefit only in the North Fremont irrigated region. Because of the interconnection between groundwater and surface water, piping canals in the other irrigated regions would reduce irrigation return flows to the river; consequently, canal piping does not show positive benefits for those areas.

Impact to Water Budget

For the Teton Valley, Lower Watershed, and Egin Bench irrigated regions (Figure 16), piping canals would reduce both total annual and nonpeak flows and would have a relatively small impact on peak flows, from a reduction of less than 1 percent to an increase of less than 1 percent. The reduction in total annual flows and nonpeak flows would have a negative impact on the Henrys Fork River basin's water budget.

In the North Fremont region, piping irrigation canals would increase total annual flows, peak flows, and nonpeak flows. This would have positive benefits to the Henrys Fork River basin's water budget.

Pipeline systems in the North Fremont irrigated region have reduced withdrawal from upstream storage by approximately 10,000 acre-feet in the past 10 years. Reductions in

withdrawals from the upstream reservoir would help mitigate the expected increase in late season demands on storage throughout the Henrys Fork River basin.

Benefits and Impacts

The installation of pipelines in canals would likely reduce the number of irrigation-induced wetlands within the Henrys Fork River basin, due to decreased canal seepage. However, pipelines would reduce the demand for stored water withdrawal which would improve management options in both the Henrys Fork River basin and the ESPA.

Key Points from Evaluation and Feedback

Piping and lining of irrigation canals would be expensive, but pipelines would provide pressurized water which would reduce pumping needs and conserve electricity. The implementation of piping systems should continue in the North Fremont irrigated region.

Partial funding for this alternative could potentially come through Reclamation's WaterSMART program. Grants for the 50/50 cost share funding are awarded through a competitive process.

5.5.3 Demand Reduction Option

Description

The Demand Reduction alternative consists of reducing the number of irrigated acres, changing to lower water demand crop types or implementing rotational fallowing practices, or reducing overall pumping of groundwater to minimize impacts to the ESPA. As part of this alternative, IWRB would continue to support the Idaho ESPA CREP and AWEP (see Sections 1.5.1 and 1.5.2 for details about the programs). CREP targets the enrollment of up to 100,000 acres of eligible irrigated cropland primarily to reduce irrigation water use with secondary benefits of increased water quality, reduce soil erosion and sedimentation and increase wildlife populations.

IWRB's AWEP award encourages projects that reduce groundwater pumping within the ESPA. It provides a Federal project cost contribution of up to 75 percent while the producer is required to provide the remaining non-Federal portion. In specific cases, IWRB has provided additional financial assistance, particularly where measuring devices are required for water management compliance purposes. Eligible projects include 1) ground water to surface water conversions which allow for the delivery of additional surface water in order to reduce groundwater pumping; 2) improvements to water delivery systems in the Thousand Springs area; 3) regulating reservoirs; 4) demand reduction projects such as end gun removal and conversion to dryland farming.

Estimating the cost to achieve an acre of demand reduction is complex and variable. During this evaluation, the estimated cost to reduce irrigation, meaning the acre would no longer be irrigated, was $1,820 per acre. The estimated cost for deficit irrigation, meaning the acre would be partially irrigated (e.g., irrigation may be stopped only after the second cutting of alfalfa hay), was $3,600 per acre-foot.

Deficit Irrigation Option

After the evaluation of demand reduction, public comments indicated an interest in more analysis related to the practice of deficit irrigation. Deficit irrigation is an irrigation technique where farmers attempt to maximize crops produced per acre-foot of water used. This is sometimes used in regions where water resources are restricted and also incorporates concepts related to water marketing. In general, this is a common practice in the Basin Study area, especially during dry water years. Water savings from deficit irrigation may remain in storage, be transferred to other users, or simply be water not available, depending on the region's volume of water shortage, infrastructure, and legal requirements.

Costs were difficult to estimate due to a scarcity of information related to land prices, crop prices, reductions in yield under deficit irrigation, the economic impact to rural economies, and other socioeconomic factors. A simplified model was developed to estimate the cost of deficit irrigation in the Henrys Fork River basin by using alfalfa hay as the sample crop.

Using the methodology described in Orloff et al. (2005), the estimated costs to use deficit irrigation for alfalfa hay, where irrigation is stopped after the first cutting, were estimated as:

1. $161 per acre-foot of water saved. This is a onetime savings.

2. $3,612 per acre-foot saved with costs amortized over a project life of 50 years, with consideration only to the farm gate. The farm gate is the value of an agricultural product when it leaves the farm which is typically lower than the retail price.

Deficit irrigation would likely be applied in the Henrys Fork River basin during periods of low water supplies. In these dry years crop prices generally rise due to the scarcity of a commodity. Consequently, the costs estimated for deficit irrigation are higher than average, but are relative to the supply and demand for water and crops during dry years.

Impact to Water Budget

The impacts to the water budget for demand reduction were evaluated using an analytical model developed by Dr. Rob Van Kirk (Van Kirk 2013). Quantitative impacts discussed here are based on reductions to irrigation withdrawals of up to 50 percent in the irrigated regions of the Henrys Fork River basin.

For all four of the irrigated regions in the Basin Study area (Figure 16), demand reduction would increase total annual flows and peak period flows. This would have a positive impact on the Henrys Fork River basin's water budget.

For the North Fremont and Egin Bench regions, demand reduction would increase nonpeak period flows which would have a positive impact on the Henrys Fork River basin's water budget.

For the Teton Valley and Lower Watershed regions, demand reduction would decrease nonpeak period flows which would be a negative impact during periods of normally low flows. While the benefit to low flows would be relatively small (less than a 1.5 percent nonpeak flow decrease), the absolute quantity of reduced nonpeak flows may result in a negative impact.

Benefits and Impacts

For the North Fremont and Egin Bench irrigated regions, the demand reduction option would be beneficial to the water budget and environmental needs due to increased nonpeak flows. For the Teton Valley irrigated region, a negative impact would be expected due to a decrease in nonpeak flows. For the Lower Watershed irrigated region with a 25-percent demand reduction, a negative impact would be expected due to a decrease in nonpeak flows. For the Lower Watershed irrigated region, a 50-percent demand reduction would be beneficial to the water budget and environmental needs due to an increase in nonpeak flows.

