Appendix B

New Surface Storage Alternatives, No. PN-HFS-002

Dam Raise Alternatives, No. PN-HFS-003

Teton Dam Storage Alternative, No. PN-HFS-005

Technical Memorandum

Henrys Fork Basin Study
New Surface Storage Alternatives

Technical Series No. PN-HFS-002

Prepared for

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

November 2012

Prepared by

CH2MHILL®

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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 surface storage alternative is provided in the sections that follow, with reservoir locations depicted in Exhibit 1-1. In many cases the alternatives also have sub-alternatives, based primarily on various combinations of source water supplies and associated conveyance infrastructure. More detailed descriptions of each alternative and lists of their sub-alternatives are provided in the alternative-specific sections at the end of the report.

1.2 Lane Lake Dam

The Lane Lake alternative features a proposed new 170-foot-tall off-channel dam and a 68,000 acre-feet (af) reservoir. The dam site is located in the Teton watershed on a generally dry drainage that is situated about one mile north of the Teton River and five miles downstream of the Bitch Creek confluence. Water for the reservoir could be supplied from several sources, including the Teton River, Conant Creek, Falls River, and Bitch Creek. Optional supply from the Teton River would require pumping. When full, Lane Lake could provide a roughly 500-foot drop to a proposed new hydropower facility on the Teton River.

1.3 Spring Creek Dam

The Spring Creek alternative features a proposed new 180-foot-tall dam and a 20,000 af reservoir. The dam site is located in the Teton watershed on the Spring Creek headwater tributary where it joins Canyon Creek. Water for the reservoir could be supplied from several sources, including Spring Creek, Canyon Creek, the Teton River, and Bitch Creek. Pumping from the Teton River or Bitch Creek would be required to satisfy storage objectives. When full, Spring Creek Reservoir could provide a roughly 160-foot drop to a proposed new hydropower facility on Spring Creek at the base of the dam.

1.4 Moody Creek Dam

The Moody Creek alternative features a proposed new 220-foot-tall dam and a 37,000 af reservoir. The dam site is located in the Teton watershed on Moody Creek, just downstream of the Dry Canyon Creek confluence. Water for the reservoir could be supplied from several sources, including Moody Creek, Canyon Creek, and the Teton River. Pumping or gravity flow from the Teton River would be required to satisfy storage objectives. When full, Moody Creek Reservoir could provide a roughly 200-foot drop to a proposed new hydropower facility on Moody Creek at the base of the dam.

1.5 Upper Badger Creek Dam

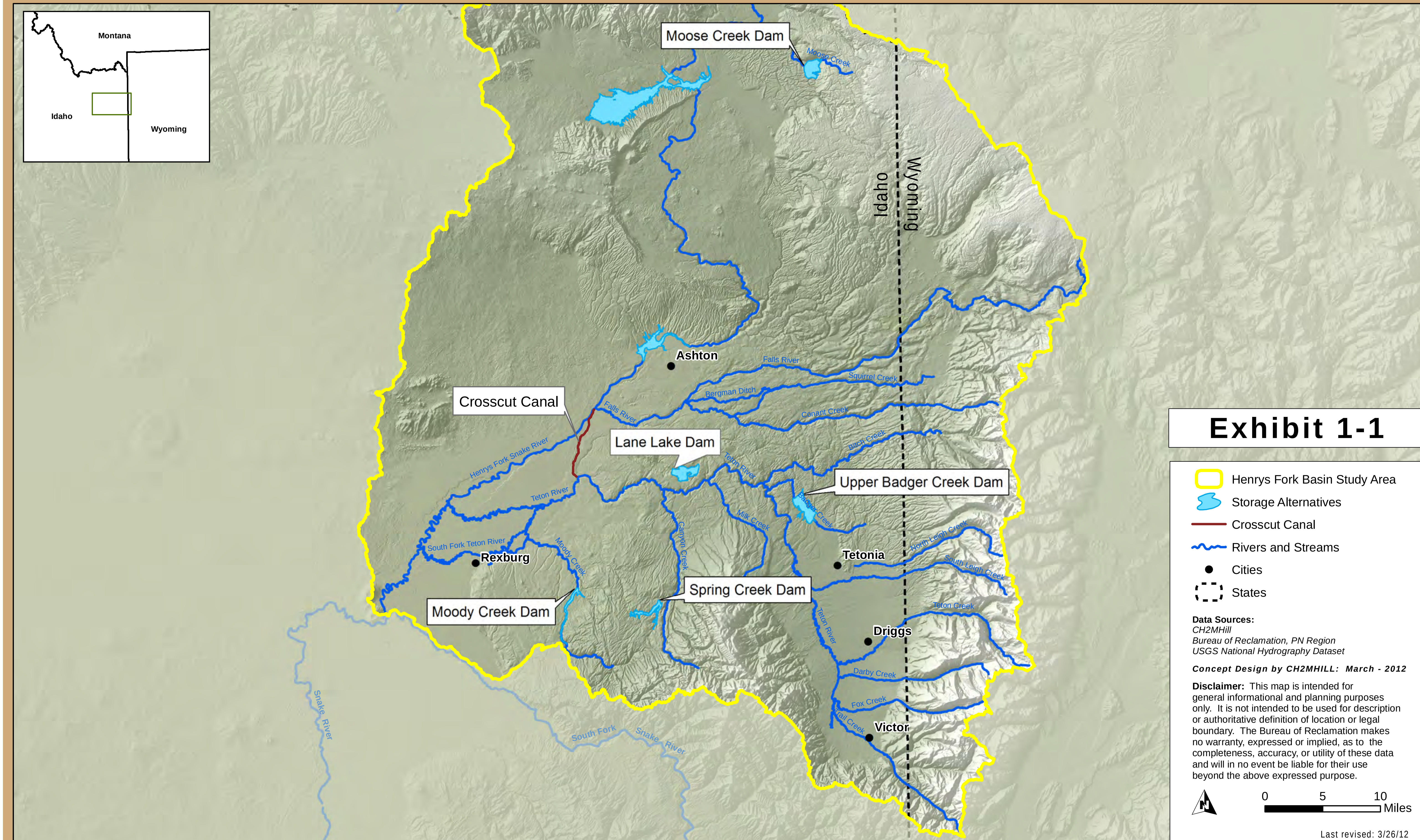
The Upper Badger Creek alternative features a proposed new 290-foot-tall dam and a 47,000 af reservoir. The dam site is located in the Teton Basin on Badger Creek approximately 5 miles upstream of the Teton River. Water for the reservoir could be supplied from Badger Creek and pumped from the Teton River. When full, Upper Badger Creek Reservoir could provide a roughly 590-foot drop to a proposed new hydropower facility on the Teton River.

1.6 Moose Creek Dam

The Moose Creek alternative features a proposed new 160-foot-tall dam and a 60,000 af reservoir. The dam site is located in the Henrys Fork Basin at the headwaters of Moose Creek between Island Park Reservoir and Big Springs. Water for the reservoir must be pumped from the Henrys Fork River, or potentially Big Springs, depending on volumes and restrictions. When full, Moose Creek Reservoir could provide a roughly 140 to 260-foot drop to a proposed new hydropower facility on Moose Creek at the base of the dam or on the Henrys Fork River. Expansion of the Crosscut Canal would also allow water released from the reservoir to be transferred to the Lower Teton watershed.

