Appendix C

Managed Recharge Alternatives, No. PN-HFS-004

Technical Memorandum

Henrys Fork Basin Study

Managed Recharge Alternatives

Technical Series No. PN-HFS-004

Prepared by

CH2MHILL®

For

Bureau of Reclamation, Idaho Water Resource Board, and Henrys Fork Watershed Council

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Part I – Introduction and Methodology

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SECTION 1

Alternatives Introduction

1.1 Alternatives Overview

A brief summary of each managed recharge alternative is provided in the sections that follow, with recharge locations depicted in Exhibit 1-1. More detailed descriptions of each alternative and a list of its sub-alternatives are provided in the alternative-specific chapters later in this report.

1.2 Expansion of Managed Recharge in Egin Basin

Expansion of Managed Recharge in Egin Basin is an alternative that increases annual water deliveries to Egin Lakes for recharge from approximately 5,000 acre-feet (af) currently to either 7,500 af or 10,000 af, an increase of 50 or 100 percent. Egin Lakes is located approximately 10 miles west of St. Anthony at the terminus of the Egin Recharge Canal. The Egin Recharge Canal capacity would be expanded to pass the increased design flows.

1.3 Development of New Recharge Facilities in the Lower Teton Basin

This alternative entails identification of one or more promising new recharge locations in the Lower Teton Basin, selection of a preferred site for development of new recharge facilities, selection of an alignment for a new canal to convey recharge water diverted from the Teton River, and design and construction of both recharge facilities and the canal. A tentative site for recharge facilities has been identified near Sugar City between the Teton and South Fork Teton Rivers. This site, hereafter referred to as the Teton Island Recharge Site, was identified because of its potential to enhance ecological flows in adjacent river reaches. For comparison purposes, the Teton Island Recharge Site and a representative water-delivery canal alignment were selected to represent the range of possible choices for a new recharge facility in the lower Teton Basin. Three sub-alternatives consisting of different annual recharge quantities (5,000 af; 7,500 af; and 10,000 af) were evaluated.

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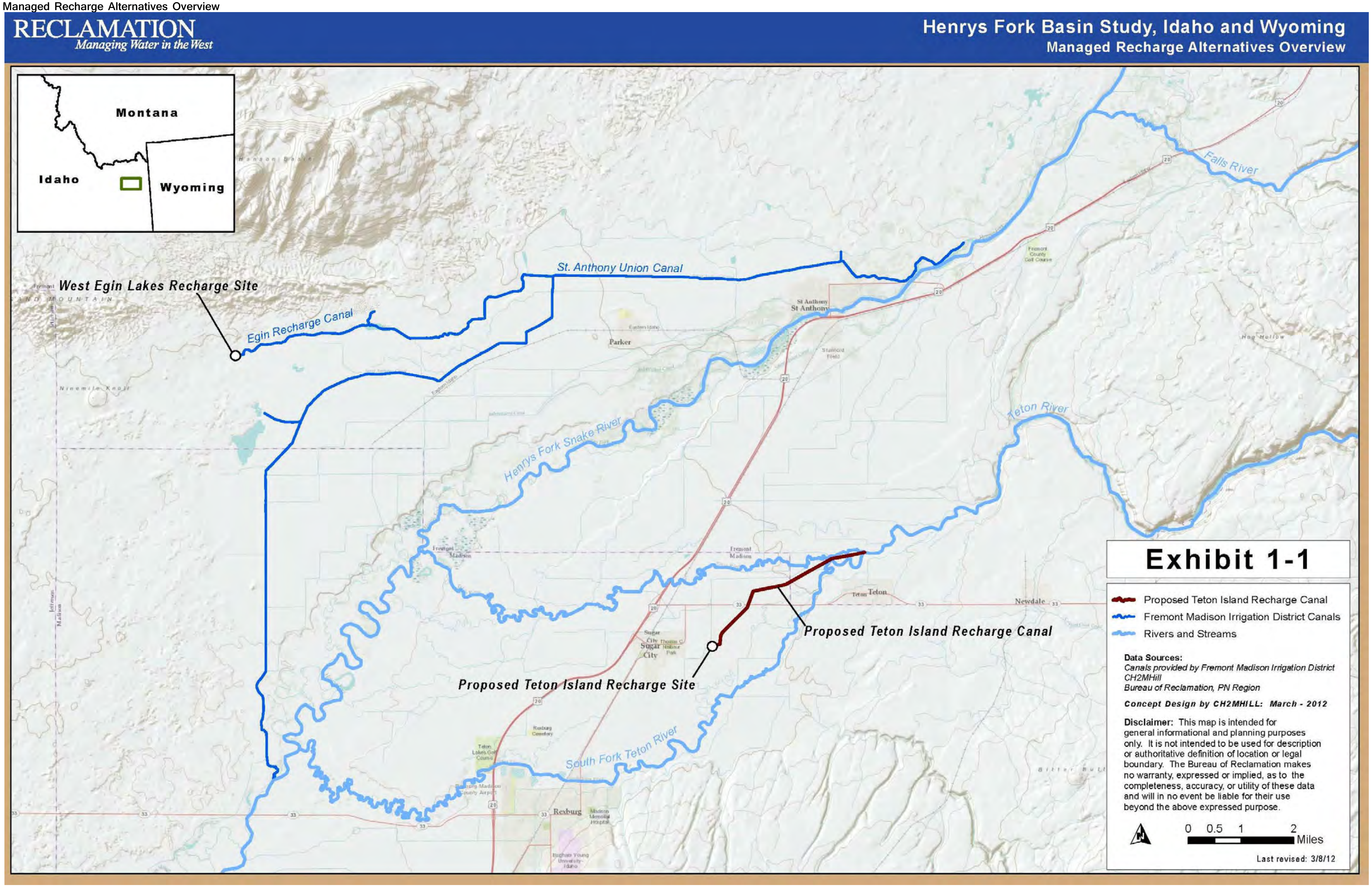
EXHIBIT 1-1
Managed Recharge Alternatives Overview



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SECTION 2

Evaluation Approaches, Assumptions, and Limitations

2.1 Overview

This chapter describes the approaches, assumptions, limitations, and data used in the reconnaissance-level evaluations. The methodology described here is applicable to each alternative, except as noted in the alternative-specific chapters in Part II of this report.

2.2 Engineering Approaches

2.2.1 Recharge Modeling

2.2.1.1 Current Model

Impacts of recharge at the West Egin Lakes and Teton Island Recharge Sites were predicted using the Eastern Snake Plain Aquifer Model, Version 1.1 (ESPAM1.1) in superposition mode, which operates on the assumption that, for a strictly linear system, a complex problem can be decomposed into more simple sub-problems (Sukow, 2012). The sum of the solutions of the sub-problems will be the same as the solution to the whole, more complex problem (Contor et al., 2006). ESPAM1.1 is a calibrated groundwater model used by the Idaho Department of Water Resources (IDWR) to determine the effects of aquifer stresses, including managed recharge projects, on the Eastern Snake Plain Aquifer (ESPA) and hydraulically-connected reaches of the Snake River.

Development of the ESPA model began in 1999 and was funded as a joint effort between the State of Idaho, Idaho Power, the Bureau of Reclamation, and the U.S. Geological Survey. Model development was overseen by the Eastern Snake Hydrologic Modeling Committee (ESHMC), a collection of scientists and engineers representing the above-identified agencies and private water user groups. Model construction and execution were accomplished by the Idaho Water Resources Research Institute (IWRRI) at the University of Idaho. Major design alternatives were presented to ESHMC members for discussion and guidance. The model development was accomplished in an open environment, with acceptance of design input from all committee members, in an attempt to allay concerns regarding technical bias.

Calibration of ESPAM1.1 was completed in 2005. The model was calibrated using data from a 22-year period of record from the spring of 1980 to the spring of 2002, and the calibration period was divided into 6-month stress periods (stress periods are time increments which can have different stresses like inputs or withdrawals applied to the model). The model was calibrated to approximately 11,000 observations of aquifer water level and river gain/loss.

As with any model of a complex physical system, the ESPAM has limitations and uncertainties. The ESPAM is a regional-scale model and is best used for prediction of impacts to the ESPA and surface water resources at a regional scale due to groundwater use or recharge. Additionally, some of the water budget elements and measured observations are known with greater certainty than others.

A primary objective of model development and calibration was to characterize interactions between the ESPA and the Snake River (including the lower Henrys Fork). Snake River and Henrys Fork gain/loss observations used in model calibration included five river reaches upstream of Minidoka. The river reaches include Ashton to Rexburg, Heise to Shelley, Shelley to near Blackfoot, near Blackfoot to Neeley, and Neeley to Minidoka. Because of the locations of the West Egin Lakes and Lower Teton recharge sites, the benefits of the modeled recharge accrue primarily to the Ashton to Rexburg and Heise to Shelley reaches. Direct interaction between the aquifer and surface flows in the Teton River is neglected in the regional-scale ESPA model.

ESPAM1.1 was also used in a recently completed independent study by IWRRI on behalf of the Idaho Water Resource Board, *Prioritization of Aquifer Recharge Sites Based on Hydrologic Benefits* (Johnson, 2012). The study was intended to identify priority recharge sites across the ESPA, including Egin Lakes and East and West sides of Fremont-Madison Irrigation District (FMID) service area (the proposed Teton Island Recharge Site is contained in the East side).

2.2.1.2 Future Model

ESPAM2.0 is currently being developed by IDWR in cooperation with the ESHMC. ESPAM2.0 will implement numerous improvements to ESPAM1.1 including extension of the model calibration period to October 2008, use of one-month stress periods, improved calibration targets incorporating additional spring discharge and return flow data, refinement of water budget parameters, and other improvements. ESPAM2.0 will use the same delineation of river reaches for the Ashton to Rexburg and Heise to Shelley reaches, which are the primary reaches of interest in model simulations of recharge at the West Egin Lakes and Teton Island Recharge Sites. ESPAM2.0 is expected to produce different results than ESPAM1.1 because of changes in calibrated model parameters such as transmissivity, storativity, and riverbed conductance. However, results are not expected to be significantly different in the vicinity of the Henrys Fork. A final calibration of ESPAM2.0 is not yet available, but could be included during a future phase of this study.

2.2.2 Conveyance

2.2.2.1 Canal Dimensions

Dimensions for an expanded Egin Recharge Canal and the new Teton Island Recharge Canal were evaluated with the Bentley FlowMaster, Version 8i (FlowMaster) software package, which uses Manning's equation to perform flow calculations. Required input parameters included cross-sectional dimensions, longitudinal slope, and channel roughness (Manning's "n"). Detailed survey data were lacking for both recharge alternatives, so elevations were extracted from Google Earth and corresponding slopes were calculated based on measured lengths. Canal parameters for capacity iterations were generally in accordance with Reclamation's Canal Design Flowchart (Reclamation, 2010).

2.2.2.2 Existing Features

For the West Egin Lakes alternative, capacity of the existing Egin Recharge Canal was estimated based on cross-sectional dimensions provided by FMID for three representative locations:

- Approximately 0.5 miles below the St. Anthony Union Canal diversion.
- Approximately 1 mile above the Egin Lakes recharge site.
- Immediately before the recharge site.

2.2.2.3 New Features

For the Teton Island alternative, GIS-based aerial photographs and topographic maps were used to establish a new, approximate canal route from the split between the Teton River and South Fork Teton River to the proposed recharge site. The canal route was laid out in GIS to confirm gravity flow at a modest slope; however, the selected route is conceptual to provide a basis for relative cost comparison, and is not a specific proposal for design.

For the Lower Teton alternative, it was assumed that water supply would be collected via a new stream diversion structure and an intake structure with fish screens.

2.3 Cost Estimation

2.3.1 Purpose

Relative construction costs were developed for the managed recharge alternatives for the sake of comparison. The costs are relative costs only, and should not be used for budget planning. Detailed site-specific design information has not been developed; therefore, the costs are based on high-level assumptions that may be significantly modified if design progresses. As such, the costs are intended to represent relative scaled costs using a limited number of factors, and are intended only for the purpose of differentiating one alternative from another to help screen alternatives prior to detailed analysis.

2.3.2 Excluded Costs and Benefits

The Total Relative Construction Cost is not intended to represent all costs for the project, and therefore may be misleading if used as the sole basis for comparing relative costs by alternative. Some of the known costs that have been excluded include the following:

- Land acquisition and easements
- Lifecycle costs for operation, maintenance, and replacement
- Impacts to wildlife and migration corridors
- Extraordinary permitting costs
- Impacts to existing infrastructure, including utilities and roads
- Litigation
- Delay due to approval challenges
- Acquisition or negotiation of water rights or exchange rights
- Cost of water, since it cannot be reliably differentiated by alternative without a detailed analysis of water rights, lease costs, water rates, and other factors for each proposed water source and water delivery destination
- Pumping costs to withdraw recharged groundwater from the aquifer for use by irrigators

Conversely, this cost estimate does not include potential project benefits. Some of the known potential benefits for some alternatives may include:

- Water supply
- Supplemental fish flows

2.3.3 Approach

A cost spreadsheet was developed to calculate relative, representative system costs for each canal delivery system, broken out by the following major system components: stream diversion and intake, canals, and bridge improvements. In general, cost calculations were based on physical or operational data that could be readily measured, assumed, or calculated in a consistent manner without performing site-specific design. The basis of cost for each system component is described in the sections that follow.

2.3.4 Cost Basis

2.3.4.1 Design Flow

Multiple cost items were based on the design flow for each canal. Examples of flow-dependent system components include intakes with fish screens and canals.

Both alternatives assumed that recharge would occur once annually for a 60-day duration. Three recharge scenarios were considered for each alternative by varying the total recharge delivery (5,000; 7,500; and 10,000 af). To convert those recharge quantities into design flow rates for the canals, the quantity was initially assumed to be delivered uniformly over the 60 day recharge period. For example, 5,000 af delivered uniformly over 60 days would translate into a uniform flow rate of approximately 42 cubic feet per second (cfs). Next, recognizing that in any given year excess water might not be available in the river over the entire 60 day period, a peaking factor of 1.5 was applied to each flow rate. This peaking factor effectively increases the required canal capacity by 150 percent to enable conveyance of larger quantities of water over a shorter period. The resulting design flow rates for each recharge scenario (applicable to both alternatives) are listed below:

- 5,000 af = 65 cfs
- 7,500 af = 100 cfs
- 10,000 af =130 cfs

It is important to note that the recharge quantities described above were modeled as recharge through a single model cell at the intended recharge site; however, during actual field delivery and application, some portion of that quantity would be lost as seepage through the canal system.

2.3.4.2 Stream Diversion and Intake

For the proposed new Teton Island Recharge Canal, it was assumed that water would be collected via a stream diversion structure and an intake structures with fish screens. Accurate costs for these items are heavily dependent on site-specific factors that were not available for this study, including precise location of the intake; local bathymetric and hydraulic data; operational criteria; geotechnical conditions; minimum and maximum inflow design floods; and other factors.

To develop relative costs based on the data that was available, diversion and intake costs were set proportional to the design inflow rate. As a rule of thumb based on numerous projects, smaller-size intakes with fish screens run about $1,500 per cfs of flow. These costs generally increase as flow rates increase within the range considered for this study. To improve the ability to differentiate alternatives, two break points (125 cfs and 200 cfs, corresponding to the 33^{rd} percentile and 66^{th} percentile inflow rates for surface storage alternatives, respectively) were selected to divide alternative flows into three ranges. Analogous to a graduated income tax, a different unit cost ($1,500/cfs, $2,000/cfs, $2,500/cfs) was assigned to each of the three ranges, with incremental flow accruing costs within its range. Although the cost range is representative, the specific break points were selected primarily to differentiate the alternatives.

Diversion costs are more difficult to predict because they are highly dependent on local stream conditions. However, without site-specific data and detailed hydrologic and hydraulic analyses, diversion rates were used as a surrogate metric. In general, diversion costs were expected to fall within the same general range as intake costs, but with a reversed trend of declining cost per cfs as the flow rate increases; therefore, the same break points (125 cfs and 200 cfs) were selected, but unit costs were applied in reverse order ($2,500/cfs, $2,000/cfs, $1,500/cfs).

2.3.4.3 Canals

Approximate canal routes were laid out in GIS to confirm gravity flow at a modest slope. Canal costs were based on six components, as summarized in Exhibit 2-1. Unit costs were selected as representative values for similar earthwork projects.