In the upper Teton Valley irrigated region, demand reduction would be beneficial for streams which go dry or go dry earlier than they did historically due to irrigation withdrawals. Demand reduction was the only alternative considered which could address these specific reaches in the upper Teton Valley irrigated region.

Key Points from Evaluation and Feedback

With recent high commodity prices, there may be no interest in reducing agricultural production. Demand reduction would have other economic impacts due to the economic importance of agriculture in the Henrys Fork River basin.

Due to the limited ability to store the conserved water in the Henrys Fork River basin, the value of the water saved through deficit irrigation may be limited. Much of the irrigated land in the basin relies on natural flows that can only be saved in downstream reservoirs. If there is insufficient natural flow to meet demands in the basin, water stored downstream is of limited value. This situation would most likely occur in consecutive years of below normal water supplies.

Limitations of Analysis

There is not a readily available, large, and directly comparable database of land transactions involving water rights so the determination of the market value of water would be difficult.

Demand reduction involves producing fewer crops and would have a ripple effect on agriculturally based economies. The extent of this impact would be difficult to assess.

Implementation Options

IWRB would continue using the demand reduction programs that are currently in place.

6.0 COMPARATIVE EVALUATION OF ALTERNATIVES

This chapter provides a summary comparison of study findings related to key parameters for the alternatives presented in Section 5.0.

6.1 Surface Storage Alternatives

Surface storage alternatives were assessed and compared from the following perspectives:

- **Benefits**: Relative performance in terms of hydrology was stated directly as potential surface storage volume. The alternatives vary widely in terms of water supply provided.

- **Costs**: The costs of implementing each alternative were compared in terms of both total cost and cost per acre-foot.

- **Environmental Effects**: Environmental effects were compared from two different perspectives: biophysical factors, and sociocultural factors.

- **Viewpoints of Involved Agencies and Stakeholders**: Reclamation, IDWR, and the Workgroup provided an indication of the relative feasibility and desirability of each alternative from the standpoint of ability to obtain required permits and gain political/stakeholder acceptance.

To enable comparison of alternatives from such widely differing perspectives and units of measure, a common numerical value system was used. This system was based simply on rating the top/best performing alternative in any evaluation factor (i.e., benefits, costs, environmental performance, or potential for acceptance) with a value of 10. Conversely, the worst performing alternative was assigned a value of zero. All other alternatives were scored as a percentage of the range between the top- and bottom-rated alternatives. For example, an alternative that would yield 50 percent as much water storage as the range between the largest and smallest storage alternative would receive a score of five. In the case of the environmental factors assessed, data available was simply ratings on a scale of 1 to 3, with one representing a high level of adverse impact, two representing a moderate level of adverse impact, and three representing low/no potential for adverse impact and/or potential for beneficial effect. For these environmental data, a score of one was given a value of zero on the graphs with a score of two rated at five and a score of three given a rating of ten.

6.1.1 Benefits – Water Storage

Surface Storage

Figure 31 illustrates how the surface storage alternatives compare from the standpoint of storage volume. As shown, the Teton Dam alternative would provide the largest amount of storage at a median annual volume of approximately 202,000 acre-fee and the lowest volume of storage would be provided by Spring Creek Dam at 10,800 acre-feet.

Related to the Teton Dam, Lane Lake Dam and Island Park Dam alternatives (for which more detailed hydrologic studies were performed), the storage volumes shown in Figure 31 are median (50-percent exceedance) values. In all three cases, as discussed further in Section 5.1.3, water available to fill additional storage capacity would be higher in a substantial proportion of years. Conversely, water to fill the additional capacity provided by these reservoirs would fall to zero in 15 to 20 percent of years. Also for these three reservoirs, projections based on climate change modeling indicate that the percentage of years in which they would meet or exceed the 80-percent fill level would increase significantly, with the percentage of years in which no or a low level of fill would occur being reduced to less than 5 percent. The same conditions related to fill variability may also be anticipated for other reservoir sites under study in this report, based on both historic and climate change conditions. Further study would be necessary to confirm this probability.

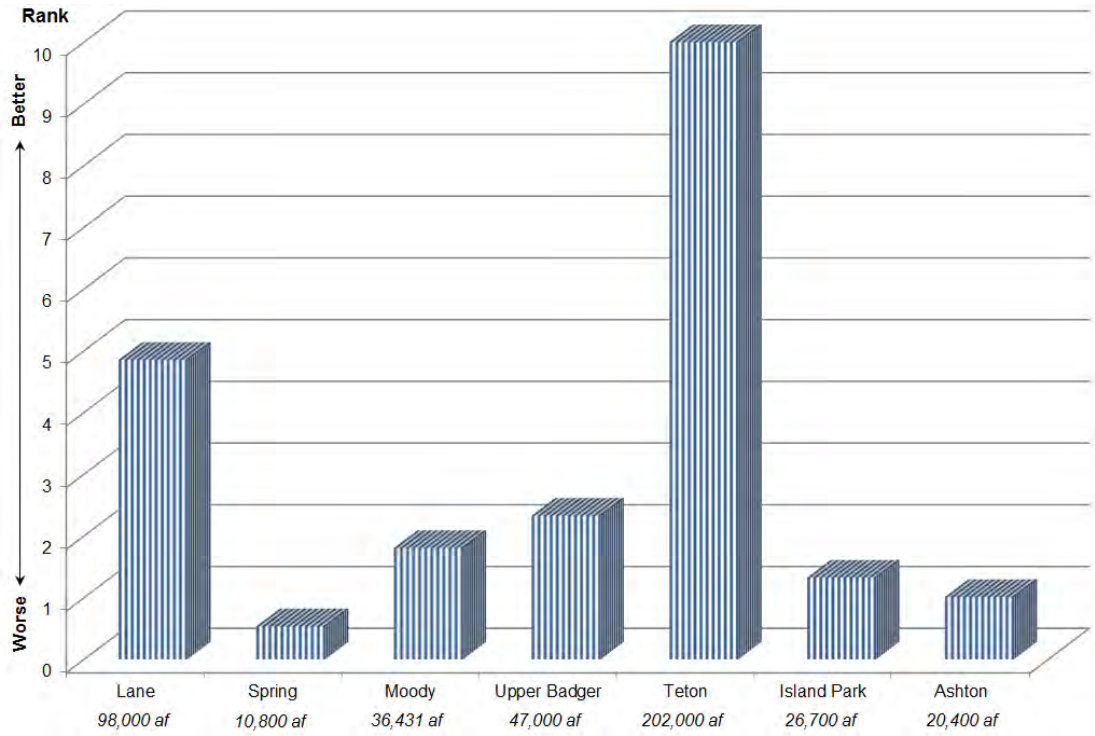

Figure 31. Water storage volumes for all of the surface storage alternatives.[13]