RECLAMATION
Managing Water in the West

Henrys Fork Basin Study, Idaho and Wyoming
New Surface Storage Alternatives Overview



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SECTION 2

Evaluation Approaches, Assumptions, and Limitations

2.1 Overview

This section 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 sections in Part II of this report.

2.2 Engineering Approaches

2.2.1 Hydrology

The hydrologic assessment was performed using StreamStats, a Web-based Geographic Information System (GIS) implemented by each state and managed by the USGS using ESRI GIS software tools. Users can obtain flow statistics, drainage-basin characteristics, and other information for user-selected sites on streams. If a user selects an ungaged site, StreamStats will delineate the drainage-basin boundary, measure basin characteristics and estimate stream flow statistics using regional regression equations under the assumption of natural (unregulated) flow conditions.

2.2.1.1 StreamStats Output

Four primary types of data were downloaded and summarized from StreamStats for each watershed:

- Watershed Delineation: delineated in Web-based GIS and downloaded as shape files.
- Watershed Characteristics: area, mean annual precipitation and mean basin elevation.
- Regression-Based Estimates of Stream Flow: average annual flow rate and average percentile flow rates by month (exceeded 20 percent, 50 percent or 80 percent of the time). These were converted to average runoff volumes.
- Standard Estimation Errors: The stream flow estimates are regression-based statistics. The standard estimation error is one standard deviation (+/-) from the best estimate, expressed as a percent. Roughly two-thirds (68.2 percent) of the indicated statistic for gaged sites fell within the standard error range indicated. Actual standard error for an ungaged site may or may not be comparable, depending on how similar the ungaged site is to regional gaged sites.

2.2.1.2 Hydrologic Summary

Using Conant Creek as an example, the StreamStats output was summarized in Exhibit 2-1. The primary table and associated chart in Exhibit 2-1 are intended to provide a high-level overview of the watershed hydrology and associated levels of uncertainty. Rows 1 to 3 of the table present the watershed characteristics, Rows 4 to 6 summarize average annual flow volumes, and Rows 7 and 8 summarize low-flow (80 percent exceedance) and high-flow (20 percent exceedance) conditions.

Column 4 indicates whether the statistic should be considered biased. Columns 5 to 7 present the standard estimation error for each statistic reported by StreamStats. StreamStats provided a single error statistic by month, which was summarized in the table as the lowest, mean, and highest standard error when monthly statistics were summed or averaged over longer periods. Columns 8 to 10 present a standard confidence interval based on reported standard estimation errors. It should be noted that results in Columns 8 to 10 do not derive directly from the summary statistics in Columns 5 to 7, but are rather calculated using standard errors and statistics for each individual month.

There were three alternative approaches to estimating average annual runoff volumes in Rows 4 to 6: direct calculation, sum of average monthly flows, and the average of these two statistics. Direct calculation of mean annual flow is an unbiased statistic. The sum of average monthly flows should also be a relatively unbiased estimate of mean annual flows. Although average annual runoff volumes are not typically produced by 12 sequential average-runoff months, the resulting skew relative to calculating average annual runoff directly should be mostly random (approximately normally distributed). With no clear preference for one method of calculating the mean annual flow, the results of both methods were averaged.

Percentile estimates were only available on a monthly basis, so monthly estimates were summed in Rows 7 and 8. Although the percentile estimate for each month should be unbiased, the resulting annual sum is expected to be skewed relative to a direct estimate of percentile annual flows. The reason for the skew is that seasonally extreme weather conditions (wet or dry) rarely persist at the same percentile severity for 12 continuous months. Therefore, percentile annual estimates are typically less extreme than the sum of percentile monthly estimates.

The standard estimation error was used to calculate the low and high bounds for the standard (68.2 percent) confidence interval. The interpretation is that the true average annual runoff is not known for an ungaged site, but based on regression analysis of gaged sites, there is a range of values that likely captures the mean. There is a best estimate of the mean runoff, and low and high values that bracket the mean runoff for roughly two-thirds of regional gaged sites. This best estimate and bracketing range of estimates is shown graphically in Exhibit 2-1, and indicates that the level of uncertainty is fairly high. The actual flow volume available at the ungaged site is not known.

2.2.1.3 Potentially Available Water

The primary table in Exhibit 2-1 does not necessarily indicate how much water would be available for impoundment. To determine a design yield from each watershed, a number of factors need to be considered, including water rights, exchange rights, the storage concept (is the reservoir sized for carry-over storage from wet years, reliable yield during drought conditions, or average yield conditions), reservoir operations, instream-flow thresholds, requirements for flushing flows, balance of diversions from multiple sources, and other factors. These analyses were not part of the study at this reconnaissance level.

At this stage, the potential water available for storage from each watershed was defined as the average excess spring runoff, summarized in the small table in Exhibit 2-1. The period of excess spring runoff was typically April to June, confirmed by visual inspection and as depicted in Exhibit 2-2 for the Conant Creek example. In concept, a baseflow volume was assigned to each of the spring months based on linear interpolation between the average flow volume for the months immediately preceding and following the spring runoff. The excess spring runoff above these baseflow volumes was then summed and converted to a percent of the total annual flow volume recorded in Column 9, Row 5 in Exhibit 2-1. That percentage was then multiplied by the balanced average annual flow volume recorded in Column 9, Row 6 in Exhibit 2-1 to calculate the potential water available for storage.