EXHIBIT 2-1
Canal Cost Components

Cost Component	Assumptions	Unit Costs
Liner Volume	No liner assumed for existing canal upgrades. For new canal, liner thickness and freeboard based on the Canal Design Flowchart (Reclamation, 2010).	$400 / CY
Excavation Volume	Channel side slope and velocity generalized to 1.5H:1V and 3.5 fps, respectively, based on the Canal Design Flowchart (Reclamation, 2010) ranges. Manning's n taken as 0.0225 for Crosscut Canal, 0.035 for earth channels, and 0.016 for concrete-lined canals. Depth and width were iterated to achieve the velocity target and minimize flow area. Depth was limited to existing depth for the Egin Recharge Canal (to limit velocity; may need to be refined depending on existing bridges). Added 2 feet above minimum freeboard for average constructed freeboard in the field. Slope was calculated from topographic maps and length of canals. Assumed a flat lateral hill slope for a simple trapezoidal cut shape volume. No over-excavation to accommodate liner thickness.	$8.00 / CY
Local Fill Volume	100% of excavated volume to fill uneven terrain and construct side embankments for freeboard allowance.	$8.00 / CY
Parallel Gravel Access Road	Width of road and one road or two based on the Canal Design Flowchart (Reclamation, 2010). Cost based on estimated material volumes and costs and previous projects.	$200,000 / mi / 20-ft width
Migration Crossings	Assume provide a concrete and earth cap on the canal every 0.5 miles for animal crossings, each 100-ft long and the width of the canal plus 5-ft abutments on each side. Unit cost based on an average concrete thickness of 2 feet. Unit price double that for the canal liner based on structural components and extensive earthwork and planting.	$5,926 / ft-width ($800 / CY)

2.3.5 Total Relative Construction Cost

Costs for the system components described in Section 2.3.4 – *Cost Basis* were summed to produce the Base Field Cost, which is the relative expected cost of listed field-based construction work. This figure is increased by 20% to account for unlisted construction items, and by 5% to account for mobilization. Together, the Base Field Cost, unlisted items, and mobilization sum to the Field Cost without Contingency. Adding a 30% contingency for uncertainty produces the Total Field Cost. Non-field costs (such as engineering, permitting, legal and administrative costs) are calculated as 30% of the Total Field Cost and were added to produce a relative Total Relative Construction Cost for comparing alternatives.

2.4 Basin Needs

Basin water needs are discussed in the *Draft Henrys Fork Watershed Basin Study Water Needs Assessment* (Reclamation, 2012). The ability of each alternative to meet basin water needs is discussed in the alternative-specific chapters later in this report.

2.5 Legal, Institutional, or Policy Constraints

There are many administrative considerations, both legal and institutional, that place restrictive limitations on water-related issues. All water rights in the Henrys Fork Basin and downstream would be fully protected and remain unchanged. Existing in-basin and out-of-basin water users would retain all their present water rights and entitlements without modifications. New water rights, if available, would be obtained from the State of Idaho and administered under Idaho State laws.

Local, state, and federal laws and policies must be considered when evaluating additional managed recharge in the Henrys Fork Basin. These include regulatory and administrative requirements related to surface and groundwater rights, property rights, public health and safety, environmental concerns, and resource conservation. The following subsections give a partial listing of Federal and State regulatory guidelines that may pertain to implementation of any of the proposed managed recharge alternatives identified in the Henrys Fork Basin Study.

2.5.1 Federal Laws and Executive Orders

Following is a partial listing of Federal laws and Executive Orders (EO) that may pertain to implementation of any of the proposed alternatives identified in the Henrys Fork Basin Study:

- Antiquities Act of 1906
- American Indian Religious Freedom Act of 1978
- Archaeological Resources Protection Act of 1979, as amended
- Archaeological and Historic Preservation Act of 1974
- Clean Air Act of 1970, as amended
- Endangered Species Act of 1973, amended in 1979, 1982, and 1988
- Executive Order 11988 - Floodplain Management
- Executive Order 11990 - Protection of Wetlands
- Executive Order 12875 - Enhancing the Intergovernmental Partnership
- Executive Order 12898 - Federal Actions to Address Environmental Justice
- Federal Land Policy and Management Act
- Federal Water Pollution Control Act (commonly referred to as the Clean Water Act)
- Fish and Wildlife Coordination Act of 1958, as amended
- Historic Sites Act of 1935
- National Environmental Policy Act of 1969
- National Historical Preservation Act of 1966, as amended
- Native American Graves Protection and Repatriation Act of 1990
- Noise Control Act of 1972, amended in 1978
- Occupational Safety and Health Administration

- Hazard Communication Standards
- Resource Conservation and Recovery Act
- Rivers and Harbors Act of 1899
- Safe Drinking Water Act, Title 28, Public Law 89-72, as amended
- Wild and Scenic Rivers Act (United States Code, Title 16, Chapter 28)

2.5.2 State Laws and Policy

"Artificial" or "managed recharge" in Idaho is considered to be artificial placement of water from a different source into a groundwater aquifer. In Idaho, managed recharge is distinguished from recharge resulting from infiltration of precipitation (natural recharge) or the unintentional placement of water into an aquifer from normal water deliveries for irrigation or other uses (incidental recharge). It is generally considered to be a large volume, low cost and passive process to help offset declines in the aquifer.

State regulatory and administrative processes should be considered in evaluating an expansion of the Egin Lakes managed recharge site. Some of the relevant laws and policies include the following:

- Idaho Water Resource Board Involvement with Recharge:
  - The Idaho Water Resource Board (IWRB) operates a Managed Aquifer Recharge Program (MARP) which has evolved over several years. The IWRB's MARP was established legislatively in order to provide a mechanism to evaluate and support the development of new recharge projects with the potential to provide basin-wide and localized benefits. It was implemented in the ESPA per direction in HB 373 passed by the 2005 Legislature. Most recently, the MARP was identified as a major component of the ESPA Comprehensive Aquifer Management Plan's (CAMP) goal to stabilize and improve aquifer levels and increase water supply reliability within the Upper Snake River basin. The ESPA CAMP was approved as a component of the State Water Plan by the 2009 Legislature through HB 264.
  - Section 42-1737, Idaho Code, requires that the IWRB approve recharge projects by others that propose the diversion of natural flow for recharge in excess of 10,000 acre-feet.
  - Conditions of the 2009 Swan Falls Reaffirmation Agreement limit the average annual amount of managed aquifer recharge in the Snake River system above Swan Falls Dam to 175,000 af through 2019. While it is legal for an individual or entity to develop a water right for recharge purposes, the diversion of natural flow from the Snake River or its tributaries above Swan Falls Dam is limited based on the Swan Falls Reaffirmation Agreement. It is therefore appropriate and compulsory to advance ideas related to recharge of natural flow through the IWRB's MARP.
  - On January 27, 2012, the IWRB passed a resolution to implement a 5-year managed aquifer recharge pilot program which includes: 1) execution of an independent analysis to recommend high-priority locations for managed recharge, 2) subsequent long-term delivery contracts with certain canal companies and irrigation districts within the recommended locations, and 3) a monitoring program to verify the effects of managed recharge over the 5-year period.
  - On March 16, 2012, the IWRB further resolved that the managed recharge efforts in 2012 would be limited to recharging natural flow to avoid placing additional pressure on storage supplies above Milner Dam. The IWRB did not want to create unnecessary competition for storage water needed for in-basin water uses, mitigation, and flow augmentation. The resolution also limited the IWRB's 2012 recharge efforts to implementation of the ESPA CAMP managed recharge goal of an annual average of 100,000 af, but did not preclude privately funded recharge efforts consistent with Idaho Law. By designating a recreational river, the IWRB shall determine which of the activities prohibited under a natural designation shall be prohibited in the specified reach and may specify the terms and conditions under which activities that are not prohibited may go forward. Designations and their corresponding recommendations are documented in the Henrys Fork Basin Plan, Idaho Water Resource Board, 1992.

- ESPA CAMP and Efforts to Stabilize the Aquifer:
  - As recognized in the ESPA CAMP, changes on the Eastern Snake Plain since the 1950s have resulted in declining storage in the aquifer. In 2011, the Idaho Department of Water Resources estimated an average annual loss of 214,000 acre-feet of aquifer storage between 1952 and 2008 (Exhibit 3-14). Stabilization of aquifer storage is a critical component of aquifer recovery.
  - Managed aquifer recharge is one strategy being implemented to help improve the condition of the aquifer. Given that the ultimate goal is to stabilize and reverse declines in aquifer storage, recharge locations with longer storage residence time in the aquifer are preferred over recharge locations with shorter duration residence times.
  - In response to the 2012 IWRB resolutions, an independent study to identify priority recharge sites was performed by the Idaho Water Resources Research Institute (IWRRI) for the IWRB (Prioritization of Aquifer Recharge Sites Based on Hydrologic Benefits, Gary S. Johnson, IWRRI, April 2012). The analysis modeled the difference in retention time of water recharged in different locations across the ESPA (see Section 3.6 – *Comparison of Recharge Locations across the ESPA*). Locations with longer retention time in the aquifer will be primary focus of the IWRB's MARP during the 5-year pilot program.
- Recharge Water Right Priority:
  - Through the IWRB's MARP, water is delivered under one of the IWRB's two recharge water right permits, one of which authorizes diversion of up to 1,200 cfs from the Snake River and the other up to 800 cfs from the Big/Little Wood Rivers. Both permits have 1980 priority dates. The IWRB's recharge rights are generally in priority before and after the irrigation season. Canal seepage and other losses that occur during irrigation are considered to be normal operating losses, or "incidental losses", and are not counted as managed recharge.
  - The IWRB typically contracts with canal companies/irrigation districts to deliver water to aquifer recharge through canal leakage before and after the irrigation season. A few dedicated recharge sites, including Egin Lakes, are used to increase recharge capacity. These are useful if the IWRB's recharge right stays in priority after the irrigation season starts. Additional dedicated recharge sites are currently under development or under consideration in accordance with the conditions of the IWRB's 5-year pilot managed recharge program.
  - American Falls Reservoir has water rights senior to the IWRB's recharge rights. If American Falls Reservoir is filling, the IWRB's recharge water rights are not in priority unless water is spilling over Milner Dam as a result of inflows to the Snake River below American Falls Reservoir.
  - If American Falls Reservoir is full and the IWRB's recharge rights are in priority, 2600 cfs of unsubordinated flow is authorized for release from the Minidoka Dam for hydropower purposes.
  - A new water right for recharge would have a priority date junior to the recharge rights held by the IWRB.
  - Privately funded recharge efforts with storage are authorized if executed through the Upper Snake Rental Pool. However, recharge with natural flow must be approved by the IWRB consistent with the Swan Falls Reaffirmation Agreement.
- Additional Considerations:
  - From 1995 to 2007 the IWRB sponsored and funded several managed recharge efforts in the ESPA culminating in 2008 with the current ESPA managed recharge program. IWRB-sponsored managed recharge in the ESPA from 2008 to 2010 totaled over 190,000 acre-feet at a cost of approximately $477,000. The annual average approached the Phase 1 ESPA CAMP average annual hydrologic target of 100,000 af of managed recharge. Over 91,000 acre-feet of this total was recharged by the FMID; 10,000 af of which was recharged at the Egin Lakes recharge site. Approximately 72.5 percent of the total was recharged above American Falls Reservoir.

At this stage of the Study, specific county and city planning and zoning and environmental regulations are not listed in detail, but would need to be considered prior to implementation.

2.6 Environmental Benefits and Impacts

During earlier phases of this study, a matrix was developed that identified alternative-specific benefits and impacts related to:

- Impacted river segments
- Change in connectivity
- State Aquatic Species of Special Concern (Yellowstone Cutthroat Trout and Rainbow Trout)
- Natural environment (including wildlife habitat impacts, federally listed species, wetlands, State species of concern, and special river designations)

The matrix was populated based on review of existing literature and input from Basin stakeholders. Matrix results are summarized below for each alternative.

2.7 Land Management, Recreation, and Infrastructure Impacts and Benefits

The same matrix also summarized benefits and impacts related to land management, recreation, and infrastructure. Matrix results for these are also summarized below for each alternative.

2.8 Key Assumptions and Limitations

- Hydrology is uncertain: Legal water available is not known. Complete water balance and refined operations have not been evaluated. Water rights and the potential to modify existing water rights were not evaluated at this stage, so the sources (Henrys Fork River for the West Egin Lakes alternative and Teton River for the Teton Island alternative) were assumed to have sufficient water available for diversion.
- Cost estimates are comparative and preliminary: Future concept refinements could potentially change the ranking of alternatives by cost. Costs are relative and are not intended for budgeting.
- No field reconnaissance or geologic mapping was conducted as part of this investigation and analysis.
- No hazards analysis was performed.
- Potential impacts along the canal and pipeline routes were not assessed during this evaluation and would require further investigation during future phases of the study. Rather, the analysis was focused on impacted river segments (supply and return flows).
- No detailed survey data was available for the existing Egin Recharge Canal or the proposed new Teton Island Recharge Canal.
- No detailed hydraulic modeling was conducted to evaluate canal capacity. At a later date, a one-dimensional hydraulic model at a finer spatial resolution would provide more accurate quantification of existing and needed future capacity.
- Pumping costs to withdraw recharged groundwater from the aquifer for use by irrigators were not included in the cost estimate.

2.9 Data Sources

2.9.1 Basin Needs

- Bureau of Reclamation (Reclamation). 2012. Draft Henrys Fork Watershed Basin Study Water Needs Assessment, March.

- Van Kirk, R., Rupp, S., and J. De Rito. 2011. Ecological Streamflow Needs in the Henrys Fork Watershed, September.

2.9.2 Recharge and Canal Flow Data

- Idaho Department of Water Resources (IDWR) unpublished records, 2008 – 2011
- FMID unpublished records, 2008 – 2011

2.9.3 Monitoring Well Data

- IDWR unpublished records, 2008 – 2010

2.9.4 Canal Dimensions, Elevations, and Alignments

- Aerial photographs: National Agriculture Imagery Program (NAIP). 2009. 1-meter color imagery (GIS-based web service).
- Topographic maps: USGS 1:24,000 Quadrangle (GIS-based web service).
- Google Earth aerial imagery and elevations: http://www.google.com/earth/index.html
- Measurements and estimates from FMID.
- Bentley FlowMaster, Version 8i (FlowMaster) software package.

2.9.5 Recharge Modeling

- Contor, B.A., Cosgrove, D.M., Johnson, G.S., and N. Rinehart. 2006. Hydrologic Effects of Curtailment of Ground-Water Pumping Using Snake River Plain Aquifer Model Version1.1 “Curtailment Scenario”, Idaho Water Resources Research Institute Technical Report 2006-001.
- Cosgrove, D.M., B.A. Contor, and G.S. Johnson. 2006. Enhanced Snake Plain Aquifer Model Final Report, Idaho Water Resources Research Institute Technical Report 06-002. http://www.if.uidaho.edu/~johnson/FinalReport_ESPAM1_1.pdf
- Eastern Snake Plain Aquifer Model Version 1.1 (ESPAM1.1), http://www.idwr.idaho.gov/waterinformation/projects/espam/
- Idaho Power. 2008. Preliminary CAMP Modeling Results. http://www.idwr.idaho.gov/waterboard/WaterPlanning/CAMP/ESPA/PDFs/LPD/2008/PreliminaryCAMPModelingResults.pdf
- Johnson, G.S. 2012. Prioritization of Aquifer Recharge Sites Based on Hydrologic Benefits. Idaho Water Resources Research Institute. Prepared for Idaho Department of Water Resources and Idaho Water Resource Board.
- Sukow, J. 2012. Recharge Analyses for West Egin Lakes and Lower Teton Sites.

2.9.6 Cost Development

- Canal design guidelines: Reclamation. 2010. Appendix A – General Canal Design Flowchart, Draft Feasibility-Level Engineering Report, Continued Phased Development of the Columbia Basin Project – Enlargement of the East Low Canal and Initial Development of the East High Area, Odessa Subarea Special Study, October.
- Proprietary projects with similar design components.

Section 3 **Expansion of Managed Recharge in Egin Basin**
Section 4 **Development of New Recharge Facilities in the Lower Teton Basin**

SECTION 3

Expansion of Managed Recharge in Egin Basin

3.1 Alternative Description

3.1.1 Overview

Expansion of Managed Recharge in Egin Basin is an alternative that increases annual water deliveries to Egin Lakes for recharge from approximately 5,000 af currently to either 7,500 af or 10,000 af, an increase of 50 or 100 percent. Egin Lakes is located approximately 10 miles west of St. Anthony at the terminus of the Egin Recharge Canal (Exhibit 3-1). The Egin Recharge Canal capacity would be expanded to pass the increased design flows.

3.1.2 Baseline

Approximately 5,000 af of recharge water is currently sent to the Egin Lakes Recharge Site over approximately 60 days each year, with slight variations in quantity, timing, and duration year to year since the program's inception in 2008. 5,000 af is not necessarily available every year, and a portion of the quantity sent to the site is lost as canal seepage, but for the purposes of this evaluation the baseline case was modeled as application of the full 5,000 af quantity at the Egin Lakes Recharge Site.

3.1.3 Alternative Variations

The following sub-alternatives were identified for possible expansion of the existing annual recharge program at Egin Lakes. Recharge quantities for the two sub-alternatives were established over time through various Workgroup meetings.