Secondary Benefit - Hydropower

A secondary benefit of surface storage reservoirs would be hydropower production. The Teton Dam alternative would provide the most power at a median value of over 5,870 kW; this is also the only alternative under consideration that would provide new hydropower throughout the year. The remainder of the surface storage alternatives would likely provide power on a seasonal basis, with the highest among these being 2,430 kW at the Upper Badger Creek Dam location. The next highest seasonal power production would be made available by the Lane Lake Dam alternative at 1,500 kW. The remainder of the alternatives would provide less than 1,000 kW, with Spring Creek Dam alternative providing the least, at 177 kW.

[13] Storage quantities represent median values. The method used to calculate these values for each alternative is specified in Section 5.0. In some cases, the values shown represent average annual flow volume; in other cases, additional analysis was performed and the data shown represents the 50 percent exceedance value.

6.1.2 Implementation Costs

Estimated Total Construction Costs

Figure 32 compares the total construction cost for each reservoir alternative. As shown, the highest construction cost by a wide margin would be for Teton Dam and Lane Lake Dam alternatives at up to $492,210,000 and $460,000,000, respectively. The lowest development cost would be associated with the increase in storage capacity at the two existing reservoirs being considered: Island Park Dam storage increase alternative at approximately $6,400,000 and Ashton Dam raise alternative at approximately $28,210,000. When compared with Lane Lake Dam and Teton Dam alternatives, the cost of Spring Creek, Moody Creek, and Upper Badger Creek dams are also relatively low at approximately $41,760,000, $123,920,000, and $128,940,000, respectively.

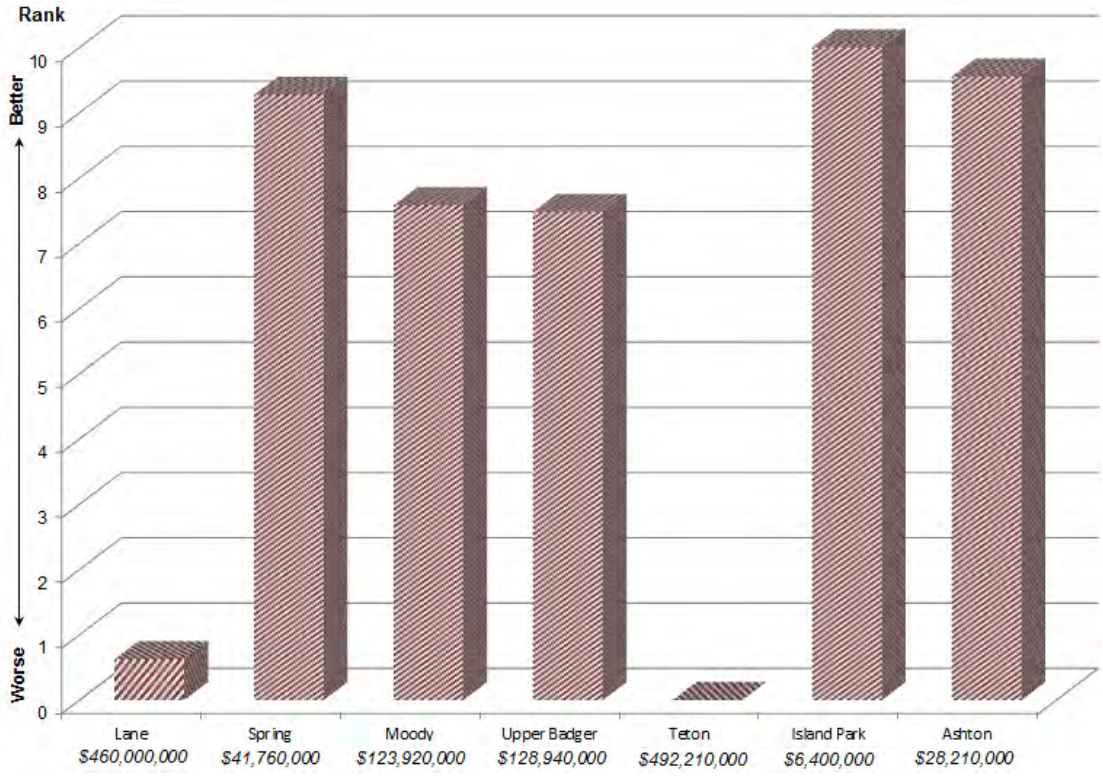

Figure 32. Estimated total construction costs for surface storage alternatives.

Estimated Costs per Acre-Foot

When viewed from the perspective of cost per acre-foot (Figure 33), a somewhat different picture is seen. While the Lane Lake Dam alternative is still the most expensive alternative at $4,600 per acre-foot, the difference between it and other new reservoir alternatives is not as severe and the relatively high cost of developing this new surface storage alternative is

illustrated. Specifically, the cost per acre-foot for the Spring Creek Dam alternative would be $3,900; for the Moody Creek Dam alternative, the cost would be $3,600 per acre-foot; for the Badger Creek Dam alternative, the cost per acre-foot would be $2,700, and for the Teton Dam alternative, the cost would be over $1,900. The enlargement of the existing reservoirs, especially Island Park Dam at $240 per acre-foot, shows a clear cost advantage over the new reservoir site alternatives.