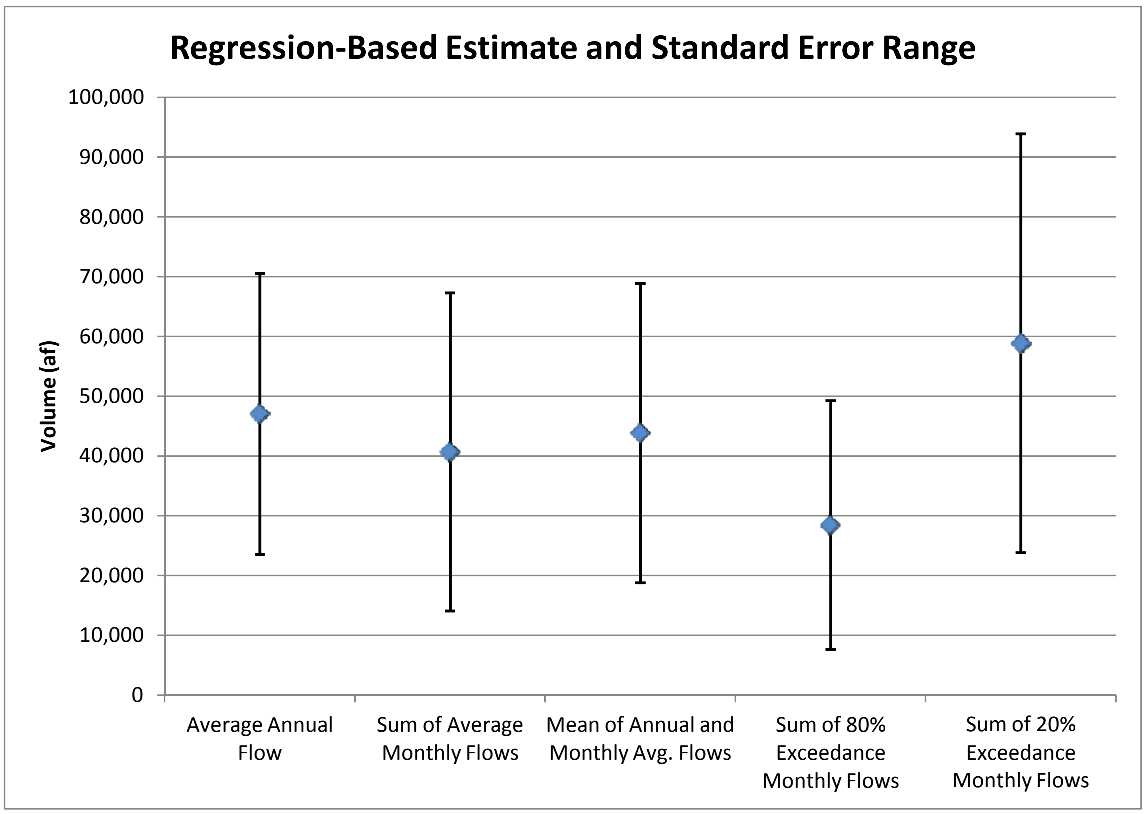
2.2.1.4 Water Assigned to Alternatives

To meet each alternative storage objective, water from multiple sources could potentially be combined in numerous different ratios. To limit the number of sub-alternatives explored, water was generally assigned as follows:

- Diversions were limited by the potentially available water from each watershed.
- Near water-source diversion volumes were generally maximized to limit diversion volumes from distant sources.

1	2	3	4	5	6	7	8	9	10
				Standard Estimation Error (%)			68% Confidence Interval		
No.	Statistic	Units	Bias	Low	Mean	High	Low	Best Estimate	High
1	Watershed Area	(sq. mi.)	None	----	----	----	----	44	----
2	Mean Annual Precipitation	(inches)	None	----	----	----	----	36.9	----
3	Mean Basin Elevation	(feet)	None	----	----	----	----	6,700	----
4	Average Annual Flow	(af)	None	----	50%	----	23,529	47,058	70,587
5	Sum of Average Monthly Flows	(af)	None	46%	73%	96%	14,104	40,691	67,278
6	Mean of Annual and Monthly Avg. Flows	(af)	None	----	----	----	18,816	**43,874**	68,933
7	Sum of 80% Exceedance Monthly Flows	(af)	Under	57%	83%	100%	7,668	28,472	49,275
8	Sum of 20% Exceedance Monthly Flows	(af)	Overe	37%	64%	81%	23,839	58,882	93,925

Mean of Annual and Monthly Avg. Flows (af)	43,874
Average Excess Spring Runoff	44%
Potential Water Available for Storage (af)	**19,210**



DEFINITION: The **"standard error range"** is the regression-based estimate +/- one standard deviation. Roughly two-thirds (68.2%) of the indicated statistic for gaged sites fell within the standard error range indicated. Results for ungaged sites may or may not be comparable, depending on how similar they are to the gaged sites used to develop the regression equation.

Exhibit 2-1

Conant Creek Watershed Hydrologic Summary

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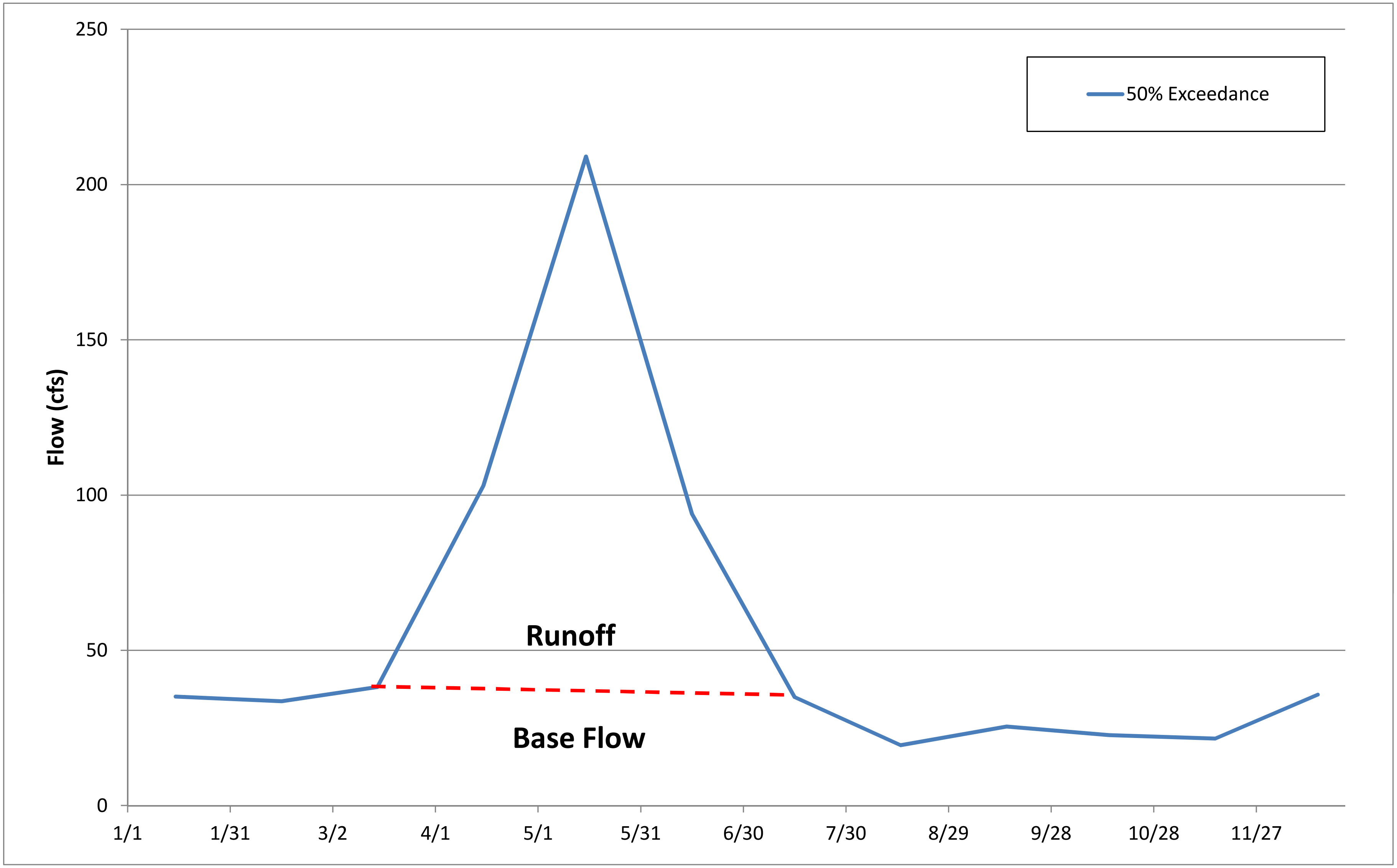

Exhibit 2-2
Conant Creek Water Potentially Available for Storage

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2.2.2 Conveyance

The following procedures outline the process used to identify the conveyance system:

- It was assumed that at each stream from which water is withdrawn, water would be collected via a stream diversion structure and an intake structure with fish screens.
- Pump station locations were identified in GIS where elevation gain was required for conveyance and could not readily be provided by a siphon. Booster pump stations in series were not considered.
- Pressure pipe was envisioned where conveyance required a lift or a siphon. These locations were identified in GIS. Lift distances were measured horizontally and adjusted for sloped length based on the average lift height at the corresponding pump stations. Pressure pipe lengths for siphons were based on the approximate depth of each ravine crossed and a standard V-shaped ravine with 5H:1V side slopes.
- Canals were envisioned for conveyance where gravity flow was possible. Approximate canal routes were laid out in GIS to ensure gravity flow at a modest slope.