- 50 percent increase = 7,500 af (2,500 af incremental increase)
- 100 percent increase = 10,000 af (5,000 af incremental increase)

3.1.4 Operational Assumptions

Detailed operations have not been evaluated or distinguished by alternative. Preliminary, generalized, non-binding operational assumptions were described in Sections 2.2 and 2.3 to select design flows for cost estimates.

3.2 Key Findings

Expansion of the Egin Lakes recharge program would provide additional water storage for the Henrys Fork 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 af (7,500 to 10,000 af total), depending on the sub-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, and that water could help satisfy unmet irrigation demands in the Egin Bench irrigated region. The remaining volume would be discharged to the Henrys Fork River, which was identified as having additional ecological streamflow needs, resulting in predicted 1.6 to 3.2 cfs flow increases beyond the baseline condition in the Ashton to Rexburg reach, depending on the recharge volume considered. Diversions would typically occur during periods when connectivity is not an issue, and no substantial populations of Yellowstone cutthroat trout would be impacted, but a priority rainbow trout fishery in the Henrys Fork River could potentially be indirectly impacted. Though the out-of-basin water budget would be reduced by an additional 2,500 to 5,000 af per year during the time of diversion and recharge, the impact would essentially be negligible given that diversion for recharge typically occurs during spring runoff when water is being passed downriver for flood control purposes. 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 Eastern Snake Plain Aquifer (ESPA).

However, previous studies indicate that water recharged upstream of American Falls (including Egin Lakes) has a low retention time, and other recharge sites further downstream with greater retention time are better candidates to stabilize and improve ESPA storage. Exhibit 3-2 provides a tabular summary of the key findings.

EXHIBIT 3-2
Key Findings from the Reconnaissance Evaluation

Estimated Cost per Acre-feet	Impact on In-Basin Water Budget	Impact on Out-of-Basin Water Budget	Change in Connectivity of Impacted River Segment
$2,700 - $4,000	7,500 – 10,000 af to be recharged annually (incremental increase of 2,500 to 5,000 af beyond existing baseline), some of which will go to aquifer storage and some of which will enhance ecological flows.	7,500 – 10,000 af/yr reduction (incremental decrease of 2,500 to 5,000 af beyond existing baseline) when diverted for recharge, in accordance with priority water rights. The majority of this quantity would be from spring runoff typically passed for flood control and would not negatively impact the water budget. Part of this quantity would be available later for out-of-basin needs.	Improvement in connectivity of downstream river segments receiving return flows, specifically the Lower Henrys Fork River. Potential impacts to the supply source (Henrys Fork River), which does not contain a conservation population of Yellowstone cutthroat trout in the diversion reach.

3.3 Engineering Results

3.3.1 Existing Recharge Program Monitoring

Water levels for several wells in the vicinity of Egin Lakes have been monitored since 2008. Exhibit 3-1 shows the location of several wells, and Exhibit 3-3 presents monitoring results.

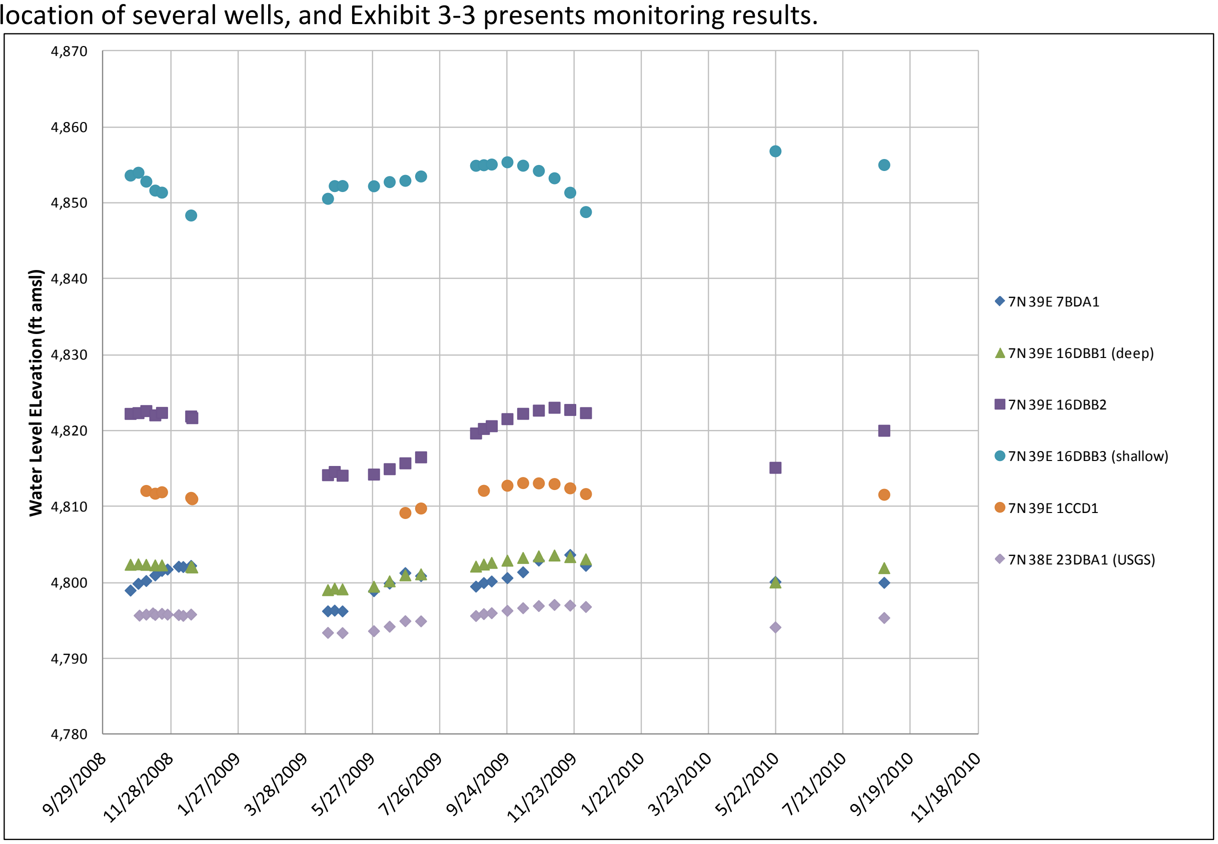
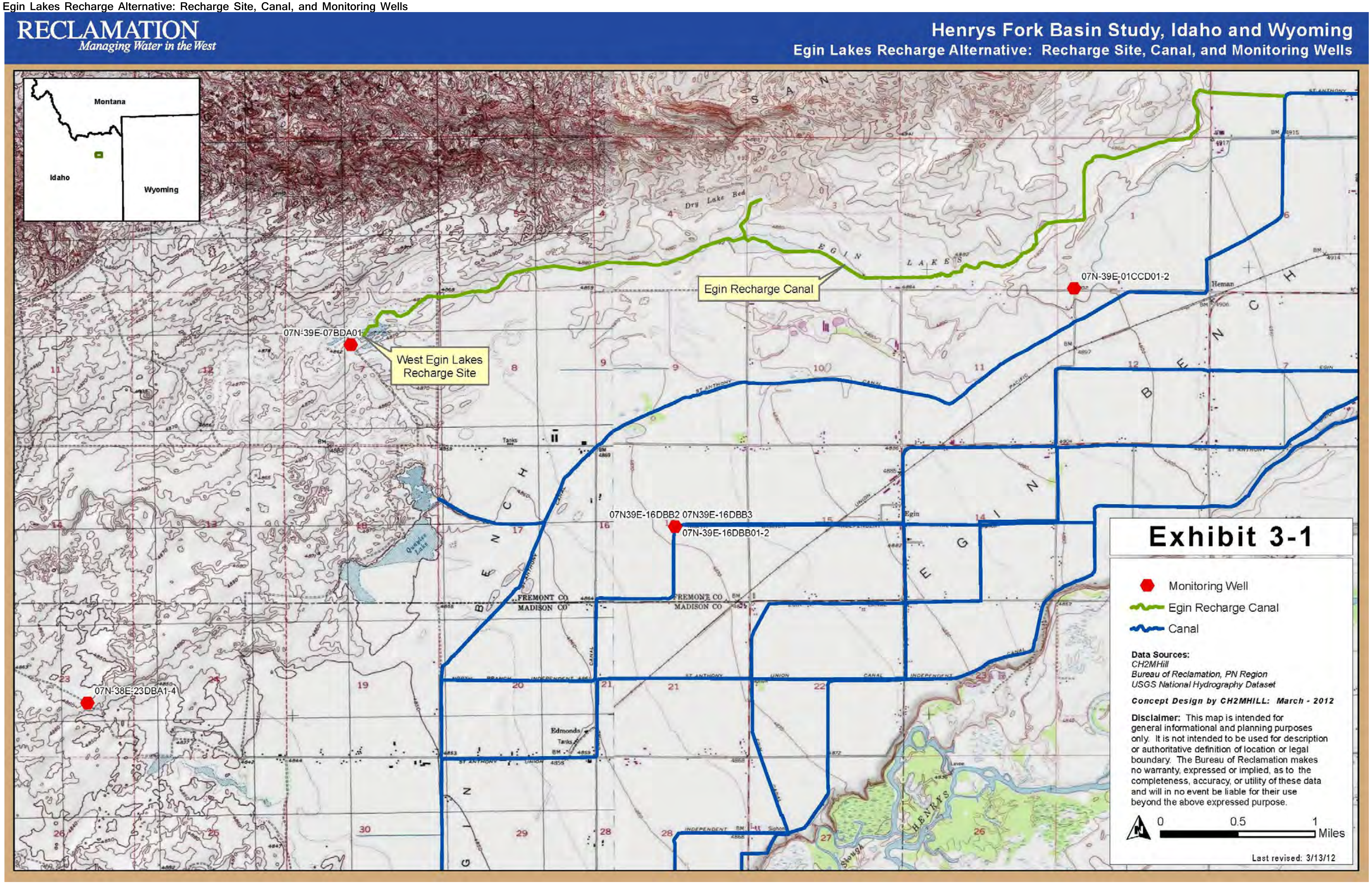


EXHIBIT 3-3
Water Level Observations for Wells in the Vicinity of Egin Lakes (Source: IDWR).

EXHIBIT 3-1
Egin Lakes Recharge Alternative: Recharge Site, Canal, and Monitoring Wells



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As shown in Exhibit 3-3, water level elevations fluctuated over time in each well. In general, water levels in most of the wells rose approximately three to four feet during recharge periods. At the end of each recharge period, water levels in wells closest to the point of application (such as 07N-39E-07BDA01, which is located adjacent to the recharge site) decreased more quickly than the more distant wells (such as 07N-39E-01CCD01-2, which is located approximately 4.6 miles east of the recharge site). The data presented in Exhibit 3-3 provide a snapshot of short-term, local water level responses to recharge input. However, water level fluctuations should not be attributed solely to managed recharge activities because these well locations are also subject to incidental recharge from surface water irrigation, recharge on non-irrigated lands, etc. A more robust modeling approach was required to predict managed recharge-induced impacts to the aquifer and stream reaches in the vicinity over a longer period of time, as detailed in the following section.

3.3.2 Recharge Modeling

Impacts of recharge at the West Egin Lakes site were predicted using the Eastern Snake Plain Aquifer Model, ESPAM1.1. ESPAM1.1 was constructed and calibrated with 6-month stress (or recharge input) periods beginning May 1, 1980. Exhibit 3-4 displays the model cells where recharge was applied and where results were obtained.

The following recharge scenarios were modeled by applying the recharge at a constant rate during the first 6-month stress period of each year (the model was not designed to apply recharge over the desired two month period or a shorter stress period). The recharge scenarios analyzed included the existing baseline condition and both expansion sub-alternatives, as described below:

- Scenario 1 (Baseline): 5,000 af recharged annually for 20 years. As noted earlier, the model applies the entire 5,000 af quantity to a single model cell at the recharge site; however, during actual field delivery and application, some portion of that quantity would be lost as seepage through the canal system.
- Scenario 2 (50% Increase Sub-Alternative): 7,500 af (2,500 af incremental increase) recharged annually for 20 years.
- Scenario 3 (100% Increase Sub-Alternative): 10,000 af (5,000 af incremental increase) recharged annually for 20 years.

Exhibits 3-5 through 3-8 provide graphical representations of the model results for select river reaches and model cells (identified in Exhibit 3-4). Annual delivery of 5,000 af of recharge water is included in Exhibits 3-5 to 3-8 because it represents the baseline condition. Incremental effects associated with the two sub-alternatives are represented by the difference between the plotted line for each sub-alternative and the baseline. The results presented in the following exhibits assume that the full recharge quantity was available every year for the 20-year period of interest, whereas in real world application the full quantity may not be available every year because of other priority water rights.

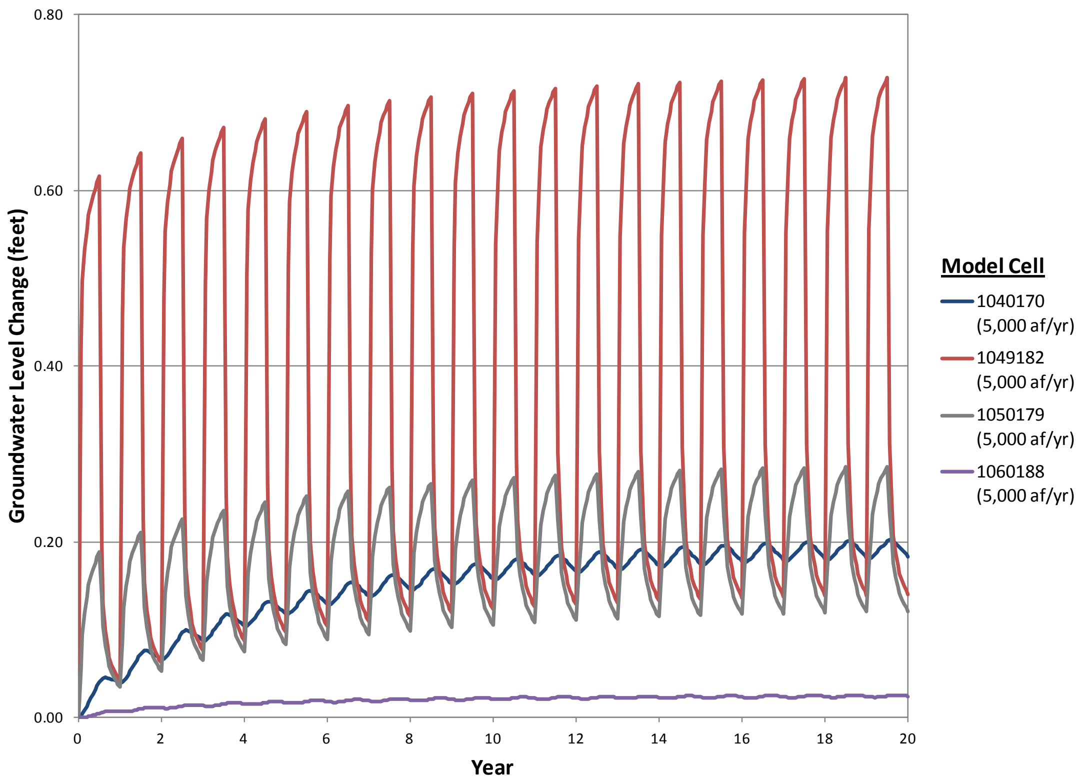


EXHIBIT 3-5
Groundwater Level Response of Select Model Cells (see Exhibit 3-4) to the Existing (Baseline) Recharge Scenario (5,000 af/yr).