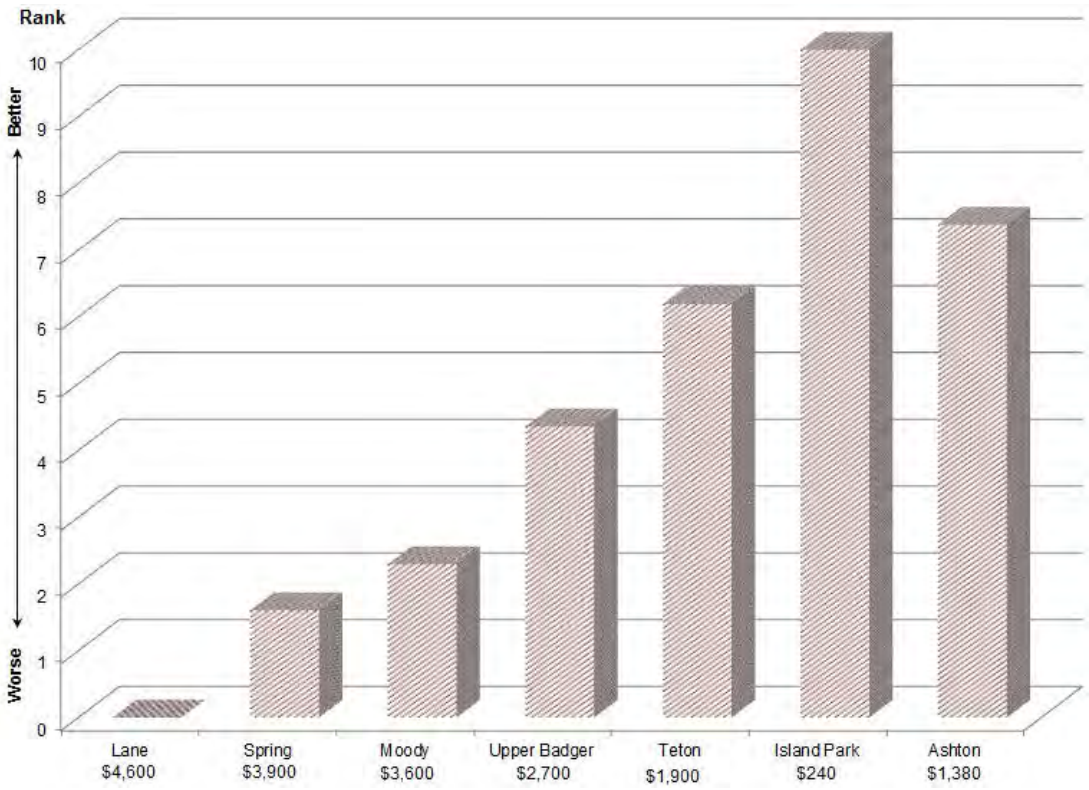

Figure 33. Estimated cost per acre-foot for all surface storage alternatives.

Composite Estimated Costs Comparison

When the total development cost and the cost per acre-foot perspectives are looked at together, the high costs of the Lane Lake and Teton Dam alternatives stand out when compared to all other alternatives. Also, the expansion of the existing reservoirs can be accomplished at the lowest relative cost with expansion of Island Park Reservoir representing the most cost-efficient option. The costs of the other three new reservoir options (Spring Creek, Moody Creek, and Upper Badger Creek dam alternatives) are similar, both substantially better than Lane Lake and Teton Dam alternatives, and considerably less cost-effective than the existing reservoir locations.

6.1.3 Environmental Impacts

Biophysical Impacts

Biophysical factors used to measure potential impact and compare alternatives are listed in Table 12. These are the factors that were considered most important in determining the potential acceptability of alternative surface storage sites. As shown in Table 12, surface storage alternative sites were rated on a scale of 1 to 3 for each of these factors, with a rating of 1 representing a high level of adverse impact and a rating of 3 representing a range from a low level of adverse impact to a beneficial effect. The resources that would be adversely affected by each alternative are shown with scores of 1 or 2 on the table.

Table 12. Biophysical resources impact evaluation. Ratings are based on probable impacts: 1 = high level of adverse impact; 2 = moderate adverse impact; and 3 = low/no adverse impact and/or potential for beneficial environmental effects (Appendix B of Reclamation 2013a).

Biological Resources	Lane Lake	Spring Creek	Moody Creek	Upper Badger Creek	Teton	Island Park Dam	Ashton Dam
Wildlife habitat – big game habitat	1	1	1	1	1	3	2
ESA-listed species	2	2	2	2	2	2	2
Wetland/Habitat value	3	3	3	2	1	3	2
State Species of Greatest Conservation Need – Yellowstone cutthroat trout present in affected streams	2	2	2	1	2	3	1
Special designation – ESA-eligible streams, State natural river, State recreational river, or designated wilderness	2	2	2	2	2	3	3
Stream connectivity	2	1	1	1	1	3	3

The results of the analysis shown in Table 12 were converted to a scale of 0 to 10 as explained above, with the results displayed in Figure 34. As illustrated on this figure, the surface storage alternative with the least biophysical resource impacts would be the Island Park Dam storage increase alternative. This alternative would have low or no impact in all but one biophysical resource category, with a moderate impact rating related to ESA-listed species. The highest level of impact is associated with the Upper Badger Creek and Teton dam alternatives. The Upper Badger Creek Dam alternative would have a high level of impact to upland large game, Yellowstone cutthroat trout and stream conductivity; and a moderate impact rating in all other categories. The Teton Dam alternative would have a high level of

impact on upland large game, wetland habitats and stream conductivity; and a moderate level of impact in all other categories. The other alternatives receive relatively low to moderate scores, but vary in the resources affected, as shown in Table 12.