2.2.3 Dam Configuration

2.2.3.1 Embankment

Dam locations for each alternative were selected to maintain consistency with prior studies (IWRRI 1981 and IWRB 1992). Professional judgment and common geotechnical design criteria were used to evaluate each site.

Rockfill or granular earthfill dams were selected as the preliminary choice to impound water at each of the new surface storage sites. Taking local topographic constraints into consideration, the dam crest was set at an elevation to maximize storage volume. A standard dam template was used, featuring 2.5H:1V upstream and downstream slopes, a central or sloping low-permeability core, chimney drain and blanket drains, random-fill zones, granular earth or rockfill shells, and a protective riprap layer on the upstream slope (Exhibit 2-3). Fifteen feet of freeboard was provided between the dam crest and the normal maximum water surface to provide surcharge capacity during floods and to prevent dam overtopping from sustained wave runup. Total embankment volume, used in Section 2.3.4.7 – *Dam – Embankment* for the cost estimate, was estimated by multiplying the average cross-sectional area by the dam crest length for each alternative. Little is known about the quantity and suitability of borrow materials at each site, so a range of potential dam types and configurations should be considered in future phases.

2.2.3.2 Spillway

For the purposes of this study, an emergency overflow spillway was located on an abutment. Additional site characterization during future phases may indicate that an alternative spillway location or configuration, including a “morning glory” type spillway or conduit spillway, would be more suitable if a specific site is found to lack durable erosion-resistant rock along the preliminary emergency spillway alignment. The spillway would be sized to safely pass both natural inflows and a reasonable range of operational inflows, but specific design flows have not been evaluated.

2.2.3.3 Outlet Works

Controlled reservoir releases would be conducted via an outlet pipeline at the base of the dam and could potentially be integrated with the powerhouse and penstock. The outlet under the dam should be founded on hard incompressible rock, and fully encased with concrete. A seepage diaphragm, cutoff drainage layers, and other measures would be required to safely control seepage under the dam and along the conduit.

A detailed outlet concept has not been developed for the sites, and will depend on objectives for conveyance integration, service deliveries, stream releases, water rights, general operations, temperature control, a service spillway, and site-specific factors. It was assumed that a tower outlet may be included in some potential operational scenarios, so it was included in cost development, but is not a specific recommendation.

2.2.4 Hydropower Potential

Hydropower generation benefits were not considered in this study, but hydropower potential was estimated. Penstocks were laid out from the outlet works below the dam to a tentative powerhouse location. Hydropower potential was calculated based on an estimated design flow (assuming the full reservoir capacity was released uniformly over a 270 day period), head between the full reservoir water surface elevation and the ground elevation at the powerhouse, 90 percent generator efficiency, 90 percent turbine efficiency, and an efficiency loss of 3 percent per mile of penstock.

2.3 Cost Estimation

2.3.1 Purpose

Relative construction costs were developed for the surface storage 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

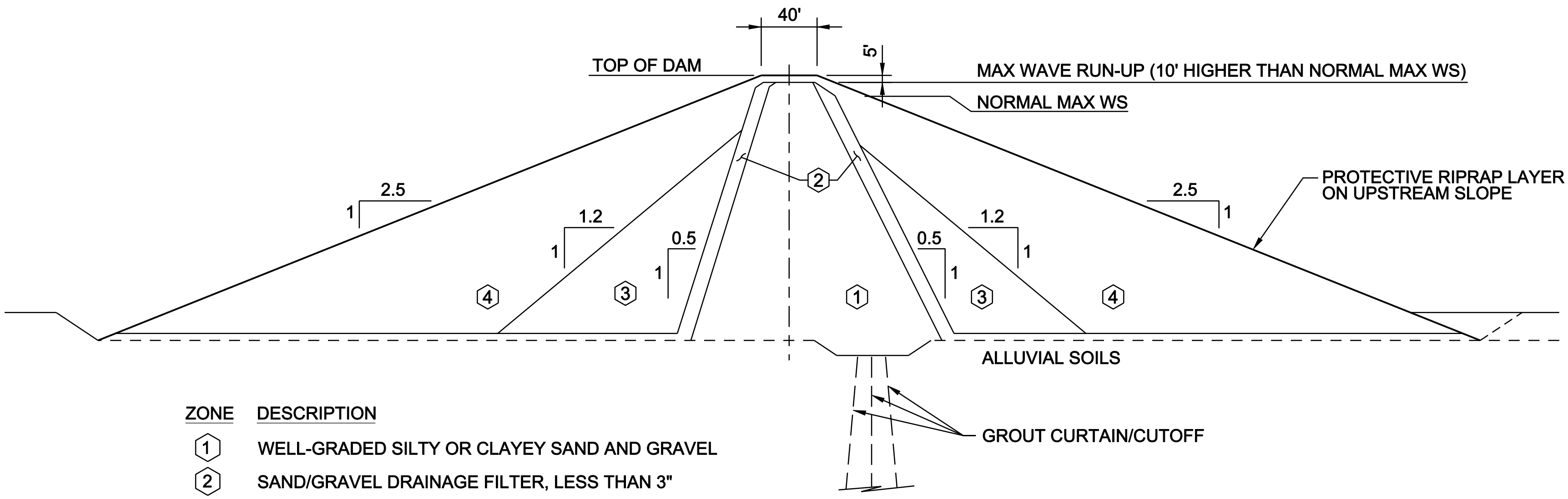
The Total Relative Construction Cost is not intended to represent all costs for the project, and therefore may be misleading if used as the sole basis for comparing relative costs by alternative. Some of the known costs that have been excluded include the following:

- Supplemental pumping and conveyance infrastructure for water distribution from the reservoir
- Provision for fish passage (upstream or downstream)
- 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

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

- Hydropower
- Water supply
- Emergency water supply or firm yield
- Recreation
- Supplemental fish flows
- Flood control

It should also be noted that only a limited number of alternatives and sub-alternatives have been evaluated. In some cases, potential variations or improvements to alternatives have been identified. Relative costs for revised alternatives should be considered separately if carried forward.



ZONE	DESCRIPTION
1	WELL-GRADED SILTY OR CLAYEY SAND AND GRAVEL
2	SAND/GRAVEL DRAINAGE FILTER, LESS THAN 3"
3	SAND/GRAVEL OR CRUSHED ROCK
4	SAND/GRAVEL OR COMPACTED ROCK FILL

Exhibit 2-3
Typical Dam Cross-Section

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2.3.3 Approach

A cost spreadsheet was developed to calculate relative, representative system costs for each dam-delivery system, broken out by the following major system components: stream diversion and intake, pump stations, pressure pipe, canals, dam embankment, spillway, outlet works, penstock and hydropower facilities. 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 Inflow

Many cost items were based on the design flow for each reservoir inflow source. Examples of flow-dependent system components include intakes with fish screens, pump stations, pipes, canals, penstocks and hydropower facilities.