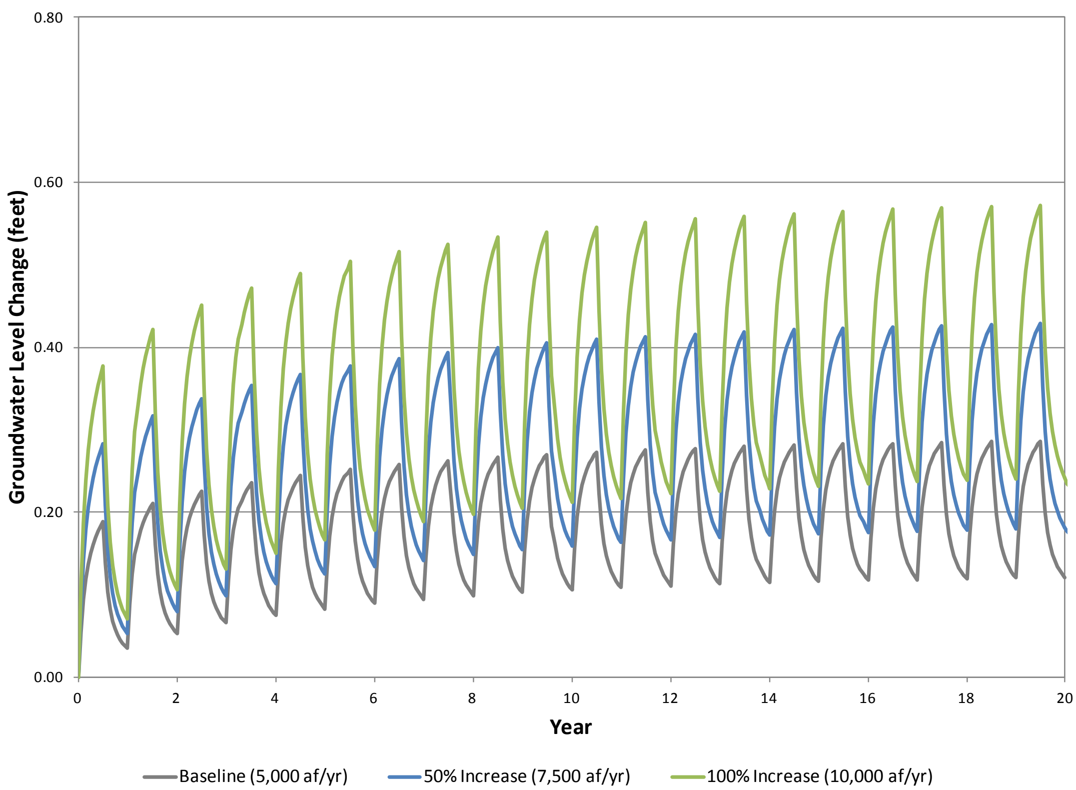
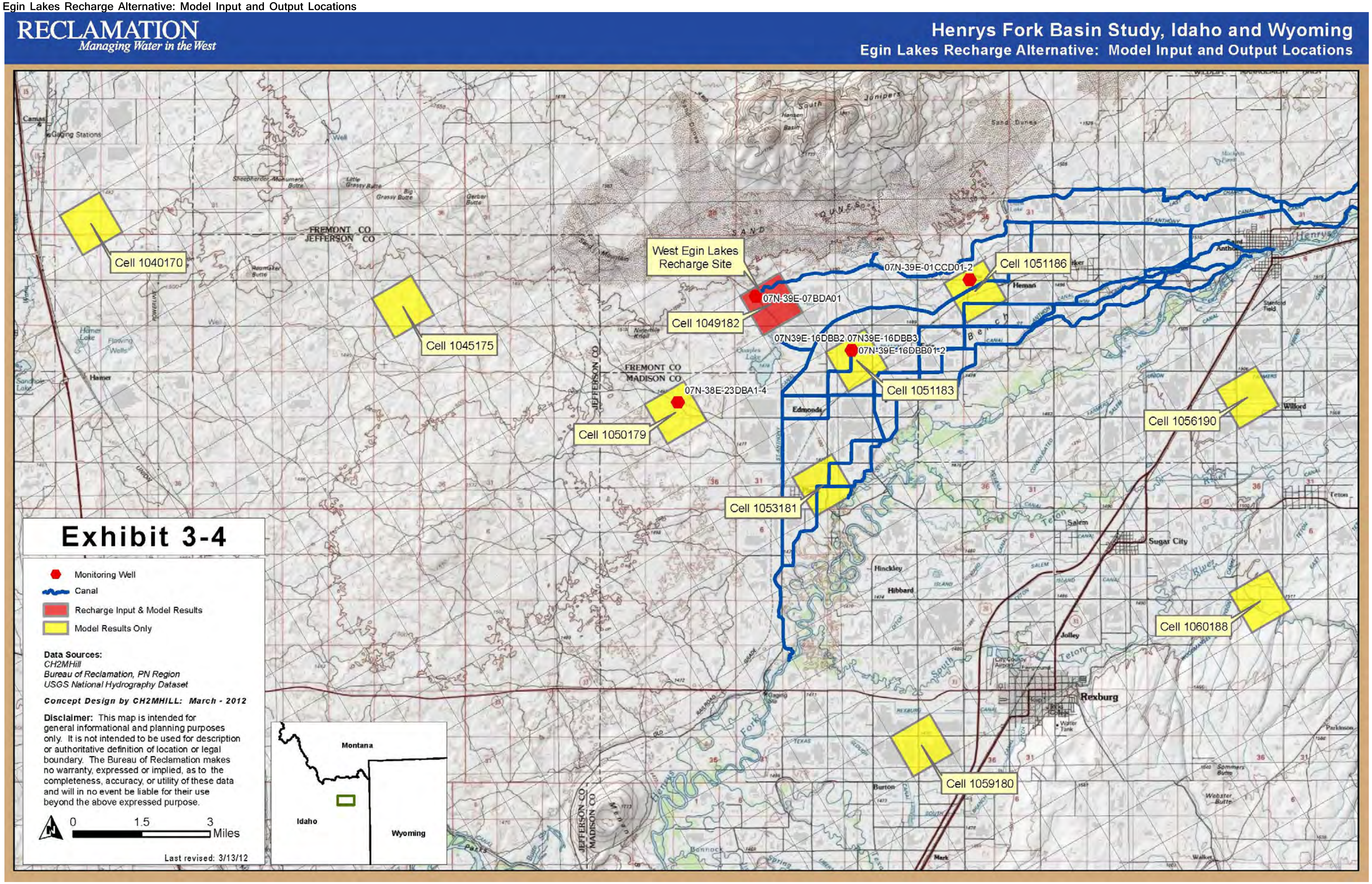


EXHIBIT 3-6
Groundwater Level Response of a Representative Model Cell (1050179; see Exhibit 3-4) to each Recharge Scenario.

EXHIBIT 3-4
Egin Lakes Recharge Alternative: Model Input and Output Locations



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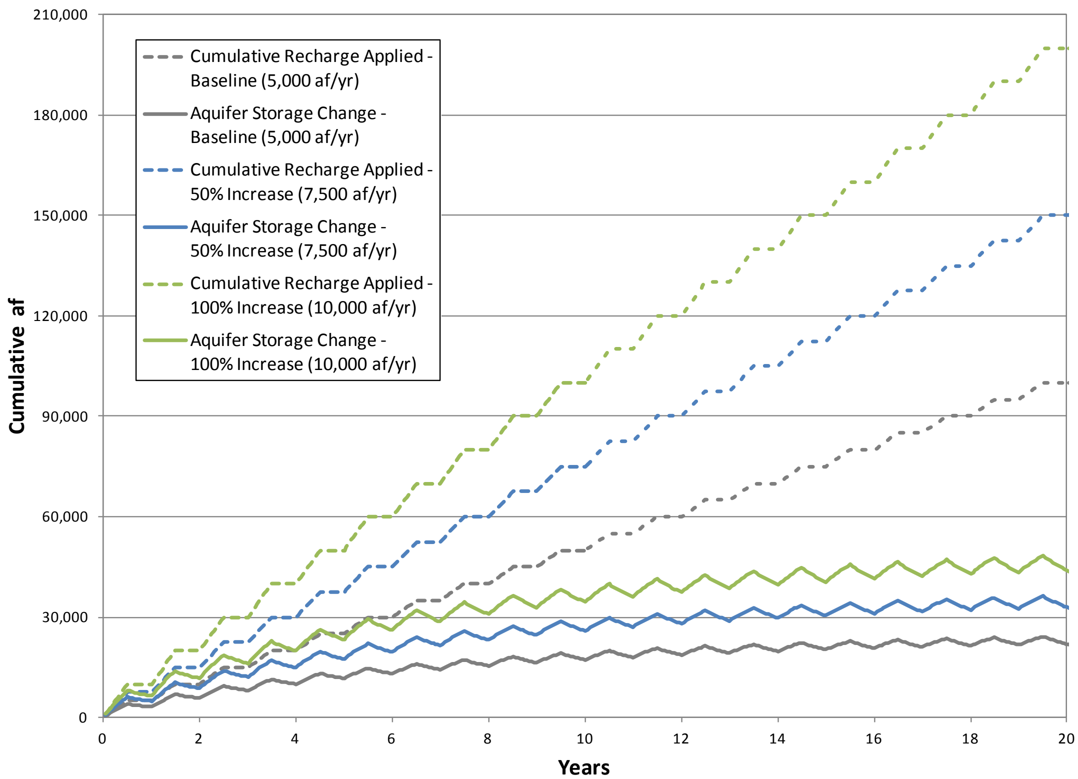


EXHIBIT 3-7
Comparison of Recharge Applied vs. Stored in ESPA for each Recharge Scenario.

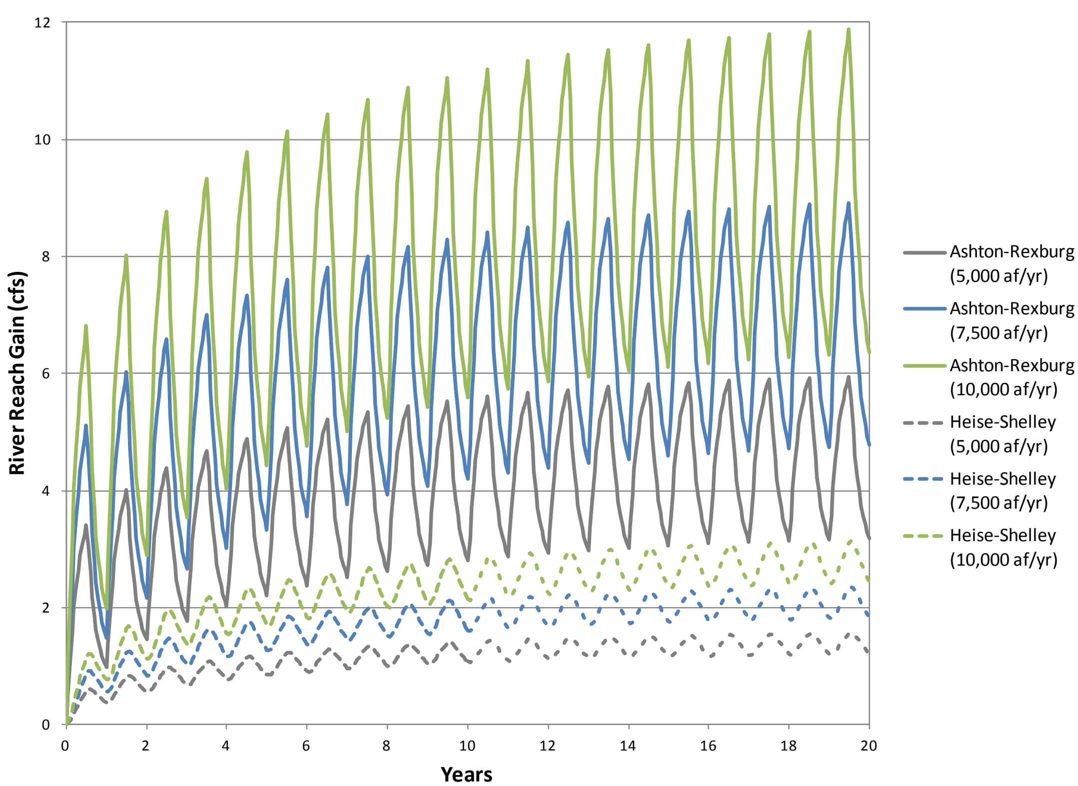


EXHIBIT 3-8
Flow Response of Two River Reaches (Ashton to Rexburg Reach of the Henrys Fork River and Heise to Shelley Reach of the Snake River) to each Recharge Scenario.

A tabular summary of model results for both sub-alternatives is presented in Exhibit 3-9, which captures incremental observations (beyond existing baseline) from Exhibits 3-5 to 3-8 and results from other model cells indicated in Exhibit 3-4.

EXHIBIT 3-9
West Egin Lakes Recharge Site Model Results at End of 20-Year Period[1]

Sub-Alternative	Incremental Annual Recharge Quantity (af)	Aquifer Storage at End of 20 Years			Incremental River Reach Gains	
		Incremental Groundwater Level Increase[2] (ft)	Incremental Volume Stored (af)	% of Volume Recharged	Ashton to Rexburg (cfs)	Heise to Shelley (cfs)
50% Increase	2,500	0.01 – 0.09	10,984	22	1.6	0.6
100% Increase	5,000	0.02 – 0.19	21,968	22	3.2	1.2

[1] – Model results reported in this table are instantaneous model predictions at the end of the 20-year period, following the final 6-month interval when recharge is not being applied (i.e., values would be higher if reported during the final recharge application interval).
[2] – Groundwater level increases predicted by the model are less than field observations presented in Exhibit 3-3. Field observations likely include responses to other sources of aquifer recharge, while the model predicts the response to only the managed recharge events. A portion of these differences may also result from the model being limited to applying discharge over a 6-month period, rather than the existing duration of approximately 2-months.

As noted above (Section 2.2.1.1 – *Current Model*), IWRRI recently completed an independent analysis of recharge sites across the ESPA using ESPAM1.1 (Johnson, 2012). While the analysis is not discussed at length in this report, results of the evaluation of Egin Lakes are generally consistent with this evaluation: 17 percent of a single, one-month recharge volume would be retained in aquifer storage 10 years after the recharge activity (see Section 3.6–*Comparison of Recharge Locations across the ESPA*).

3.3.3 Conveyance

The Egin Recharge Canal is an existing supply route that delivers water to the Egin Lakes recharge site, as depicted in Exhibits 3-1 and 3-10.

EXHIBIT 3-10
Existing Egin Recharge Canal (Source: FMID).

As described in Section 2.2.2 – *Conveyance,* FlowMaster software was used to evaluate the hydraulic capacity of the existing canal and determine expansion requirements needed to accommodate the 50 and 100 percent increased recharge sub-alternatives. Exhibit 3-11 summarizes the key physical characteristics of the canal for the existing baseline condition and each increased recharge sub-alternative.

EXHIBIT 3-11
Egin Recharge Canal Characteristics

							Upstream Cross-Section		Downstream Cross-Section	
Sub-Alternative	**Incremental Recharge Quantity (af)**	**Design Flow (cfs)**	**Manning's Roughness (n)**	**Length (mi)**	**Longitudinal Slope**	**Side Slope**	**Bottom Width (ft)**	**Flow Depth[1] (ft)**	**Bottom Width (ft)**	**Flow Depth[1] (ft)**
N/A (Baseline)	*0 (5,000 total)*	*65[2]*	*0.035*	*7.2*	*0.0015*	*1.5H:1V*	*10*	*2.0*	*7*	*2.0*
50% Increase	2,500 (7,500 total)	100	0.035	7.2	0.0015	1.5H:1V	19	2.0	13	2.5
100% Increase	5,000 (10,000 total)	130	0.035	7.2	0.0015	1.5H:1V	25	2.0	17	2.5

[1] – Two feet of freeboard would be provided above the water surface to replicate existing conditions.
[2] – 5,000 af/yr represents the existing condition scenario, but the existing dimensions and assumed physical parameters of the Egin Recharge Canal are not capable of conveying 65 cfs (existing downstream capacity is approximately 37 cfs).

The Egin Recharge Canal passes under numerous roads, and some retrofit or replacement of those crossings would be necessary to enhance the conveyance capacity of the system. However, details for those existing structures are unknown and upgrades are not accounted for in the cost estimate at this time. Other existing conveyance features, such as stream diversions, intake and fish screen structures, and the St. Anthony Union Canal (which supplies water to the Egin Recharge Canal), were assumed adequately sized to handle additional flow requirements.

3.4 Cost Estimate

A summary of the total construction cost and cost per acre-foot of water stored for each recharge scenario is presented in Exhibit 3-12, and a more detailed breakdown of each cost element is provided in Exhibit 3-13.

EXHIBIT 3-12
Egin Lakes Increased Recharge Scenario Cost Estimate[1] Summary

Sub-Alternative	**Total Annual Recharge Quantity (af)**	**Incremental Recharge Quantity Beyond Baseline (af)**	**Total Relative Construction Cost**	**Cost Per Incremental Unit Yield ($/af)**
50% Increase	7,500	2,500	$10,060,000	$4,000
100% Increase	10,000	5,000	$13,620,000	$2,700

[1] – Total relative construction costs were rounded to the nearest $10,000 and costs per unit yield were rounded to the nearest $100.

EXHIBIT 3-13
Detailed Relative Construction Cost for Egin Lakes Increased Recharge Sub-Alternatives

Component	Quantity	Unit	Cost Basis	Estimated Costs	
				50% Increase	**100% Increase**
Stream Diversion and Intake	0	No.	diversion structures, intakes with fish screens	$0	$0
Canals	7.2	Miles	excavation, local fill, parallel gravel access road, migration crossings	$4,763,819	$6,446,293
Base Field Cost				$4,763,819	$6,446,293
Unlisted Items (20%)				$952,764	$1,289,259
Mobilization (5%)				$238,191	$322,315
Field Cost w/out Contingency				$5,954,773	$8,057,867
Contingency (30%)				$1,786,432	$2,417,360
Total Field Cost				$7,741,205	$10,475,227
Non-Field Cost (30%)				$2,322,362	$3,142,568
Total Relative Construction Cost				$10,063,567	$13,617,795

3.5 Basin Needs

Expansion of the Egin Lakes recharge program would enhance the in-basin water budget by annually recharging an additional 2,500 to 5,000 af (7,500 to 10,000 af total) depending on the sub-alternative. At the end of the 20-year period, approximately 22 percent of the water recharged would be expected to be stored in the ESPA (Sukow, 2012), and that water may help satisfy unmet irrigation demands in the Egin Bench irrigated region (Reclamation, 2012). The remaining volume would be discharged to the Henrys Fork River, which may enhance ecological in-stream flows (see Section 3.8.2 – *Change in Connectivity*).