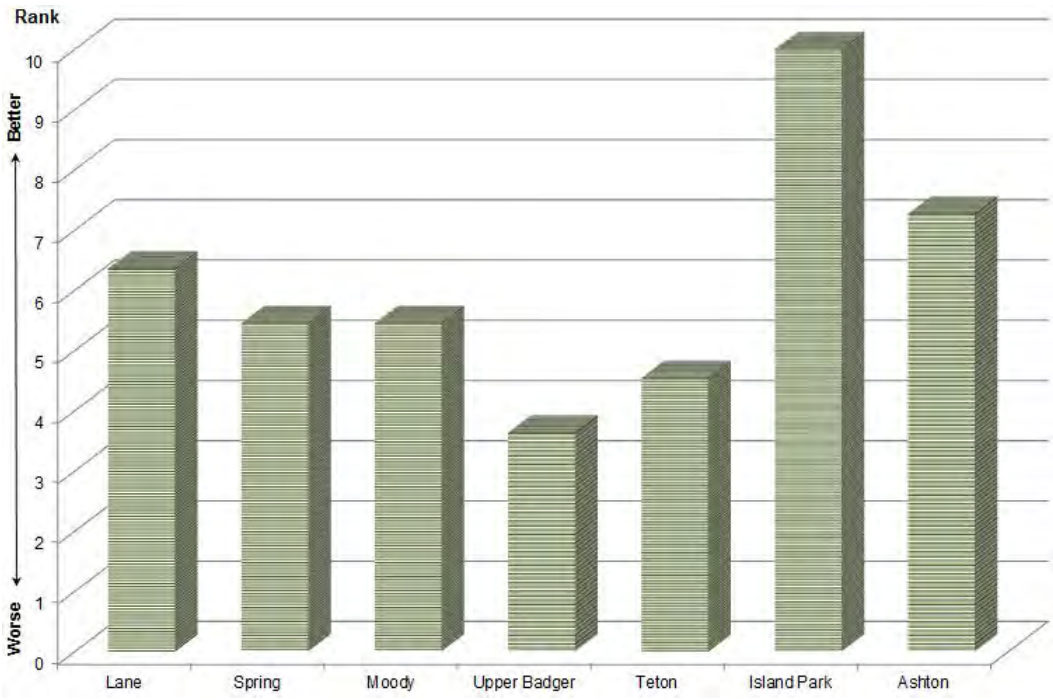

Figure 34. Biophysical environmental impacts of the surface storage alternatives.

Sociocultural Effects

Sociocultural factors used to measure potential impact and compare alternatives are listed in Table 13. As with biophysical resources, alternative surface storage sites were rated on a scale of 1 to 3 for each of the evaluation factors shown. The resources that would be adversely affected by each alternative are shown in Table 13.

Table 13. Sociocultural resources impact evaluation for the surface storage alternatives. Ratings are based on probable impacts: 1 = high level of adverse impact; 2 = moderate adverse impact; and 3 = low/no adverse impact and/or potential for beneficial effects (Appendix B of Reclamation 2013a).

Biological Resources	Lane Lake	Spring Creek	Moody Creek	Upper Badger Creek	Teton	Island Park Dam	Ashton Dam
Land Management – land ownership or special designation	3	2	3	2	1	3	1
Recreation/Economic value – potential for significant adverse impact to high-value resources	3	2	3	3	1	3	1
Developed land use/infrastructure – relative value and potential for significant adverse impact	3	3	3	3	3	3	1

As with other evaluation categories, the results of the analysis shown in Table 13 were converted to a scale of 0 to 10, with 10 being the best (least impact among the alternatives). As shown in Figure 35, the alternatives with the least sociocultural impacts in this analysis would be Lane Lake, Moody Creek Dam, and the Island Park raise alternatives, each with low or no impact in any sociocultural resource category. The highest levels of impact (lowest scores) would be associated with the Ashton Dam raise and Teton Dam alternatives. Impacts with the Ashton Dam raise alternative would be high from the standpoints of land management, recreation/economic value, and developed land use/infrastructure. With the Teton Dam alternative, impacts would be high related to land management and recreation/economic value, and would be low related to developed land use/infrastructure.

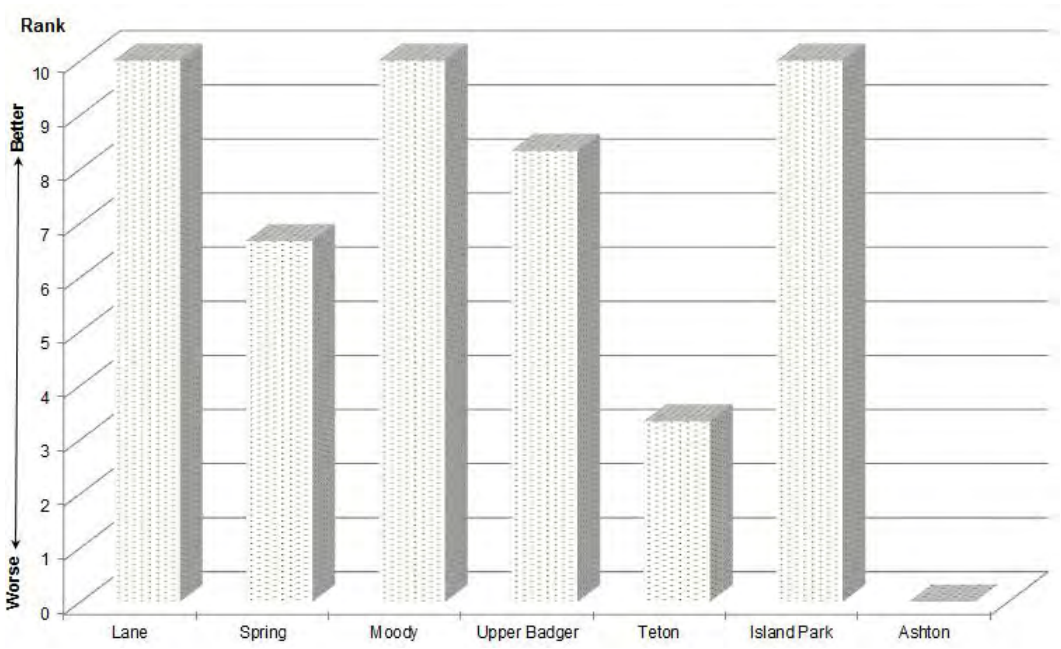

Figure 35. Sociocultural environmental impacts of the surface storage alternatives.