See the *Part II Hydrology* sections (e.g., Section 3.3.1 for Lane Lake) for details on estimated annual inflow volumes available from each potential water source. Water rights and the potential to modify existing water rights were not evaluated at this stage, so the potential available water for diversion from each stream source was equated with the average excess spring runoff above baseflow. In general, the annual inflow volume from each source stream for each alternative or sub-alternative was based on maximizing withdrawals from those streams that were closest to the reservoir, and supplementing flows from more distant sources as required to equal the target reservoir storage volume.

The excess spring runoff typically occurs over a two to three month window from April to June. The exact timing of peak runoff will vary from year to year, and may be characterized by a series of separated floods. For consistency, it was assumed that 60 percent of the total reservoir capacity would be filled over 30 contiguous or non-contiguous high-flow days, and that the reservoir would be effectively empty at the start of the inflow cycle. The design flow rate was calculated as a steady inflow rate over the peak 30 days.

2.3.4.2 System Water Balance

At this stage, no accounting was done for direct precipitation on the reservoir. Nor were inflow sources increased to account for seepage losses during transmission, seepage losses in the reservoir, system evaporation losses, or other types of potential losses such as stream releases or canal wasteways. Canals were assumed to be concrete lined to minimize seepage losses during transmission and reduce maintenance costs. Because most other types of losses would primarily occur after the spring filling, such losses could not necessarily be made up through excess deliveries. Instead, losses could be accounted for by reducing the effective storage volume available to end users and balancing against direct precipitation inflows.

Water balance considerations were not evaluated at this stage and will depend on the elevation-capacity relationship for each reservoir, how the reservoir is operated, and whether drought conditions are considered.

2.3.4.3 Stream Diversion and Intake

It was assumed that at each stream from which water is withdrawn, 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 33rd percentile and 66th percentile inflow rates, 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).

2.3.4.4 Pump Stations

Pump station locations were identified in GIS where elevation gain was required for conveyance and could not readily be provided by a siphon. Booster pump stations in series were not considered. Pump station costs consisted of two components: installed cost per station and cost to supply power to each station.

The pump station cost was based on a 2002 CH2M HILL cost curve, factored up by 1.39 based on the ENR index ratio between the 3rd quarter of 2002 and the 4th quarter of 2011. The input to the cost curve was the pump station horsepower, which was calculated from the average lift for the pump stations on a given conveyance route, the design flow rate for that route, and a pump efficiency of 85 percent.

The cost to provide power to each pump station was a lump sum of $250,000, based on an average cost of $100,000 per mile and an assumed average distance of 2.5 miles to the nearest power source. Actual power sources were not identified.

2.3.4.5 Pressure Pipe

Pressure pipe was envisioned where conveyance required a lift or a siphon. These locations were identified in GIS. Costs were based on length and diameter of installed pipe, assuming steel pipe. Lift distances were measured horizontally and adjusted for sloped length based on the average lift height at the corresponding pump stations. Pressure pipe lengths for siphons were based on the approximate depth of each ravine crossed, and a standard V-shaped ravine with 5H:1V side slopes.

Installed pipe costs per linear foot were based on pipe costs for similar scale projects. For pipe up to approximately 80 inches in diameter, costs were based on a 2002 CH2M HILL cost curve, factored up by 1.39 based on the ENR index ratio between the 3rd quarter of 2002 and the 4th quarter of 2011. This curve was checked against a recent project and shown to provide reasonable results. However, for large pipe, the curve begins to depart from recent project records. Above 80 inch diameter (corresponding to roughly $10/dia-inch on the curve), we assigned a linearly increasing scale up to $15/dia-inch for 144-inch diameter pipe (consistent with the pipe price in Reclamation's Columbia River Mainstem Offchannel Storage Study). The input to the hybrid cost curve was pipe diameter, which was calculated based on the design flow rate and a target pipe velocity of 6 fps.

2.3.4.6 Canals

Canals were envisioned for conveyance where gravity flow was possible. Approximate canal routes were laid out in GIS to ensure gravity flow at a modest slope. Canal costs were based on six components, as summarized in Exhibit 2-4. Unit costs were selected as representative values for similar earthwork projects.

EXHIBIT 2-4
Canal Cost Components

Cost Component	Assumptions	Unit Costs
Liner Volume	Liner thickness and freeboard based on USBR Canal Design Guide.	$400 / CY
Excavation Volume	Base width (B), Manning's "n", minimum ratio of base width and flow depth (B/y), and minimum canal freeboard (F) based on USBR Canal Design Guide. Channel side slope and velocity generalized to 1.5H:1V and 3 fps, respectively, based on USBR Canal Guideline ranges. Increased B/y ratio by 20% above design minimum. Added 1 foot above minimum freeboard for average constructed freeboard in the field. Allowed flexible slope to fit other parameters. Assumed a flat lateral slope for a simple trapezoidal cut shape volume. No over-excavation to accommodate liner thickness.	$8.00 / CY
Local Fill Volume	50% of excavated volume to fill uneven terrain and construct side embankments as need to cross shallow depressions and ravines.	$8.00 / CY
Long-Haul Volume	50% of excavated volume to fill distance depressions/ravines or dispose off site.	$14.00 / CY
Parallel Gravel Access Road	Width of road and one road or two based on USBR Canal Design Guide. 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)

2.3.4.7 Dam – Embankment

Embankment costs were based on total embankment volume, a "Remoteness Factor" and a "Foundation Factor." The representative unit cost ($10/CY) represents a weighted average of all embankment materials, including relatively low-cost local cut and fill and higher-cost imported materials such as low-permeability core material, filter/seepage material, riprap, and foundation treatment. Site-specific adjustment to this unit cost was facilitated by providing two subjective factors to account for perceived site challenges. Future refinements will be possible once site-specific borrow locations, material properties, embankment dimensions, and volumes are developed.

2.3.4.8 Dam – Spillway

Spillway costs were based on abutment cut volume at an excavation price of $20/CY, a subjective "Site Factor," and a lump sum allowance of $1 million to provide a concrete weir and lining, a spillway chute, and a stilling basin. Future refinements will be possible once inflow design floods and specific spillway concepts are developed.

2.3.4.9 Dam - Outlet Works

A lump sum base allowance of $1 million dollars was assigned to a standard 150-ft high tower outlet configuration. This base cost was then scaled up and down based on the ratio of the dam height to the 150-ft standard. An additional "Site Factor" was included to allow for subjective site conditions.

2.3.4.10 Penstock

Penstock costs were calculated using the same cost curve and target velocity used for pressure pipe. The design flow rate and resulting pipe diameter was based on discharging 80 percent of the total reservoir storage capacity uniformly over 270 days. This allows for reservoir loss and seasonal powerhouse operation, and results in an 8 percent higher discharge rate than uniformly releasing the full reservoir capacity over 365 days.

2.3.4.11 Hydropower

Hydropower costs were based on the same cost curve used for pump stations, but using output power in place of input power. The full reservoir head above the stream was used for powerhouse costs. Detailed operational scenarios, including variable reservoir head, were not evaluated. KW output was based on 90 percent generator efficiency, 90 percent turbine efficiency, and an efficiency loss of 3 percent per mile of penstock.