Based on available information, impacts to the out-of-basin water budget are not likely to be significant. Though the out-of-basin water budget would be temporarily reduced an additional 2,500 to 5,000 af per year during the time of diversion and recharge, the impact would essentially be negligible given that diversion for recharge typically occurs during the spring runoff when water is being passed downriver for flood control purposes. In terms of potential benefits, water returning to the river may increase carryover storage by adding natural flow to the river during the irrigation season and offsetting withdrawals from storage. This water may be used for 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 (Reclamation, 2012). However, results of a 2008 modeling effort (Idaho Power, 2008) performed during the development of the ESPA CAMP indicated that return flows from managed recharge in parts of the Snake River Basin above American Falls Reservoir, including the Henrys Fork, had a minor beneficial impact to increasing reservoir carryover. The benefit of increased carryover is negligible if the system fills (the upper Snake River system fills approximately eight out of ten years) because return flows would be lost in flood control releases.

3.6 Comparison of Recharge Locations across the ESPA

As recognized in the ESPA CAMP, changes on the Eastern Snake Plain since the 1950s have resulted in declining storage in the aquifer. The loss of storage has resulted in declining water levels and reduced springflows from the ESPA leading to severe water use conflicts. In 2011, the Idaho Department of Water Resources estimated an average annual loss of 214,000 acre-feet of aquifer storage between 1952 and 2008 (Exhibit 3-14). Managed aquifer recharge is one strategy identified to help improve the condition of the aquifer. Given that the ultimate goal is to stabilize and reverse declines in aquifer storage, recharge locations with longer storage residence time in the aquifer are preferred over recharge locations with shorter duration residence times.

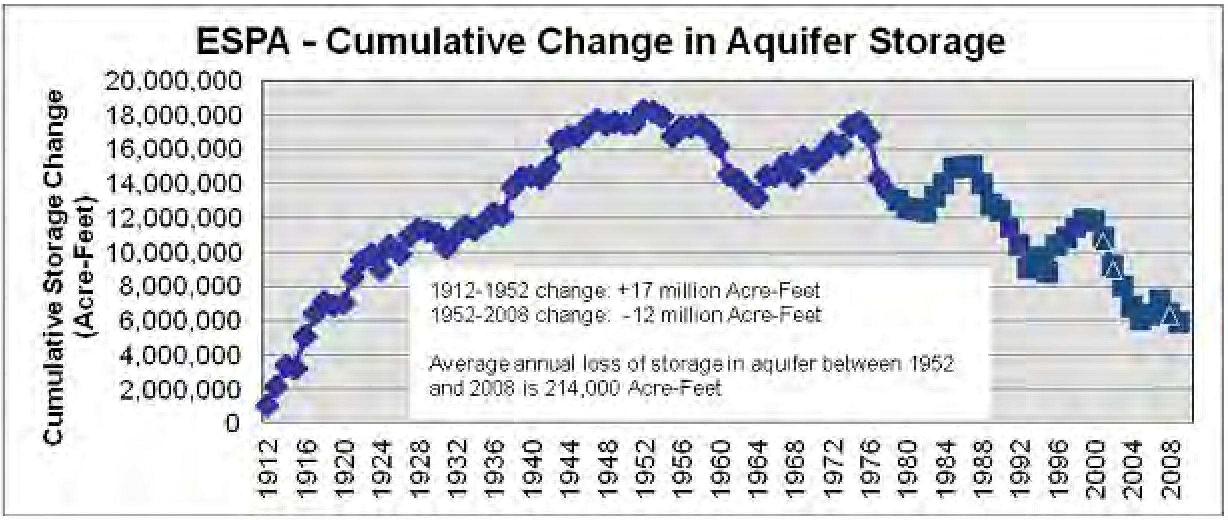


EXHIBIT 3-14
ESPA Water Level Changes and Estimated Volume of Water, Presentation by McVay, IDWR, March 10, 2011

As indicated by the model, water from recharge events at the Egin Lakes site dissipates quickly, with most of the recharged water leaving the aquifer and surfacing in the Ashton to Rexburg reach of the Henrys Fork or further downstream in the river within six to seven months. Monitoring well observations in the vicinity of Egin Lakes all show substantial water level increases resulting from recharge, but rapid declines when recharge ceases. In comparison to other recharge opportunities in the Eastern Snake Plain, water recharged at West Egin Lakes has a relatively short retention time, as demonstrated in Exhibits 3-15 and 3-16.

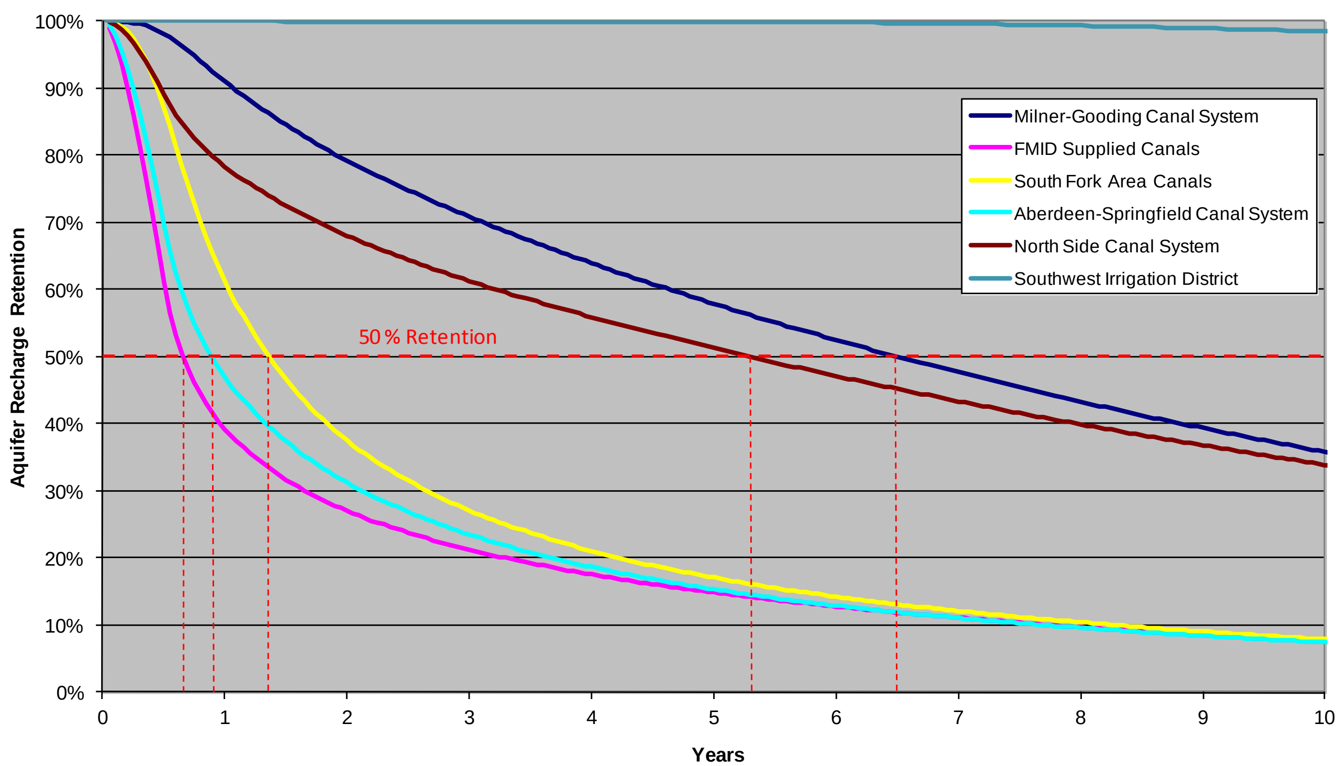


EXHIBIT 3-15
Comparison of Aquifer Recharge Retention (One Time Event) in the Eastern Snake Plain

Exhibit 3-15 illustrates the retention time of a one-time recharge event at several locations across the ESPA. The Egin Lakes site is included in the analysis of all canals supplied by the Fremont Madison Irrigation District (labeled FMID Supplied Canals), which is the irrigation district responsible for conveying water to the recharge site via the Egin Recharge Canal. The Milner-Gooding Canal System includes the Milner-Gooding canals, the existing Shoshone Recharge site (developed by the Lower Snake River Aquifer Recharge District), and the proposed Mile Post 31 site. The South Fork Area Canals include the Great Feeder system as well as the Enterprise, Farmers Friend, and Progressive Canal systems.

As demonstrated in Exhibit 3-15, 50 percent of the water recharged at Egin Lakes/FMID supplied canals will be retained in the aquifer after approximately seven months, which is similar to the recharge within the Aberdeen-Springfield canal system (50 percent retained after approximately 11 months) and recharge within South Fork of the Snake Area canals (50 percent retained after approximately 1.3 years). However, the Northside Canal and the Milner-Gooding Canal system recharge sites maintain 50 percent retention after 5.3 and 6.5 years, respectively, and recharge through the Southwest Irrigation District achieves nearly 100 percent retention after a 10-year period.

Exhibit 3-16 displays the recharge site locations referenced in Exhibit 3-15 on a map of the Eastern Snake River Plain model boundary. The map also shows a model of the percentage of return flows to the Snake River and springs within a 5-year period from a one-time recharge event (5-year response function). This analysis demonstrates that recharge in areas downstream of American Falls and generally upstream of Twin Falls provide greater retention time in the aquifer.

An analysis recently published by IWRRI, *Prioritization of Aquifer Recharge Sites Based on Hydrologic Benefits* (Johnson, 2012), compares the effects of recharge at nineteen different sites across the ESPA. Multiple objectives were evaluated, one of which was to increase aquifer water levels throughout the ESPA aquifer over extended periods. The effectiveness of recharge at different sites was evaluated using two criteria: the percentage of a one month recharge event that is retained in aquifer storage after 10 years, and the average water level change in the Snake River Plain after 10 years of continuous recharge at a rate of 100,000 af per year.

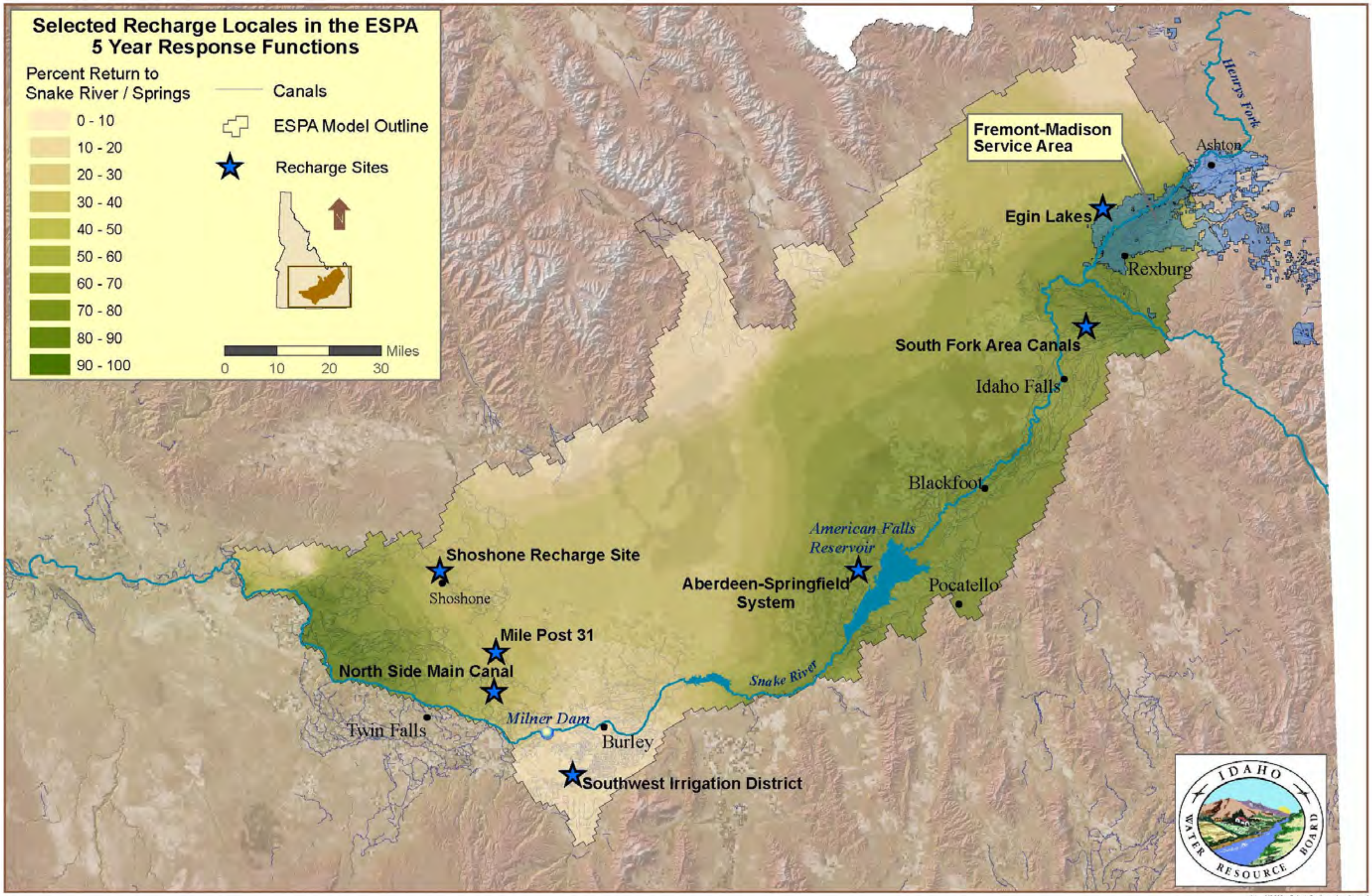
Results showed that for the most part the relative ranking between sites was consistent for both criteria and was consistent with results of the two analyses described in Exhibits 3-15 and 3-16. The percent of a single, one-month recharge volume retained in the aquifer 10 years after the recharge event was 4 percent in Fremont-Madison East (which contains the proposed Teton Island Recharge Site described in Section 4) and 17percent at Egin Lakes, as opposed to 33 percent at the Milepost 31 and Shoshone Recharge sites, 37 percent at the Milner-Gooding Canal, 40 percent at Northside Canal, and 96 percent in the Southwest Irrigation District. The average water level change in the ESPA after 10 years of continuous recharge at 100,000 af per year was 0.2 feet at Fremont-Madison East, 0.4 feet at Egin Lakes, and from 1.3-1.4 feet at Milepost 31, Shoshone Recharge site, Northside Canal, Milner-Gooding Canal, and Southwest Irrigation District.

Results of the analyses described above indicate that recharge sites in areas such as the Northside Canal system, Milner-Gooding Canal system, and the Southwest Irrigation District experience greater retention time in the aquifer. They also show that several recharge events at the Egin Lakes or Teton Island Recharge Sites would be required to equal the effect of a one-time recharge event at these locations. Recharge sites with greater retention time are better candidates than Egin Lakes or Teton Island to support efforts intended to stabilize and improve ESPA storage.

3.7 Legal, Institutional, or Policy Constraints

Legal, institutional, and policy constraints that may affect the implementation of this alternative are described in Section 2.5 – *Legal, Institutional, or Policy Constraints*. Also, The BLM right-of-way grant (101-36709) allows Egin Bench Canals, Inc. to use the current recharge site on BLM property for recharge of up to 10,000 af within 253.25 acres adjacent to, but not within, the Sand Mountain Wilderness Study Area (WSA). Per restrictions in the current BLM manual related to WSAs, the BLM cannot authorize expansion of the existing right-of-way within the boundaries of the WSA.

EXHIBIT 3-16
IWRB Sponsored Recharge Sites in the ESPA, 5-Year Response Functions



3.8 Environmental Benefits and Impacts

3.8.1 Impacted River Segments

River segments potentially impacted by various sub-alternatives include the Henrys Fork River, as identified in Exhibit 3-17.

3.8.2 Change in Connectivity

Potential impacts to river connectivity consist of decreased flow (diversions to the recharge site) for river segments providing recharge supply and increased flow for river segments receiving subsurface return flow. Potential impacts to connectivity of each impacted river segment are identified in Exhibit 3-17. In summary, the Lower Henrys Fork River, which has been identified as having additional ecological streamflow needs (Van Kirk et al., 2011), would be predicted to experience 1.6 to 3.2 cfs flow increases beyond the baseline condition in the Ashton to Rexburg reach.