Summary Environmental Impact Comparison Observations

Overall, if both biophysical and sociocultural impacts are looked at together, the Island Park alternative would rank the highest by a relatively high margin. The next-highest ranked alternatives would be Lane Lake and Moody Creek because of their relative absence of sociocultural impacts despite rating relatively low for biophysical impacts. The lowest ranking alternatives would be Ashton Dam raise and Teton Dam. In the case of the Ashton Dam raise alternative, the major reason for the low overall environmental rating would be its high levels of impact in all sociocultural evaluation factors, as described previously. Related to the Teton Dam alternative, a low rating is due to the relatively high levels of adverse impact in both biophysical and sociocultural categories.

6.1.4 Viewpoints of Involved Agencies and Stakeholders

This perspective represents a consolidated review and assessment of input received from both involved agencies and stakeholders through the planning process. Much of this input is summarized in the discussions of each alternative in Section 5.0. After considering all the evaluation factors for each alternative, study participants were able to determine those storage alternatives they can support for further study and evaluation. Conversely, clear indications have been provided regarding alternatives that either do not have broad support (including agency support) or would be actively opposed by participating stakeholder groups. Figure 36 illustrates a ranking of the alternatives based on the input received.

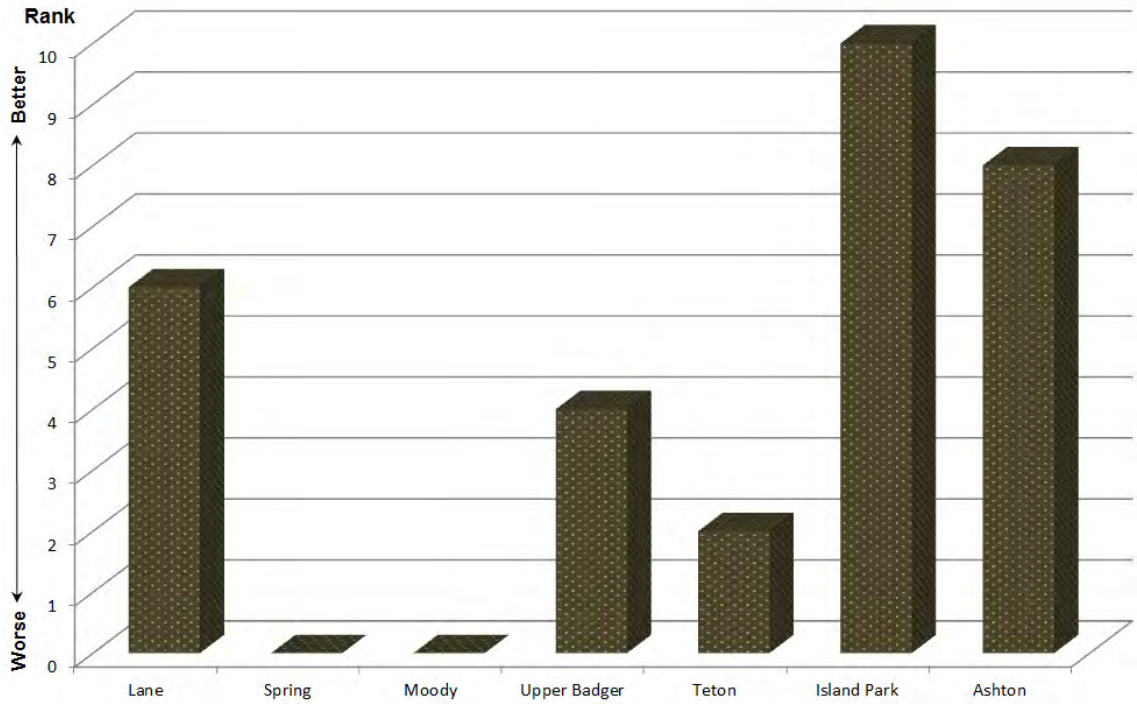

Figure 36. Relative ranking of storage alternatives based on the viewpoints of agencies and stakeholders.

The Island Park Dam storage increase alternative on the Henrys Fork River drainage appears to have the highest degree of acceptance and support by irrigators, conservation groups, and State water managers. Because Island Park Dam is a Federal facility, there is a clear Federal nexus associated with this alternative and future Federal involvement in the planning processes would be necessary. IWRB water managers and water users consider this to be a high State priority and are interested moving forward on this alternative in the near future.

Ashton Dam raise also appears to have a certain degree of acceptance by the irrigators, conservation groups, and State water managers for further study; however, the willingness of the private dam owners to raise Ashton Dam has not yet been explored. IWRB water managers place interest in further evaluating Ashton Dam raise behind/below State interests in moving forward on Island Park Dam, and consider this something to be pursued in future decades if necessary. The Ashton Dam status as a privately owned dam eliminates any Federal nexus by Reclamation, but future Federal involvement in studies would be necessary because Ashton Dam is part of a hydropower plant licensed by FERC.

Water storage alternatives in the Teton River drainage have received mixed support. Conservation groups cautiously support further study of Lane Lake while water users and State water managers consider this alternative an option for long-term consideration in the next quarter century.

State water managers and irrigators would also like to keep their long-range options open to include future studies on Teton River or Upper Badger Creek. These are two on-stream reservoir alternatives the conservation groups have clearly stated they would not support.

The two smaller potential reservoirs in the Teton River drainage, Spring Creek and Moody Creek, do not appear to have support from any of the stakeholders.

6.2 Managed Groundwater Recharge Alternative

6.2.1 Egin Lake Expansion

Benefits

Expansion of the Egin Lakes recharge program would enhance the in-basin water budget by annually recharging an additional 2,500 to 5,000 acre-feet (7,500 to 10,000 acre-feet total), depending on the alternative. At the end of the 20-year period that was examined, approximately 22 percent of the water recharged would be expected to be stored in the ESPA, helping satisfy unmet irrigation demands in the Egin Bench irrigated region. The remaining volume would be discharged to the Henrys Fork River, which has been identified as having additional ecological streamflow needs. The increase in instream flow is predicted to be from 1.6 to 3.2 cfs in the Ashton to Rexburg reach, depending on the recharge volume considered. However, these results must be evaluated in light of the State's goals of stabilization and recovery of the ESPA.

Estimated Implementation Costs

The estimated construction costs for increasing the capacity the recharge facilities, including necessary canal improvements, is $10,063,567 ($4,000 per acre-foot) for 2,500 acre-foot and $13,617,795 ($2,700 per acre-foot) for a 5,000 acre-foot enlargement.