2.3.5 Total Relative Construction Cost

Exhibit 2-5 presents the rolled-up costs from the calculation spreadsheet for each system component for one example sub-alternative. System component costs were then 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 percent to account for unlisted construction items, and by 5 percent to account for mobilization. Together, the Base Field Cost, unlisted items, and mobilization sum to the Field Cost without Contingency. Adding a 30 percent contingency for uncertainty produces the Total Field Cost. Non-field costs (such as engineering, permitting, legal and administrative costs) are calculated as 30 percent of the Total Field Cost and were added to produce a relative Total Relative Construction Cost for comparing alternatives.

EXHIBIT 2-5
Relative Construction Cost for the Lane Lake – Teton (LL-T) Sub-Alternative

Component	Quantity	Unit	Cost Basis	Estimated Costs
Stream Diversion and Intake	1	No.	diversion structures, intakes with fish screens	$2,742,667
Pump Stations	1	No.	horsepower (lift and design flow)	$66,487,253
Pressure Pipe	0.8	Miles	design flow, length and diameter	$9,278,533
Canals	0.0	Miles	excavation, liner, local and distant fill, parallel gravel access road	$0
Dam - Embankment	4,330,000	CY	embankment, remoteness factor, foundation factor	$62,352,000
Dam - Spillway	266,667	CY	spillway excavation, lump sum (weir, chute, stilling)	$6,333,333
Dam - Outlet Works	1	LS	embankment, foundation factor, remoteness factor, spillway excavation, spillway, outlet, site factors	$1,633,333
Penstock	2.9	Miles	design flow, length and diameter	$8,270,266
Hydropower	3,108	KW	KW (head and design flow), penstock length and diameter	$6,263,718
Base Field Cost				$163,361,103
Unlisted Items (20%)				$32,672,221
Mobilization (5%)				$8,168,055
Field Cost w/out Contingency				$204,201,379
Contingency (30%)				$61,260,414
Total Field Cost				$265,461,792
Non-Field Cost (30%)				$79,638,538
Total Relative Construction Cost				$345,100,330

2.4 Basin Water 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 sections 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 surface water storage 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 surface water storage 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

State regulatory processes should be considered in the evaluation of new storage projects, and some of the relevant laws and policies include the following:

- Water rights:
  - The necessary water rights must be obtained and administered in accordance with state law including Chapter 2, Title 42, Idaho Code.

- For new water right permit applications, Section 42-203A requires that the following criteria be considered:
  - whether the proposed use will reduce the quantity of water under existing water rights, or
  - whether the water supply itself is insufficient for the purpose for which it is sought to be appropriated, or
  - whether it appears to the satisfaction of the director that such application is made in good faith, is not made for delay or speculative purposes, or
  - whether the applicant has sufficient financial resources with which to complete the work involved therein, or
  - whether it will conflict with the local public interest as defined in section 42-202B, Idaho Code, or
  - whether it is contrary to conservation of water resources within the state of Idaho, or
  - whether it will adversely affect the local economy of the watershed or local area within which the source of water for the proposed use originates, in the case where the place of use is outside of the watershed or local area where the source of water originates.

- A new project should be consistent with policies set forth in the State Water Plan implemented by the Idaho Water Resource Board (IWRB). Pertinent policies include:
  - State protected river designations: When designated as a natural river in accordance with Section 42-1734A, Idaho Code, the following activities are prohibited:
    - Construction or expansion of dams or impoundments
    - Construction of hydropower projects
    - Construction of water diversion works
    - Dredge or placer mining
    - Alterations of the stream bed
    - Mineral or sand and gravel extraction within the stream bed
  - 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.
  - State minimum stream flow water rights: Management of the Snake River consistent with minimum stream flow water rights established at the Milner, Murphy, Weiser, Johnson Bar and Lime Point gaging stations is fundamental to State policy. In addition, a number of minimum stream flow water rights have been developed in the Henrys Fork Basin. Each minimum stream flow was established to address specific management objectives, and together, the minimum stream flows form an integrated plan for management of the Basin and Snake River as a whole. The basis and intention of the minimum stream flows as well as the current management of the system should be included in the evaluation of a new project tributary to the Snake River to ensure consistency with the State Water Plan and State regulatory obligations.
  - Eastern Snake Plain Aquifer Comprehensive Aquifer Management Plan (ESPA CAMP 2009): The long-term goal of the ESPA CAMP is to incrementally achieve an annual net addition of 600,000 af to the aquifer water budget, with a short-term target of between 200,000 af and 300,000 af. A new project in the Henrys Fork Basin should support the ESPA CAMP objectives.

- Pursuant to Section 42-1737, Idaho Code, approval by the IWRB is required for all project proposals involving the impoundment of water in a reservoir with an active storage capacity in excess of 10,000 af.

- Water Quality Certification from the Idaho Department of Environmental Quality in connection with the Federal Clean Water Act.
- Obtain approval of engineering designs, operation, and maintenance through the Idaho Safety of Dams program.
- Stream Channel Alteration Permit for improvements made to the channel to accommodate flood flows and routine releases.
- Coordinate with the IDWR floodplain manager to confirm compliance with the National Flood Insurance Program (NFIP) requirements in Idaho.

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

- <u>Hydrology is uncertain</u>: Legal water available is not known. Physical water availability has been approximated based on regression equations, but actual runoff has not been measured, and firm yield has not been evaluated. Complete water balance and refined operations have not been evaluated.
- <u>Storage potential is preliminary</u>: A limited number of site and alignment alternatives have been explored, and judgment has been used to balance maximum storage potential with efficient embankment configurations.
- <u>Embankment configurations are generalized</u>: Site-specific materials and material properties have not been evaluated, and optimized dam approaches have not been proposed.
- <u>Cost estimates are comparative and preliminary</u>: Future concept refinements could potentially change the ranking of alternatives by cost. Costs are relative and are not intended for budgeting.
- Geologic and geotechnical site facility analysis is based on available geologic literature, soil mapping, and review of geotechnical literature and reports. No field reconnaissance or geologic mapping was conducted as part of this investigation and analysis.
- No quantitative hazards analysis was performed.
- 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.

2.9 Data Sources

2.9.1 Storage and Needs Studies

- Bureau of Reclamation (Reclamation). 2012. Draft Henrys Fork Watershed Basin Study Water Needs Assessment, March.
- Idaho Water and Energy Resources Research Institute (IWRRI). 1981. A Preliminary Appraisal of Offstream Reservoir Sites for Meeting Water Storage Requirements in the Upper Snake River Basin, for the U.S. Army Corps of Engineers, Walla Walla District, February.
- Idaho Water Resource Board (IWRB). 1992. Comprehensive State Water Plan – Henrys Fork Basin.
- Van Kirk, R., Rupp, S., and J. De Rito. 2011. Ecological Streamflow Needs in the Henrys Fork Watershed, September.

2.9.2 Hydrology

- United States Geological Survey (USGS), 2011, StreamStats Idaho: http://water.usgs.gov/osw/streamstats/idaho.html

  Six reports document the regression equations available in StreamStats for Idaho, the errors associated with the estimates, and the methods used to develop the equations and to measure the basin characteristics used in the equations.