State Aquatic Species of Special ConcernThe recharge site is not in Yellowstone cutthroat trout habitat, nor would modifications to the hydrology of the Henrys Fork impact a substantial population. However, the Henrys Fork River is home to a priority rainbow trout fishery. State Aquatic Species of Special Concern in potentially impacted river segments are indicated in Exhibit 3-17.

3.8.3 Other Environmental Factors

The Egin Lakes recharge site is adjacent to both winter range and migration corridors for big game. No federally listed threatened or at-risk species have been noted in the area, but the St. Anthony Sand Dunes evening primrose (*Oenothera psammophila*) is a BLM sensitive plant found only at the St. Anthony Sand Dunes, and the largest and most viable population of a rare tiger beetle (*Cicindela arenico/a*) is found at the St. Anthony Sand Dunes. The NWI dataset indicates that further development of the site would have minimal impact on mapped wetlands, affecting an area less than one acre in size. Potential impacts along the canal and pipeline routes were not assessed during this evaluation and would require further investigation during future phases of the study, but expansion of the already existing Egin Recharge Canal would be unlikely to have substantial environmental impacts. This reach of the Henrys Fork is not currently subject to special state or federal status designations; however, 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 WSA.

Potential wildlife habitat impacts, federally listed species, and wetlands habitat impacts within the reservoir inundation area are summarized in Exhibit 3-18. State of Idaho aquatic species of concern (Yellowstone cutthroat trout and rainbow trout) and special river designations for all potentially impacted river segments are summarized in Exhibit 3-17.

3.9 Land Management, Recreation and Infrastructure impacts and benefits

The Egin Lakes recharge site is located on federal property (adjacent to the Sand Mountain Wilderness Study Area), has a moderate recreation and economic rating, and is rated as having few potential infrastructure impacts, as summarized in Exhibit 3-19.

3.10 Assumptions and Limitations

General assumptions and limitations applicable to each alternative are described in Section 2.8 – *Key Assumptions and Limitations*, and additional assumptions and limitations specific to this alternative are listed below:

- Expansion of the already existing Egin Recharge Canal would be unlikely to have substantial environmental impacts, but potential impacts along the canal alignment were not assessed during this evaluation and would require further investigation during future phases of the study.

EXHIBIT 3-17

Impacts to Connectivity, Yellowstone Cutthroat Trout, and Special River Designations for Affected River Reaches

		Connectivity		State Aquatic Species of Special Concern			Special Designation[a]				
Recharge Site	Impacted River Segments	Flow Decrease (Supply Source)	Flow Increase (Receives Return Flow)	Yellowstone Cutthroat Trout (YCT) Presence	Rainbow Trout (RBT) Priority Fishery[b]	YCT Conservation and Management Tier[c] and RBT Fishery Rating	BLM/USFS Eligible Stream	State Natural River	State Recreational River	Designated Wilderness[d]	Rating
Egin Lakes	Henrys Fork	•	•		•	RBT Priority				•[e]	None

Notes:

[a]Special designations noted in this exhibit apply to the river reach impounded, diverted for water supply, or directly receiving return flows (if applicable).

[b]Based on personal communications with IDFG, rainbow trout are the primary focus in the Henrys Fork Watershed, whereas YCT are the primary focus in the Teton Watershed.

[c]Three tiers for prioritizing YCT conservation and management options per Montana Fish Wildlife & Parks database (2009) supplemented with anticipated data revisions per personal communications with IDFG.

1) **core conservation** populations composed of > 99 percent cutthroat trout genes;
2) **conservation** populations that generally "have less than 10 percent introgression, but in which introgression may extend to a greater amount depending upon circumstances and the values and attributes to be preserved"; and
3) **sport** populations of cutthroat trout that, "at a minimum, meet the species phenotypic expression defined by morphological and meristic characters of cutthroat trout."

[d]Per the 1997 Revised Forest Plan - Targhee National Forest.

[e]According to the BLM, 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 WSA.

Legend

State Aquatic Speices of Special Concern (YCT and RBT)

YCT Core / RBT Priority	Core Conservation Population of YCT or Priority RBT Fishery
YCT Conservation	Conservation Population of YCT
YCT Sport / None	None or Sport Population of YCT

Special Designation

Federal	Federal Wild and Scenic River (WSR) or Wilderness Area
State/ Eligible Federal	State Protected (Natural and Recreational) or eligible Federal WSR
None	None

EXHIBIT 3-18

Impacts to Wildlife Habitat, Federally Listed Species, and Wetland Habitat at the Recharge Site

	Wildlife Habitat[a]			Federally Listed Species			Wetland/Habitat Value	
Recharge Site	Big Game Winter Range	Big Game Migration Corridors	Rating	At-Risk (USFS & BLM sensitive species, and Idaho Species of Greatest Conservation Need)[b]	Threatened, Endangered, Candidate and Experimental Nonessential Species[c]	Rating	NWI Wetlands	Rating
Egin Lakes	•[4]	•[4]	Winter Range		St. Anthony Sand Dunes evening primrose[d], tiger beetle[d]	None		None

Notes:

[a]Sources of Wildlife Habitat data

[1]Per review comments from Trout Unlimited, Friends of the Teton River, and American Rivers.

[2]Per personal communications with IDFG on the Sand Creek and Teton Canyon winter ranges.

[3]Per the USFS 1997 Revised Forest Plan - Targhee National Forest.

[4]Per personal communications with BLM.

[b]Per IDFG special species February 2011 GIS dataset (1-mile buffer area).

[c]Threatened and Endangered and Candidate species list obtained from USFWS; however, location specific information based on data compiled by Trout Unlimited, Friends of the Teton River, and American Rivers (unless otherwise specified, some identified in the IDFG February 2011 dataset).

[d]These species are not threatened/endangered; rather, they are considered rare or sensitive by the BLM.

Legend

Wildlife Habitat

Winter Range	Winter Range Habitat
Migration	Migration Corridor
None	None

Federally Listed Species

Federal Aquatic/ Prime Conservation	Federally Listed Aquatic Species and Prime Conservation Area[h]
Federal Terrestrial/ Sensitive	Federally Listed Terrestrial Species and State Species of Greatest Conservation Need
None	None

Wetland and Habitat Values

Extensive	Extensive wetland impacts (> 200 Acres)
Moderate	Moderate wetland impacts (>1 - 200 Acres)
None/Minimal	No or minimal wetland impacts (<1 Acre)

EXHIBIT 3-19

Land Management Implications and Impacts to Recreation/Economic Value and Infrastructure at the Recharge Site

	Land Management Data[a]					Recreation/Economic Value								Infrastructure[d]				
Recharge Site	Private	Federal	State	Conservation Easements[b]	Rating	Boating	Fishing	Yellowstone National Park	Guiding/ Outfitting	Scenic/ Natural Features[c]	Cultural/ Historic Resources[c]	Land Recreation[c]	Rating	Roads	Structures	Habitation	Additional Infrastructure Notes	Rating
Egin Lakes		•			Federal							•	Moderate	•			Improve road/driveway crossing capacity	Few

Notes:

[a]Land management data per the BLM Idaho Surface Management Agency (2010). For federal government lands, the data displays the managing agency which may or may not be the same as the agency that "owns" the land.

[b]Per feedback from Trout Unlimited, Friends of the Teton River, American Rivers, and the Henry's Fork Foundation.

[c]Per the Resource Evaluation (IWRB 1992)

[d]Preliminary impacts based on cursory review of aerial photography.

Legend

Land Management

Federal/ Conservation	Federal, Conservation Easement
State	State
Private	Private

Recreation/Economic Value

High	Significant Impacts to Recreation/ Economic Values
Moderate	Moderate Impacts to Recreation/ Economic Values
Low	Minimal Impacts to Recreation/ Economic Values

Infrastructure

High	Impacts to major infrastructure/development
Moderate	Moderate impacts to human environment
Few	Few impacts to human environment

- The Egin Recharge Canal passes under numerous roads, and some retrofit or replacement of those crossings would be necessary to enhance the conveyance capacity of the system. However, details for those existing structures are unknown and upgrades are not accounted for in the cost estimate at this time.

3.11 Evaluation Criteria

3.11.1 Stakeholder Group Measurable Criteria

There are four Stakeholder Group Measurable Criteria, with results summarized in Exhibit 3-20:

- Water Supply: The net change for in-basin and out-of-basin water budgets in acre-feet is described above in Section 3.5 and summarized in Section 3.2.
- Water Rights: Water rights were not specifically addressed during this level of study, but known legal, institutional, and policy constraints are summarized in Section 3.7.
- Environmental Considerations: Environmental benefits and impacts are summarized above in Section 3.8.
- Economics: The estimated reconnaissance-level field cost to construct the project is summarized in Section 3.4.

EXHIBIT 3-20
Stakeholder Group Measurable Criteria Summary

Stakeholder Group Measurable Criteria	Criteria Characterization
Water Supply (in-basin water transfer)	2,500 – 5,000 af/yr
Water Supply (out-of-basin water transfer)	2,500 – 5,000 af/yr
Legal, Institutional, or Policy Constraints (yes, no)	Yes
Environmental Considerations (net positive, negative or neutral)	Negative to Positive[1]
Economics (reconnaissance-level field costs for implementation)	\$10,060,000 - \$13,620,000

[1] – Further analysis during future phase of study required to determine net environmental impact.

3.11.2 Federal Viability Tests

The four federal viability tests used to evaluate potential projects are listed below:

- **Acceptability**
- **Effectiveness** (extent to which basin needs are met)
- **Completeness** (extent to which all needs are met)
- **Efficiency** (relative construction/implementation cost per af)

- For alternatives that are carried forward to future phases of the Basin Study, the information needed to evaluate each of the criteria listed above will be further developed and refined.

SECTION 4

Development of New Recharge Facilities in the Lower Teton Basin

4.1 Alternative Description

4.1.1 Overview

This alternative entails identification of one or more promising new recharge locations in the Lower Teton Basin, selection of a preferred site for development of new recharge facilities, selection of an alignment for a new canal to convey recharge water diverted from the Teton River, and design and construction of both recharge facilities and the canal. A tentative site for recharge facilities has been identified near Sugar City between the Teton and South Fork Teton Rivers (Exhibit 4-1). This site, hereafter referred to as the Teton Island Recharge Site, was identified because of its potential to enhance ecological flows in adjacent river reaches. For comparison purposes, the Teton Island Recharge Site and a representative water-delivery canal alignment were selected to represent the range of possible choices for a new recharge facility in the lower Teton Basin. Three sub-alternatives consisting of different annual recharge quantities (5,000 af; 7,500 af; and 10,000 af) were evaluated.

4.1.2 Baseline

There is no existing recharge program at the Teton Island Recharge Site; therefore, the existing baseline recharge is zero.

4.1.3 Alternative Variations

A range of recharge quantities may be possible at the Teton Island Recharge Site. Three sub-alternative recharge quantities were selected for evaluation to maintain some consistency with the baseline and two sub-alternatives for Expansion of Managed Recharge in Egin Basin (see Section 3):

- 5,000 af
- 7,500 af
- 10,000 af

4.1.4 Operational Assumptions

Detailed operations have not been evaluated or distinguished by alternative. Preliminary, generalized, non-binding operational assumptions were described in Sections 2.2 and 2.3 to select design flows for cost estimates. Presumably, diversions would occur over a roughly 60-day period of peak spring runoff, mimicking current operations for the Egin Lakes diversion.

4.2 Key Findings

Development of a recharge program at Teton Island would provide additional water storage for the Henrys Fork Basin, effectively enhancing water supply by improving aquifer storage and increasing ecological flows in the river. The Teton Island recharge program would enhance the in-basin water budget by annually recharging 5,000 to 10,000 af, depending on the sub-alternative. At the end of the 20 year period that was examined, approximately 8 percent of the water recharged would be expected to be stored in the ESPA, and that water may help satisfy unmet irrigation demands in the Lower Watershed irrigated region. The remaining volume would be discharged to the Teton and South Fork Teton Rivers (ultimately flowing into the Lower Henrys Fork River), which were identified as having additional ecological streamflow needs, resulting in predicted 3.0 to 6.0 cfs flow increases beyond the existing condition in the Ashton to Rexburg reach depending on the recharge volume considered. Diversions 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 and South Fork

Teton Rivers. Though the out-of-basin water budget would be reduced by 5,000 to 10,000 af per year during the time of diversion and recharge, the impact would essentially be negligible given that diversion for recharge typically occurs during spring runoff when water is being passed downriver for flood control purposes. 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 Eastern Snake Plain Aquifer (ESPA). However, previous studies indicate that water recharged upstream of American Falls (including the Teton Island area) has a low retention time, and other recharge sites further downstream with greater retention time are better candidates to stabilize and improve ESPA storage. Exhibit 4-2 provides a tabular summary of the key findings.

EXHIBIT 4-2
Key Findings from the Reconnaissance Evaluation

Estimated Cost per Acre-feet	Impact on In-Basin Water Budget	Impact on Out-of-Basin Water Budget	Change in Connectivity of Impacted River Segment
$700 - $900	5,000 – 10,000 af to be recharged annually, some of which would go to aquifer storage and some of which would enhance ecological flows.	5,000 – 10,000 af /yr reduction when diverted for recharge, in accordance with priority water rights. The majority of this quantity would be from spring runoff typically passed for flood control and would not negatively impact the water budget. Part of this quantity would be available later for out-of-basin needs.	Improvement in connectivity of downstream river segments receiving return flows, specifically the Teton River, South Fork Teton River, and Lower Henrys Fork River. Potential impacts to the supply source (Teton and South Fork Teton Rivers), which contain conservation populations of Yellowstone cutthroat trout in the diversion reach.

4.3 Engineering Results

4.3.1 Recharge Modeling

Impacts of recharge at the Teton Island site were predicted using the Eastern Snake Plain Aquifer Model, ESPAM1.1. ESPAM1.1 was constructed and calibrated with 6-month stress (or recharge input) periods beginning May 1, 1980. Exhibit 4-3 displays the model cells where recharge was applied and where results were obtained.

The following recharge scenarios were modeled by applying the recharge at a constant rate during the first 6-month stress period of each year (the model is incapable of applying recharge over the desired two month period or a shorter stress period). The recharge scenarios analyzed included the existing three recharge quantity sub-alternatives, as described below:

- Scenario 1: 5,000 af recharged annually for 20 years.
- Scenario 2: 7,500 af recharged annually for 20 years.
- Scenario 3: 10,000 af recharged annually for 20 years.

Exhibits 4-4 through 4-7 provide graphical representations of the model results for select river reaches and model cells (identified in Exhibit 4-3). The results presented in the following exhibits assume that the full recharge quantity was available every year for the 20-year period of interest, whereas in real world application the full quantity may not be available every year because of other priority water rights.