Environmental Impacts

Expanding recharge volume at the Egin Lake site would have few, if any, significant adverse environmental impact and may have beneficial impacts on streamflow (especially temperature) below the St. Anthony gage. The potentially adverse consequences would be in direct effects on a priority rainbow trout fishery in the Henrys Fork River, the entrainment of trout in new diversions, and reduced flows. Diversion structures could be designed with fish screens to prevent entrainment and flows would need to be managed with consideration to fisheries needs.

6.3 Water Marketing

The water marketing alternative does not lend itself to the kind of comparative analysis provided above for surface and groundwater storage options, but it is common to all of the alternatives put forward in Section 5.0. Water markets (water banks, rental pools) do not increase the water supply in a region or watershed such as the Henrys Fork River basin; instead, they provide a means of managing available water supplies. They are used to maximize the economic and/or environmental value of water by exchanging water rights that would have otherwise been unused and/or forfeited and minimize the economic and/or environmental consequences of water shortages. Typically water marketing involves a voluntary water transfer agreement for a temporary or permanent change in the type, time, or place of use of water and/or a water right (see Section 5.4 for details).

These water management tools are already in use in parts of the Henrys Fork River basin, and can be expected to expand over time, especially in light of the predictions for climate change. In fact, the Water Transaction Program in the Teton River basin would be the only alternative analyzed capable of addressing stream connectivity and Yellowstone cutthroat trout issues in the basin. Other such programs would undoubtedly be part of the long-term water management program in the basin.

6.4 Conservation Alternatives

The alternatives discussed in this section do not lend themselves to the kind of comparative analysis provided above for surface storage alternatives. Instead, each was discussed individually with available indications of water volume, cost, and environmental effects addressed to the extent information is available. In each case, more information is provided in the corresponding sections of Section 5.5.

6.4.1 Canal Automation

Benefits

Automated canals allow irrigators to match diversions with irrigation requirements and reduce the demand for water, particularly late-season storage withdrawals, especially given the effects of projected climate changes. These benefits could have a significant value in the Henrys Fork River basin.

Installation of automated gates at the nine principal stream diversion points in the basin would conserve approximately 1,687 acre-feet annually. Among the nine diversion points, individual water savings from gate installation would range from 333 to 92 acre-feet.

Estimated Implementation Costs

The total cost of gate installation at all nine principal stream diversion points is estimated to be $1,588,000, with individual location/facility costs ranging from approximately $68,000 to $262,000. The average cost per acre-foot would be $941, with individual location costs ranging from $491 to $2,843 per acre-foot.

Environmental Impacts

Overall, automated canals would reduce the demand for stored water withdrawal which would improve management options in both the Henrys Fork River basin and the ESPA.

For all four of the irrigated regions in the Henrys Fork River basin, canal automation would increase both total annual and peak flow volumes and would have a positive impact on the basin's overall water budget. For the North Fremont region, canal automation would increase nonpeak flows by approximately 2 percent. While this increase is relatively small, it would still represent a positive effect during periods of normally low flows. For the Teton Valley, Lower Watershed, and Egin Bench regions, canal automation would decrease nonpeak flows and thus would have a negative environmental impact.

6.4.2 Canal Piping

The installation of pipelines in irrigation canals to limit water loss due to canal seepage has been shown to be of practical benefit only in the North Fremont irrigated region. Irrigators in this region have installed several gravity pressurized pipeline systems which have (1) increased total annual flows, peak flows, and nonpeak flows, (2) reduced the demand for Fall River flows (both natural and stored water), and (3) saved significant amounts of energy. Overall, the pipelines and canal linings installed to date have reduced withdrawal from upstream storage by approximately 10,000 acre-feet in the past 10 years, an average of 1,000 acre-feet per year. These reductions in withdrawals from Island Park Reservoir would help mitigate the expected increase in late season demands on storage throughout the Henrys Fork River basin due to climate change. Current proposed projects were estimated to cost $10 million. The total volume of water to be conserved in this next program increment was not determined for this report.

Because of the interconnection between groundwater and surface water, pipelines in canals in the other irrigated regions (Teton Valley, Lower Watershed, and Egin Bench) would reduce later summer return flows to the Henrys Fork or Teton rivers and result in a negative environmental impact.

6.4.3 Agricultural Demand Reduction

Agricultural demand reduction, as a means of managing local water supply and meeting State needs, means reducing the number of irrigated acres or changing farming practices to use less water. There are active State programs pursuing each of these strategies; for example, one State program provides financial assistance for irrigated-to-dryland crop conversions. Another program, focused more on groundwater restoration, promotes conversions of cropland from groundwater to surface water sources.

Though specific data related to these programs within the Henrys Fork River basin was not gathered for this study, the programs are active in the basin and would be part of any water management strategy in the future. The cost for converting irrigated cropland to dryland farming or simply ceasing irrigation was estimated to be $1,860 per acre, while the estimate for such an approach as deficit irrigation, meaning the acre would be partially irrigated (e.g., irrigation may be stopped only after the second cutting of alfalfa hay), was $3,600 per acre.

From an environmental standpoint, reducing or stopping irrigation would have different consequences in different parts of the overall Henrys Fork River basin. In the North Fremont, Egin Bench, and Upper Teton Valley irrigated regions, reduced irrigation would generally have positive environmental effects focused on increases in nonpeak streamflows. However, in the Teton Valley and Lower Watershed, adverse impacts would be expected due to a decrease in nonpeak flows, with the degree of adverse impact varying dependent upon the percentage reduction in irrigation.

7.0 Conclusions and Next Steps

The findings of this study make it clear that a meaningful contribution to meeting the existing and future water supply needs of the Henrys Fork Basin, as well as such high state priorities as the ESPA, cannot be made by any single action. Rather, it is clear that success in meeting these needs must be built through an integrated program of actions. Grouping of alternatives into one or more integrated packages is likely to be necessary in order to meet the broadest set of needs.