  - Hortness, J. E., and Berenbrock, Charles, 2001, Estimating Monthly and Annual Streamflow Statistics at Ungaged Sites in Idaho : U.S. Geological Survey Water Resources-Investigations Report 01-4093, 36 p.
  - Berenbrock, Charles, 2002, Estimating the Magnitude of Peak Flows at Selected Recurrence Intervals for Streams in Idaho: U.S. Geological Survey Water Resources-Investigations Report 02-4170, 59 p.
  - Hortness, J. E., and Berenbrock, Charles, 2001, 2003, Estimating the Magnitude of Bankfull Flows for Streams in Idaho : U.S. Geological Survey Water Resources-Investigations Report 03-4261, 36 p.
  - Hortness, J.E., 2006, Estimating low-flow frequency statistics for unregulated streams in Idaho: U.S. Geological Survey Scientific Investigations Report 2006-5035, 31 p.
  - Wood, M.S., Rea, Alan, Skinner, K.D., and Hortness, J.E., 2009, Estimating locations of perennial streams in Idaho using a generalized least-squares regression model of 7-day, 2-year low flows: U.S. Geological Survey Scientific Investigations Report 2009-5015, 26 p.
  - Rea, Alan, and Skinner, K.D., 2009, Estimated perennial streams of Idaho and related geospatial datasets: U.S. Geological Survey Data Series 412, 32 p.

2.9.3 Geotechnical Review

- Aerial photographs: National Agriculture Imagery Program (NAIP). 2009. 1-meter color imagery (GIS-based web service).
- Soil maps: NRCS 1:24,000 soil map units (1988).
- Topographic maps: USGS 1:24,000 Quadrangle (GIS-based web service).
- Available water well logs in the vicinity of the project.
- Gilbert, J.D., Ostenaa, D., and C. Wood. 1983. Seismotectonic Study, Island Park Dam and Reservoir, Minidoka Project, Idaho-Wyoming. Bureau of Reclamation, Seismotectonic Report 83-1.
- Gilbert, J.D., Ostenaa, D., and C. Wood. 1983. Seismotectonic Study, Jackson Lake Dam and Reservoir, Minidoka Project, Idaho-Wyoming. Bureau of Reclamation, Seismotectonic Report 83-8.

- Patrick, D.M., and C.B. Whitten. 1981. Geological and Seismological Investigations at Ririe Dam, Idaho, Miscellaneous Paper GL-81-7, for the U.S. Army Corps of Engineers, Walla Walla District, September.
- URS Greiner Woodward Clyde. 2000. Preliminary Probabilistic Seismic Hazard Analyses: Island Park, Grassy Lake, and Jackson Lake Dams – Minidoka Project; Palisades Dam – Palisades Project; Ririe Dam – Ririe Project; Eastern Idaho and Western Wyoming, for the Bureau of Reclamation, June.

2.9.4 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.
- Cost indices: Engineering News-Record. 2012. http://enr.construction.com/economics/historical_indices/
- Proprietary projects with similar design components

2.9.5 Crosscut Canal

- Reclamation. 1936. Crosscut Canal Profile and Sections, Upper Snake River Project-Idaho.

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Part II – Alternative Evaluation Results

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SECTION 3

Lane Lake Dam

3.1 Alternative Description

3.1.1 Overview

The Lane Lake alternative features a proposed new 170-foot-tall off-channel dam and a 68,000 acre-feet (af) reservoir. The dam site is located in the Teton watershed on a generally dry drainage that is situated about one mile north of the Teton River and five miles downstream of the Bitch Creek confluence. Water for the reservoir could be supplied from several sources, including the Teton River, Conant Creek, Falls River, and Bitch Creek. Optional supply from the Teton River would require pumping. When full, Lane Lake could provide a roughly 500-foot drop to a proposed new hydropower facility on the Teton River.

3.1.2 Alternative Variations

The following sub-alternatives were identified by varying potential water-supply sources. Conveyance routes for the sub-alternatives are collectively shown on Exhibits 3-2 and 3-4. Specific conveyance lengths and features are summarized below in Section 3.3.2 – *Conveyance.*

- LL-T: Lane Lake supplied by the Teton River (pumped-storage with no canal)
- LL-CoF: Lane Lake supplied by Conant Creek and Falls River (both gravity-flow canals)
- LL-B: Lane Lake supplied by Bitch Creek (gravity-flow canal)
- LL-F: Lane Lake supplied by Falls River (gravity-flow canal)

3.1.3 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 evaluate potential water availability and design flow to identify sub-alternatives and develop relative costs.

3.2 Key Findings

Lane Lake would provide additional storage water for the Teton Basin, effectively enhancing water supply by capturing excess peak flows and redistributing that water during periods of higher demand. The available storage would enhance the in-basin water budget by diverting 68,000 af during the annual high flow period and storing that water until more critical, higher demand periods. This storage water could help satisfy unmet irrigation demands in the Lower Watershed and Egin Bench irrigated regions. Reservoir releases during low flow periods would improve connectivity in downstream river segments, including the North Fork Teton River, South Fork Teton River, and the Lower Henrys Fork River, which have all been identified as having additional ecological streamflow needs. Diversions would typically occur during periods when connectivity is not an issue, but nonetheless withdrawals may be expected to impact a core conservation population of Yellowstone cutthroat trout in Bitch Creek and conservation populations in Conant Creek, Falls River, and the Teton River. The out-of-basin water budget would be temporarily reduced by up to 68,000 af during the annual high flow period when water is diverted to the reservoir, but some or all of that quantity may be available at a later time 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). The site may be prone to high seepage rates, and measures intended to maintain structural stability by limiting seepage led to elevated estimated construction costs. Exhibit 3-1 provides a tabular summary of the key findings.

EXHIBIT 3-1
Key Findings from the Reconnaissance Evaluation

Estimated Cost per af	Impact on In-Basin Water Budget	Impact on Out-of-Basin Water Budget	Change in Connectivity of Impacted River Segment
$3,900 - $5,100	68,000 af, to be diverted during the annual high flow period and released during high demand periods.	68,000 af reduction during the annual high flow period, in accordance with priority rights. Part or all of this quantity would be available later for out-of-basin needs.	Improvement in connectivity of downstream river segments, including North Fork Teton River, South Fork Teton River, and the Lower Henrys Fork River. Potential impacts to supply sources, including Bitch Creek, which contains a core conservation population of Yellowstone cutthroat trout, and Conant Creek, Falls River, and the Teton River, which contain conservation populations.

3.3 Engineering Results

3.3.1 Hydrology

Four potential water supply sources were identified: Teton River, Conant Creek, Falls River, and Bitch Creek (Exhibit 3-2). Exhibit 3-3 presents a summary of potentially available water from each source based on analyses using StreamStats (USGS, 2011; see Section 2.2.1 – *Hydrology*).