EXHIBIT 4-1
Teton Island Recharge Alternative: Recharge Site and Canal

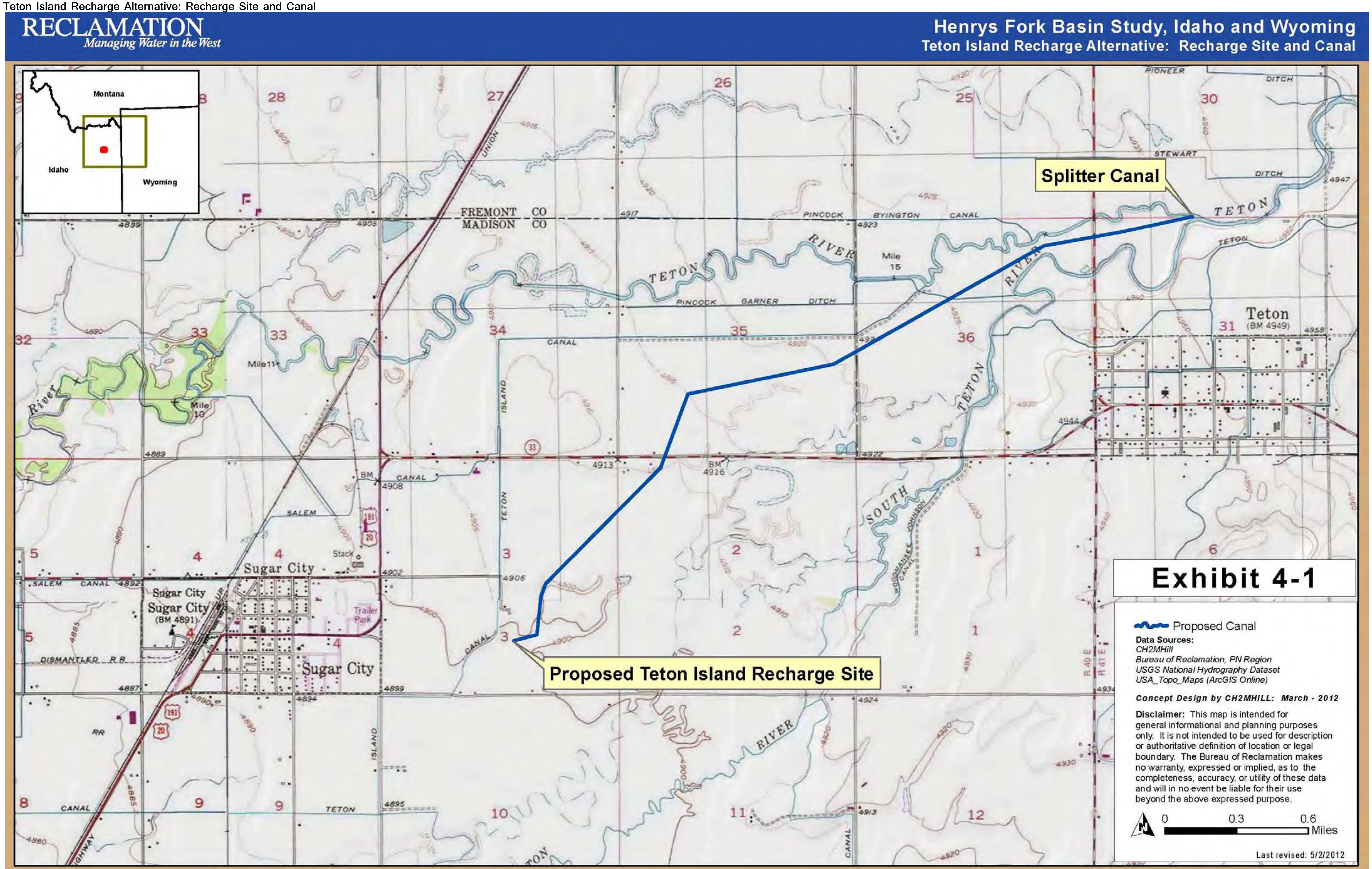


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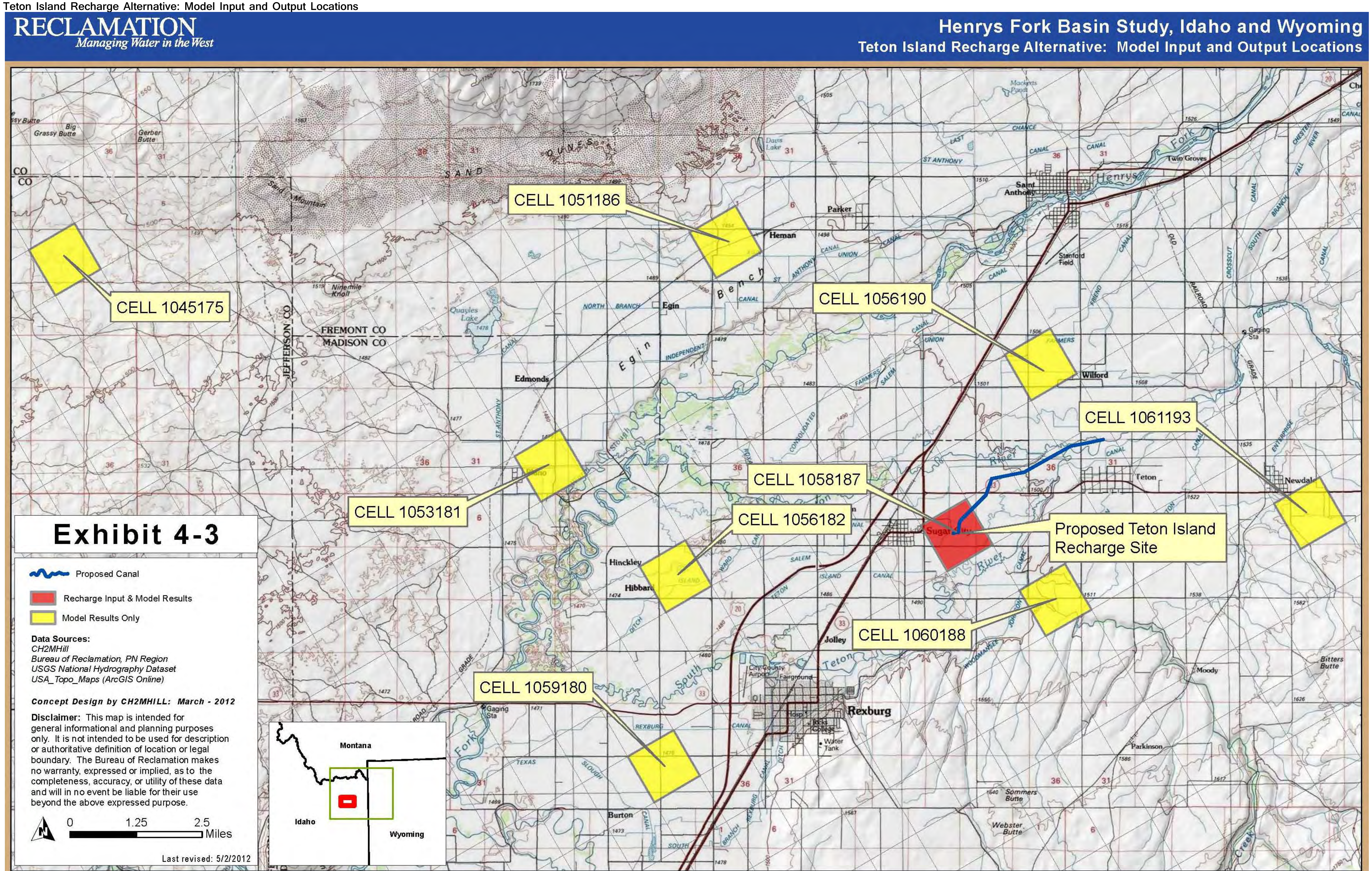
EXHIBIT 4-3
Teton Island Recharge Alternative: Model Input and Output Locations



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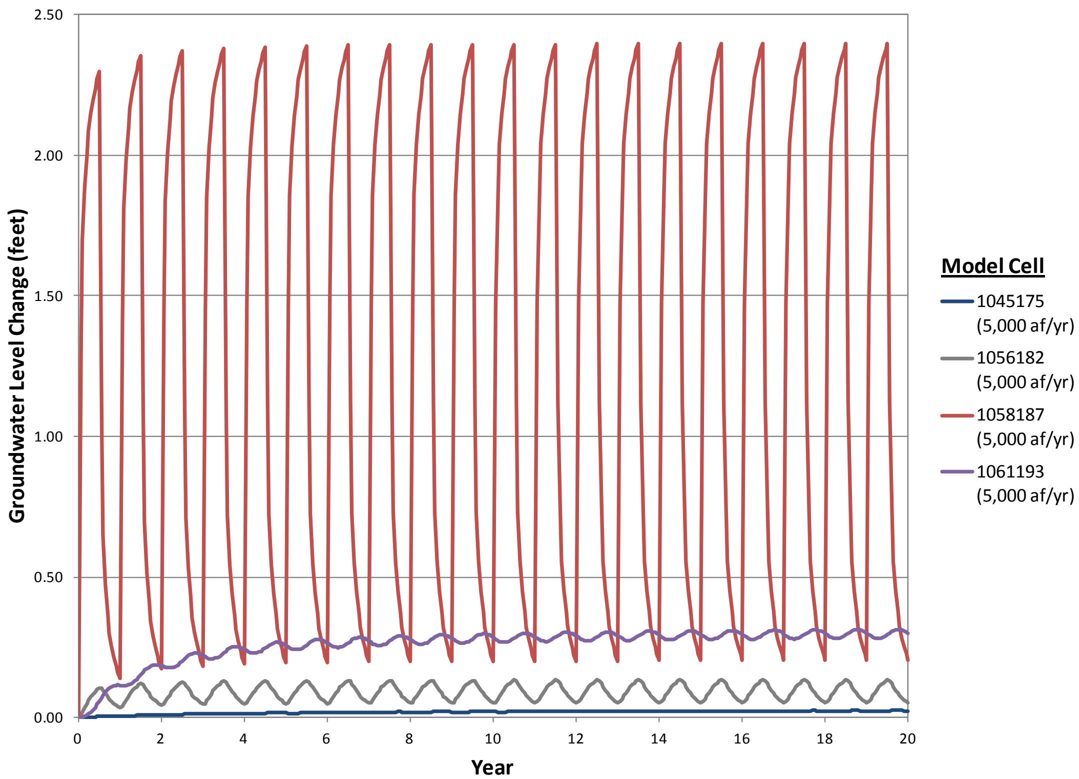

EXHIBIT 4-4
Groundwater Level Response of Select Model Cells (see Exhibit 4-3) to the Existing (Baseline) Recharge Scenario (5,000 af/yr).

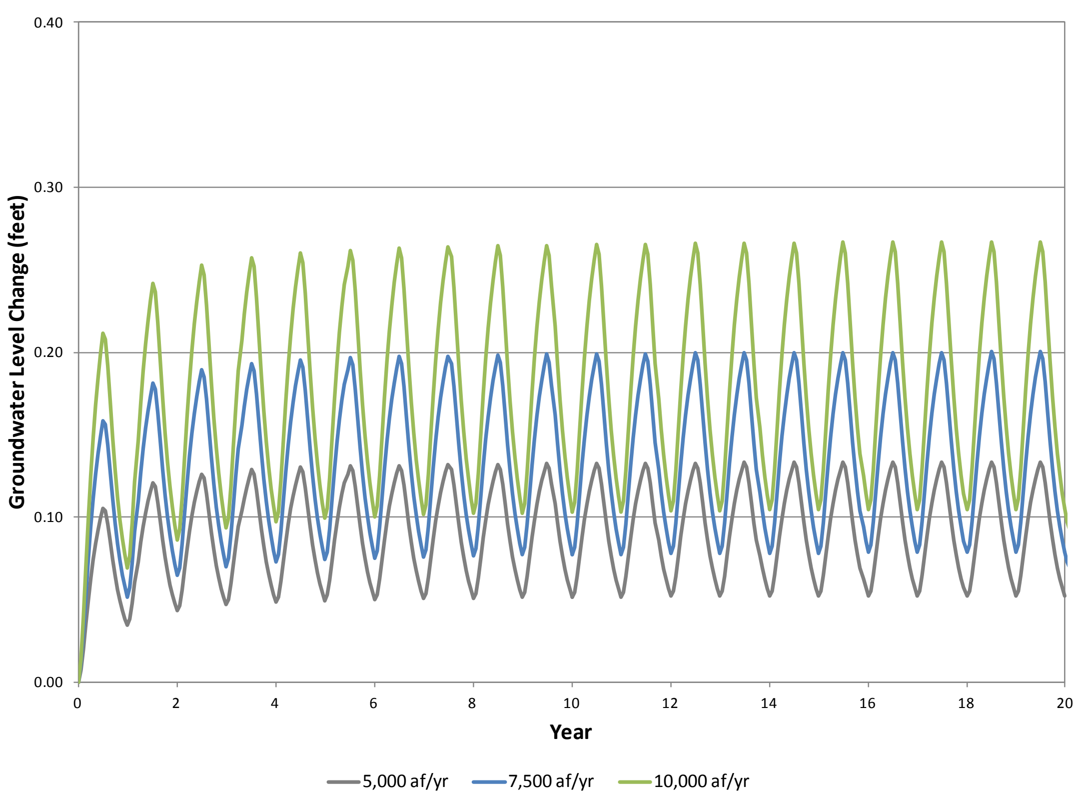

EXHIBIT 4-5
Groundwater Level Response of a Representative Model Cell (1056182; see Exhibit 4-3) to each Recharge Scenario.

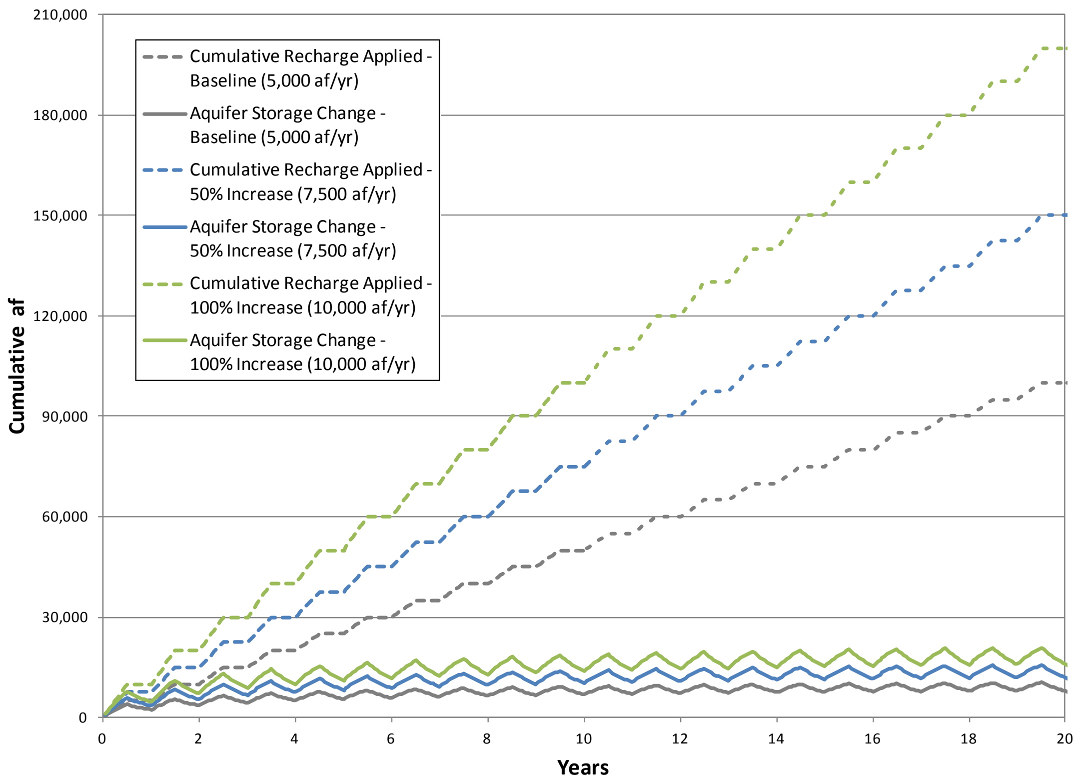

EXHIBIT 4-6
Comparison of Recharge Applied vs. Stored in ESPA for each Recharge Scenario.

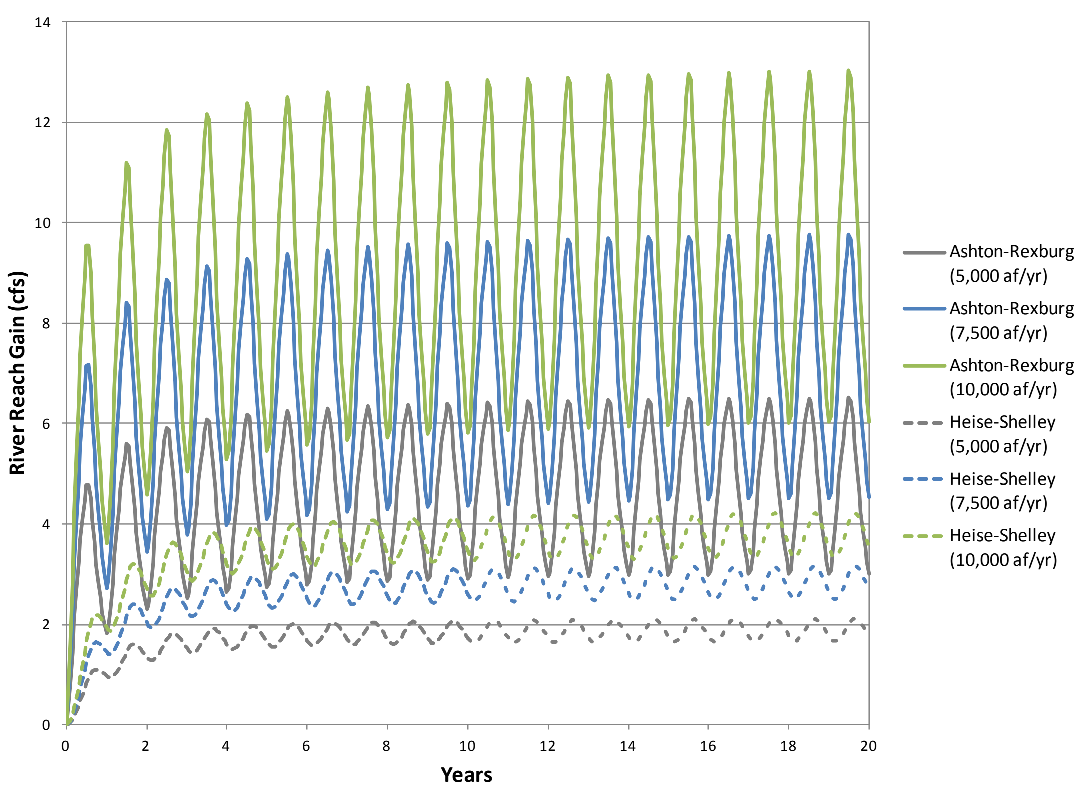

EXHIBIT 4-7
Flow Response of Two River Reaches (Ashton to Rexburg Reach of the Henrys Fork River and Heise to Shelley Reach of the Snake River) to each Recharge Scenario.