However, groups of projects would involve discussions of the likelihood and risk of funding and developing the facilities; the viability of proposed combination(s); and the environmental, fisheries, and ESPA components to assure that all three needs are addressed. Even when implementation details are finalized, more rigorous analyses would be necessary before progressing with the project or group of projects. In the end, IWRB will decide what actions it can take to address the challenges and how it will move forward to resolve the remaining issues of funding and implementation.

Public acceptability would likely mean compromises on all sides and finding a balance that all participants could support could be a challenging process. Maximizing the benefits for all categories of need is likely not realistic so some of the total potential water supply needs may have to be ceded to accommodate the agricultural, environmental, and fisheries needs.

Once public acceptability is achieved, obtaining sufficient funding can be particularly challenging. Depending on the total cost of the package, IWRB could move forward with funding on its own, seek partnerships with local entities, or seek the assistance of the Federal government in funding the projects; however, State and Federal funding are getting increasingly difficult to secure. A number of funding sources will likely be required to implement any package.

Resolving any inherent legal problems, like existing ownership of land and facilities, obtaining rights-of-way or easements, and the needed legal framework, could be a daunting process. In addition, if project implementation were to trigger litigation, then the legal entanglements become more complex and deplete funding that would have otherwise been available for project implementation.

Should a Federal nexus exist in any implementation package (more than likely some nexus will exist), then compliance with the NEPA, ESA, National Historic Preservation Act, and other Federal statutes has historically been time consuming and costly. Issues with potential new ESA listings and designations of Wild and Scenic Rivers in the Basin Study area could significantly complicate implementation efforts.

In completing the efforts of the Basin Study, IWRB and Reclamation agreed to utilize a two-document approach. This Final Report contains the technical information and the discussions of the Basin Study. A companion document will be produced by the IWRB in collaboration with the Workgroup and Reclamation to document IWRB's decisions regarding the path forward in future actions in the Henrys Fork River basin; the recommendations and prioritization for which alternatives to pursue; and the sequence of steps for the recommended alternatives or group of alternatives. The Path Forward document will be submitted to the Governor and the Legislature to comply with the State Senate Bill 1511 and inform those officials of the recommendations and prioritization of alternatives, the investments in water management infrastructure most advantageous to the State, and seek further financial support to help implement alternatives.

A Path Forward document does not preclude any member of the Workgroup from independently developing its own vision for a path forward. Since the Basin Study presents an array of alternatives, any person or group, private or public, may seek to move an alternative(s) forward as they deem appropriate.

8.0 Documents Completed During the Basin Study

Table 14 shows the reports that were produced by Reclamation, IWRB, and CH2MHILL (Reclamation contractor) during the course of the Basin Study.[14]

Table 14. List of reports produced during the course of the Henrys Fork Basin Study.

Report Name	Author(s)	Date of Release
Henrys Fork Watershed Basin Study, Water Needs Assessment, Technical Series No. PN-HFS-001	Reclamation	October 2012
Henrys Fork Basin Study, New Surface Storage Alternatives, Technical Series No. PN-HFS-002	CH2MHill	November 2012
Henrys Fork Basin Study, Dam Raise Alternatives, Technical Series No. PN-HFS-003	CH2MHill	November 2012
Henrys Fork Basin Study, Managed Recharge Alternatives, Technical Series No. PN-HFS-004	CH2MHill	November 2012
Henrys Fork Basin Study, Teton Dam Storage Alternative, Technical Series No. PN-HFS-005	Reclamation	October 2012
Henrys Fork Basin Study, Conservation Alternatives, Technical Series Report No. PN-HFS-006	Reclamation	October 2012
Henrys Fork Basin Study, Municipal Water Conservation Measures and New Non-potable Water Supply Options, Technical Series PN-HFS-007	CH2MHill	November 2012
Henrys Fork Basin Study, Preliminary Water Market Analysis, Technical Series PN-HFS-008	CH2MHill	November 2012
Henrys Fork Basin Special Study, Interim Report	Reclamation and State of Idaho	July 2013
Addendum to Henrys Fork Basin Study, New Surface Storage Alternatives, Technical Series No. PN-HFS-002	CH2MHill	February 2014
Technical Memorandum, MODSIM modeling of Henrys Fork basin alternatives	Reclamation	September 2013
Technical Memorandum No. ISL-8130-FEA-2013-1- Island Park Dam Flood Routing for Service Spillway Raise	Reclamation	September 2013

[14] These reports may be accessed from Reclamation's web site at http://www.usbr.gov/pn/programs/studies/idaho/henrysfork/techrept/index.html.

9.0 LITERATURE CITED

Parenthetical Reference	Bibliographic Citation
Bayrd 2006	Bayrd, G. 2006. *The Influences of Geology and Water Management on Hydrology and Fluvial Geomorphology in the Henry's Fork of the Snake River, Eastern Idaho and Western Wyoming*. A master's thesis at Idaho State University. 2006.
BLM 2009	Bureau of Land Management. 2009. Wild and Scenic River Eligibility Report. U.S> Department of the Interior, Bureau of Land Management, Upper Snake Field Office, Idaho Falls, Idaho. March 2009.
Census 2011	U.S. Census Bureau. http://quickfacts.census.gov/qfd/states/16000.html. Site visited on February 18, 2011.
CH2MHILL 2012	CH2MHILL. 2012. *Henrys Fork Basin Study New Surface Storage Alternatives Technical Series No. PN-HFS-02*. Prepared for the Bureau of Reclamation, Idaho Water Resource Board, and Henrys Fork Watershed Council. November 2012.
CH2MHILL 2013	CH2MHILL. 2013. Draft *Henrys Fork Basin Study New Surface Storage Alternatives, Addendum to Technical Series No. PN-HFS-02*. Prepared for the Bureau of Reclamation, Idaho Water Resource Board, and Henrys Fork Watershed Council. November 2013.
DeRito 2012	DeRito, J. 2012. Presentation at the Henry's Fork Watershed Council 2011 Annual Watershed Conference. "Yellowstone Cutthroat Trout Status for the Henry's Fork, Teton, and Sinks Drainages." November 29, 2011. http://www.henrysfork.org/shared/hff/files/HFWC%20Nov%2029%202011%20mtg%20notes%20FINAL.pdf accessed on June 21, 2012.
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