A tabular summary of model results for each sub-alternative is presented in Exhibit 4-8, which captures observations from Exhibits 4-4 to 4-7 and results from other model cells indicated in Exhibit 4-3.

EXHIBIT 4-8
Teton Island Recharge Site Model Results at End of 20-Year Period[1]

	Aquifer Storage at End of 20 Years			Incremental River Reach Gains	
Sub-Alternative	**Groundwater Level Increase (ft)**	**Volume Stored (af)**	**% of Volume Recharged**	**Ashton to Rexburg (cfs)**	**Heise to Shelley (cfs)**
5,000 af	0.02 – 0.30	7,986	8	3.0	1.8
7,500 af	0.03 – 0.45	11,979	8	4.5	2.7
10,000 af	0.03 – 0.60	15,973	8	6.0	3.5

[1] – Model results reported in this table are instantaneous model predictions at the end of the 20-year period, following the final 6-month interval when recharge is not being applied (i.e., values would be higher if reported during the final recharge application interval).

As noted above (Section 2.2.1.1 – *Current Model*), IWRRI recently completed an independent analysis of recharge sites across the ESPA using ESPAM1.1 (Johnson, 2012). While the analysis is not discussed at length in this report, results of the evaluation of Fremont-Madison East (which contains the Teton Island Recharge Site) are generally consistent with this evaluation: 4 percent of a single, one-month recharge volume would be retained in aquifer storage 10 years after the recharge activity (see Section 3.6 – *Comparison of Recharge Locations across the ESPA*).

4.3.2 Conveyance

A new supply canal would be constructed to deliver water to the proposed Teton Island Recharge Site, as depicted in Exhibit 4-1. As described in Section 2.2.2 – *Conveyance,* FlowMaster software was used to evaluate the hydraulic capacity of the new supply canal. Exhibit 4-9 summarizes the key physical characteristics of the canal for each recharge sub-alternative.

EXHIBIT 4-9
Teton Island Recharge Supply Canal Characteristics

Sub-Alternative	Design Flow (cfs)	Manning's Roughness (n)	Length (mi)	Longitudinal Slope	Side Slope	Bottom Width (ft)	Flow Depth[1] (ft)
5,000 af	65	0.0225	3.6	0.0016	1.5H:1V	7	2.0
7,500 af	100	0.0225	3.6	0.0016	1.5H:1V	12	2.0
10,000 af	130	0.0225	3.6	0.0016	1.5H:1V	16	2.0

[1] – Two feet of freeboard would be provided above the water surface.

The proposed supply canal would need to pass under numerous existing roads, and some type of crossing (culvert or bridge) would be necessary at each. However, details for those existing structures are unknown and are not accounted for in the cost estimate at this time.

4.4 Cost Estimate

A summary of the total construction cost and cost per acre-foot of water stored for each sub-alternative is presented in Exhibit 4-10, and a more detailed breakdown of each cost element is provided in Exhibit 4-11. The values in Column 4 of Exhibit 4-10 are analogous to the values in Column 5 of Exhibit 3-12.

EXHIBIT 4-10
Teton Island Recharge Cost Estimate[1] Summary

Sub-Alternative (Total Annual Recharge Quantity)	Total Relative Construction Cost	Cost per Unit Yield ($/af)	Cost per Incremental Unit Yield above 5,000 af ($/af)
5,000 af	$4,550,000	900	---
7,500 af	$5,690,000	800	500
10,000 af	$7,470,000	700	600

[1] – Total relative construction costs were rounded to the nearest $10,000 and costs per unit yield were rounded to the nearest $100.

EXHIBIT 4-11
Detailed Relative Construction Cost for Teton Island Recharge Sub-Alternatives

				Estimated Costs by Sub-Alternative		
Component	**Quantity**	**Unit**	**Cost Basis**	**5,000 af**	**7,500 af**	**10,000 af**
Stream Diversion and Intake	1	No.	diversion structures, intakes with fish screens	$260,000	$400,000	$520,000
Canals	3.6	Miles	excavation, local fill, parallel gravel access road, migration crossings	$1,894,725	$2,292,763	$3,014,923
Base Field Cost				$2,154,725	$2,692,763	$3,534,923
Unlisted Items (20%)				$430,945	$538,553	$706,985
Mobilization (5%)				$107,736	$134,638	$176,746
Field Cost w/out Contingency				$2,693,407	$3,365,953	$4,418,653
Contingency (30%)				$808,022	$1,009,786	$1,325,596
Total Field Cost				$3,501,429	$4,375,739	$,744,249
Non-Field Cost (30%)				$1,050,429	$1,312,722	$1,723,275
Total Relative Construction Cost				$4,551,857	$5,688,461	$7,467,524

4.5 Basin Needs

Development of a recharge program at Teton Island would enhance the in-basin water budget by annually recharging 5,000 to 10,000 af depending on the sub-alternative. At the end of the 20 year period, approximately 8 percent of the water recharged would be expected to be stored in the ESPA (Sukow, 2012), and that water may help satisfy unmet irrigation demands in the Lower Watershed irrigated region (Reclamation, 2012). The remaining volume would be discharged to the Teton and South Fork Teton Rivers (ultimately flowing into the Lower Henrys Fork River), which may enhance ecological in-stream flows (see Section 4.8.2 – *Change in Connectivity*).

Based on available information, impacts to the out-of-basin water budget are not likely to be significant. Though the out-of-basin water budget would be temporarily reduced an additional 5,000 to 10,000 af per year during the time of diversion and recharge, the impact would essentially be negligible given that diversion for recharge typically occurs during the spring runoff when water is being passed downriver for flood control purposes. In terms of potential benefits, water returning to the river may increase carryover storage by adding natural flow to the river during the irrigation season and offsetting withdrawals from storage. This water may be used for 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 (Reclamation, 2012). However, results of a 2008 modeling effort

(Idaho Power, 2008) performed during the development of the ESPA CAMP indicated that return flows from managed recharge in parts of the Snake River Basin above American Falls Reservoir, including the Henrys Fork, had a minor beneficial impact to increasing reservoir carryover. The benefit of increased carryover is negligible if the system fills (the upper Snake River system fills approximately eight out of ten years) because return flows would be lost in flood control releases.

4.6 Comparison of Recharge Locations across the ESPA

A detailed comparison of ESPA recharge opportunities is presented in Section 3.6 – *Comparison of Recharge Locations across the ESPA*. In summary, water from recharge events at the Teton Island site dissipates quickly, with most of the recharged water leaving the aquifer and surfacing in the Ashton to Rexburg reach of the Henrys Fork or further downstream in the river, and recharge sites with greater retention time are better candidates than Teton Island to support efforts intended to stabilize and improve ESPA storage.

4.7 Legal, Institutional, or Policy Constraints

Legal, institutional, and policy constraints that may affect the implementation of this alternative are described in Section 2.5 – *Legal, Institutional, or Policy Constraints*.

4.8 Environmental Benefits and Impacts

4.8.1 Impacted River Segments

River segments potentially impacted by various sub-alternatives include the Henrys Fork River, as identified in Exhibit 4-12.

4.8.2 Change in Connectivity

Potential impacts to river connectivity consist of decreased flow (diversions to the recharge site) for river segments providing recharge supply and increased flow for river segments receiving subsurface return flow. Potential impacts to connectivity of each impacted river segment are identified in Exhibit 4-12. In summary, the Lower Henrys Fork River, which has been identified as having additional ecological streamflow needs (Van Kirk et al., 2011), would be predicted to experience 3.0 to 6.0 cfs flow increases above the existing condition in the Ashton to Rexburg reach. The model is incapable of representing flow increases in the Teton and South Fork Teton Rivers, which have also been identified as having additional ecological streamflow needs (Van Kirk et al., 2011), but similar temporary flow increases presumably occur in those river segments.

State Aquatic Species of Special ConcernThe recharge site is not in Yellowstone cutthroat trout habitat. Modifications to the hydrology of the Teton River and the South Fork Teton River would impact a conservation population of Yellowstone cutthroat trout. State Aquatic Species of Special Concern in potentially impacted river segments are indicated in Exhibit 4-12.

4.8.3 Other Environmental Factors

The Teton Island recharge site does not contain winter range or migration corridors for large game. No federally listed threatened or at-risk species have been noted in the area. The NWI dataset indicates that further development of the site would have minimal impact on mapped wetlands, affecting an area less than one acre in size. Potential impacts along the canal and pipeline routes were not assessed during this evaluation and would require further investigation during future phases of the study. These reaches of the Teton River and the South Fork Teton River are not currently subject to special state or federal status designations.

Potential wildlife habitat impacts, federally listed species, and wetlands habitat impacts within the reservoir inundation area are summarized in Exhibit 4-13. State of Idaho aquatic species of concern (Yellowstone cutthroat trout and rainbow trout) and special river designations for all potentially impacted river segments are summarized in Exhibit 4-12.

EXHIBIT 4-12
Impacts to Connectivity, Yellowstone Cutthroat Trout, and Special River Designations for Affected River Reaches

		Connectivity		State Aquatic Species of Special Concern			Special Designation[a]				
Recharge Site	Impacted River Segments	Flow Decrease (Supply Source)	Flow Increase (Receives Return Flow)	Yellowstone Cutthroat Trout (YCT) Presence	Rainbow Trout (RBT) Priority Fishery[b]	YCT Conservation and Management Tier[c] and RBT Fishery Rating	BLM/USFS Eligible Stream	State Natural River	State Recreational River	Designated Wilderness[d]	Rating
Teton Island	Teton	•	•	•		YCT Conservation					None
	South Fork Teton	•	•	•		YCT Conservation					None

Notes:

[a]Special designations noted in this exhibit apply to the river reach impounded, diverted for water supply, or directly receiving return flows (if applicable).

[b]Based on personal communications with IDFG, rainbow trout are the primary focus in the Henrys Fork Watershed, whereas YCT are the primary focus in the Teton Watershed.

[c]Three tiers for prioritizing YCT conservation and management options per Montana Fish Wildlife & Parks database (2009) supplemented with anticipated data revisions per personal communications with IDFG.

1) **core conservation** populations composed of > 99 percent cutthroat trout genes;
2) **conservation** populations that generally "have less than 10 percent introgression, but in which introgression may extend to a greater amount depending upon circumstances and the values and attributes to be preserved"; and
3) **sport** populations of cutthroat trout that, "at a minimum, meet the species phenotypic expression defined by morphological and meristic characters of cutthroat trout."

[d]Per the 1997 Revised Forest Plan - Targhee National Forest.

Legend

State Aquatic Speices of Special Concern (YCT and RBT)

YCT Core / RBT Priority	Core Conservation Population of YCT or Priority RBT Fishery
YCT Conservation	Conservation Population of YCT
YCT Sport / None	None or Sport Population of YCT

Special Designation

Federal	Federal Wild and Scenic River (WSR) or Wilderness Area
State/ Eligible Federal	State Protected (Natural and Recreational) or eligible Federal WSR
None	None

EXHIBIT 4-13

Impacts to Wildlife Habitat, Federally Listed Species, and Wetland Habitat at the Recharge Site

	Wildlife Habitat[a]			Federally Listed Species			Wetland/Habitat Value	
Recharge Site	Big Game Winter Range	Big Game Migration Corridors	Rating	At-Risk (USFS & BLM sensitive species, and Idaho Species of Greatest Conservation Need)[b]	Threatened, Endangered, Candidate and Experimental Nonessential Species[c]	Rating	NWI Wetlands	Rating
Teton Island			None			None		None

Notes:

[a]Sources of Wildlife Habitat data

[1]Per review comments from Trout Unlimited, Friends of the Teton River, and American Rivers.

[2]Per personal communications with IDFG on the Sand Creek and Teton Canyon winter ranges.

[3]Per the USFS 1997 Revised Forest Plan - Targhee National Forest.

[b]Per IDFG special species February 2011 GIS dataset (1-mile buffer area).

[c]Threatened and Endangered and Candidate species list obtained from USFWS; however, location specific information based on data compiled by Trout Unlimited, Friends of the Teton River, and American Rivers (unless otherwise specified, some identified in the IDFG February 2011 dataset).

Legend

Wildlife Habitat

Winter Range	Winter Range Habitat
Migration	Migration Corridor
None	None

Federally Listed Species

Federal Aquatic/ Prime Conservation	Federally Listed Aquatic Species and Prime Conservation Area[h]
Federal Terrestrial/ Sensitive	Federally Listed Terrestrial Species and State Species of Greatest Conservation Need
None	None

Wetland and Habitat Values

Extensive	Extensive wetland impacts (> 200 Acres)
Moderate	Moderate wetland impacts (>1 - 200 Acres)
None/Minimal	No or minimal wetland impacts (<1 Acre)

4.9 Land Management, Recreation and Infrastructure impacts and benefits

The Teton Island recharge site is located on private property, has a low recreation and economic rating, and is rated as having few potential infrastructure impacts, as summarized in Exhibit 4-14.

4.10 Assumptions and Limitations

General assumptions and limitations applicable to each alternative are described in Section 2.8 – *Key Assumptions and Limitations*, and additional assumptions and limitations specific to this alternative are listed below:

- Potential impacts along the canal alignment were not assessed during this evaluation and would require further investigation during future phases of the study.
- The proposed supply canal would need to pass under numerous existing roads, and some type of crossing (culvert or bridge) would be necessary. However, details for those existing structures are unknown and are not accounted for in the cost estimate at this time.

4.11 Evaluation Criteria

4.11.1 Stakeholder Group Measurable Criteria

There are four Stakeholder Group Measurable Criteria, with results summarized in Exhibit 4-15:

- Water Supply: The net change for in basin and out of basin water budgets in acre-feet is described above in Section 4.5 and summarized in Section 4.2.
- Water Rights: Water rights were not specifically addressed during this level of study, but known legal, institutional, and policy constraints are summarized in Section 4.7.
- Environmental Considerations: Environmental benefits and impacts are summarized above in Section 4.8.
- Economics: The estimated reconnaissance-level field cost to construct the project is summarized in Section 4.4.

EXHIBIT 4-15
Stakeholder Group Measurable Criteria Summary

Stakeholder Group Measurable Criteria	Criteria Characterization
Water Supply (in-basin water transfer)	5,000 – 10,000 af/yr
Water Supply (out-of-basin water transfer)	5,000 – 10,000 af/yr
Legal, Institutional, or Policy Constraints (yes, no)	Yes
Environmental Considerations (net positive, negative or neutral)	Negative to Positive[1]
Economics (reconnaissance-level field costs for implementation)	$4,550,000 - $7,470,000

[1] – Further analysis during future phase of study required to determine net environmental impact.

4.11.2 Federal Viability Tests

The four federal viability tests used to evaluate potential projects are listed below:

- **Acceptability**
- **Effectiveness** (extent to which basin needs are met)
- **Completeness** (extent to which all needs are met)
- **Efficiency** (relative construction/implementation cost per af)

For alternatives that are carried forward to future phases of the Basin Study, the information needed to evaluate each of the criteria listed above will be further developed and refined.

EXHIBIT 4-14

Land Management Implications and Impacts to Recreation/Economic Value and Infrastructure at the Recharge Site

	Land Management Data[a]					Recreation/Economic Value								Infrastructure[d]				
Recharge Site	Private	Federal	State	Conservation Easements[b]	Rating	Boating	Fishing	Yellowstone National Park	Guiding/ Outfitting	Scenic/ Natural Features[c]	Cultural/ Historic Resources[c]	Land Recreation[c]	Rating	Roads	Structures	Habitation	Additional Infrastructure Notes	Rating
Teton Island	•				Private								Low	•			Would require road crossings (culverts or bridges)	Few

Notes:

[a]Land management data per the BLM Idaho Surface Management Agency (2010). For federal government lands, the data displays the managing agency which may or may not be the same as the agency that "owns" the land.

[b]Per feedback from Trout Unlimited, Friends of the Teton River, American Rivers, and the Henry's Fork Foundation.

[c]Per the Resource Evaluation (IWRB 1992)

[d]Preliminary impacts based on cursory review of aerial photography.

Legend

Land Management

Federal/ Conservation	Federal, Conservation Easement
State	State
Private	Private

Recreation/Economic Value

High	Significant Impacts to Recreation/ Economic Values
Moderate	Moderate Impacts to Recreation/ Economic Values
Low	Minimal Impacts to Recreation/ Economic Values

Infrastructure

High	Impacts to major infrastructure/development
Moderate	Moderate impacts to human environment
Few	Few impacts to human environment