RECLAMATION
Managing Water in the West

Henrys Fork Basin Study, Idaho and Wyoming
Lane Lake Dam Alternative: Hydrology

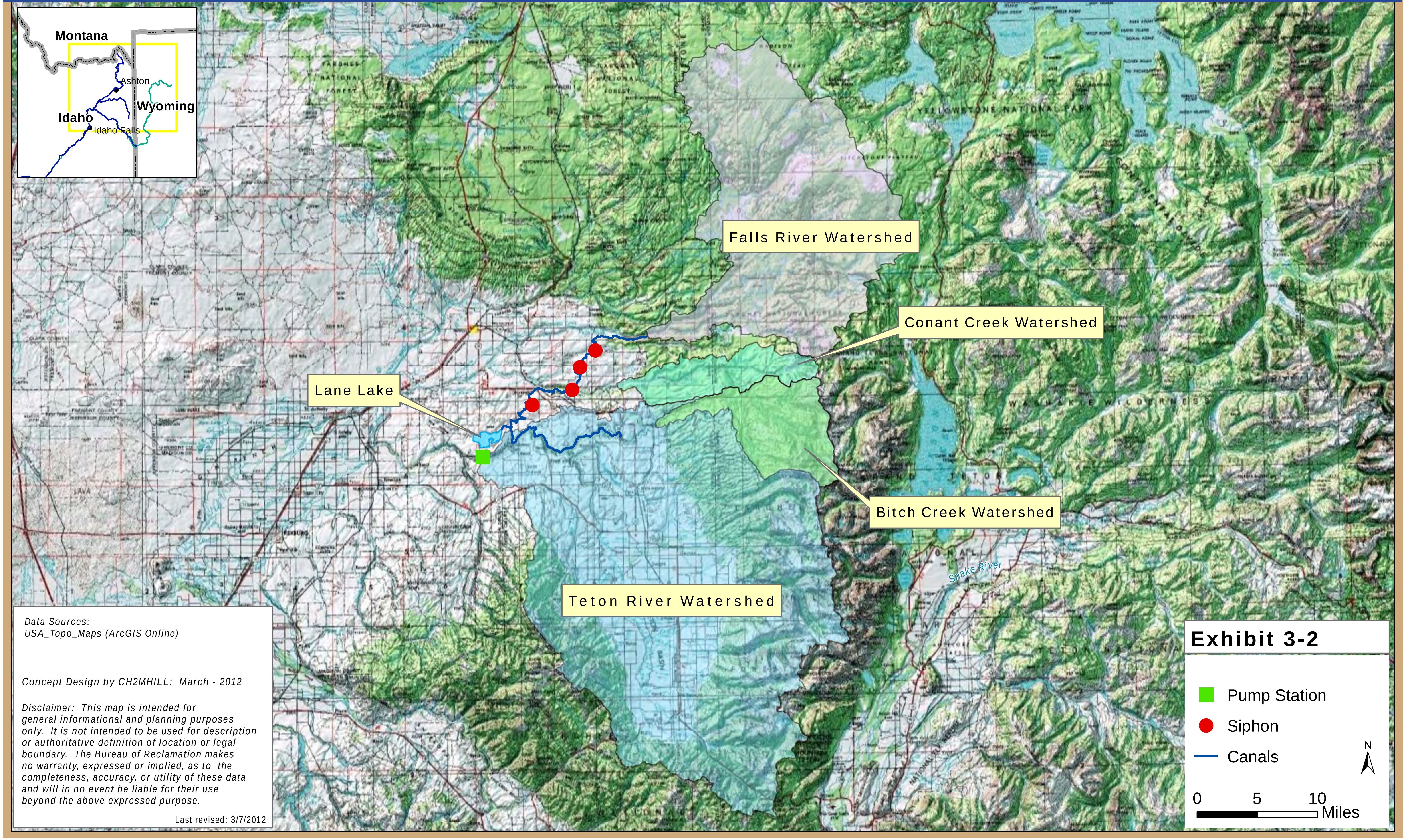

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EXHIBIT 3-3
Water Potentially Available for Storage at Lane Lake

Source	Watershed Area (sq. mi)	Quantity (af/year)
Hog Hollow (impounded drainage)	Negligible	0
Teton River[1]	720.5	668,160
Conant Creek	43.9	19,210
Falls River	322.8	146,920
Bitch Creek	65.9	67,820

[1] – Quantity reported for regulated systems is total estimated water in system. Excess spring runoff calculation was considered invalid for these systems because of upstream dam regulation.

3.3.2 Conveyance

Water supply routes were established from each source, using a combination of pressurized pipelines, canals, and siphons, as depicted in Exhibit 3-4. Conveyance routes are conceptual, and are intended only to provide a basis for relative cost comparison, rather than reflect actual alignments and features for design. Exhibit 3-5 summarizes the key physical characteristics of each sub-alternative.

EXHIBIT 3-5
Lane Lake Sub-Alternative Characteristics

			Conveyance Length (mi)	
Sub-Alternative	Source	Volume Diverted (af/year)	Canal	Pipe[1]
LL-T	Teton River	68,000	0.0	0.8
LL-CoF	Conant Creek	19,210	4.5	0.0
	Falls River	48,790	11.6	0.4
	Combined	0[2]	12.4	0.1
LL-B	Bitch Creek[3]	67,820	15.7	0.4
LL-F	Falls River	68,000	24.0	0.5

[1] – Pipe length includes siphons and pressurized pipe from pump stations, if applicable.
[2] – No additional diversion at the confluence of canals from Conant Creek and Falls River. Total conveyed quantity of canal segment is 68,000 af/yr.
[3] – The potentially available water in Bitch Creek was less than the desired volume of Lane Lake, but it was not considered economically warranted to construct the infrastructure needed to supplement that small deficit with another source.

Other conveyance features were also assessed during the evaluation including stream diversions, intake and fish screen structures, pump stations, and siphons. Those features are accounted for in the cost estimate, and the procedures used to identify and size those features are documented in Section 2.3.4 – *Cost Basis*.

3.3.3 Dam Configuration

A rockfill or granular earthfill dam would be constructed to impound Lane Lake. The cross-section presented in Exhibit 2-3 shows a typical configuration for the proposed dam at this location, which features a central core with filter blanket drains and earthfill/rockfill shells. A concrete grout curtain/cutoff would also be required to limit seepage through the dam foundation. The bottom of the valley at the proposed dam location is at an approximate elevation of 5,415 feet and the top of the dam would be at an approximate elevation of 5,585 feet for a maximum height of about 170 feet. The length of the dam at this elevation would be about 3,100 feet. The resulting reservoir would have about 68,000 af of storage with a maximum surface area of 1,270 acres. Exhibit 3-6 shows the general locations for the dam, appurtenant structures, and emergency spillway.

A potential spillway alignment has been identified on the left abutment, and the dam would require a low-level outlet that provides a safe way to drain the reservoir and integrate with ultimate water distribution and hydropower schemes. The lowest part of the existing valley is located near the right abutment, which would serve as a likely location for the outlet. The depth to rock along this alignment is unknown but steep slopes and rock mapping along the sides of the valley suggest that rock could be encountered at relatively shallow depths on the slopes.

The dam foundation is expected to consist of alluvial and/or colluvial materials in the valley bottom, and colluvium overlying tuff at the abutments. The depth of overburden and the thickness of sediments that fill the valley are unknown. The proposed Lane Lake site is in Hog Hollow, which is a fault-bounded valley formed by extension and faulting. The resultant opening of this pull-apart valley has exposed older unconsolidated sediments (older alluvium) in the valley floor that underlie the Huckleberry Ridge Tuff. Based on geologic mapping, this older alluvium underlies the entire valley bottom in Hog Hollow and consists of tuffaceous gravel, sand and clay, with local basalt interbeds. This unit would underlie the dam foundation and therefore the depth to competent rock is not known and could potentially be buried under a large thickness of alluvial sediments. In addition, these unconsolidated sediments are not anticipated to be saturated and could potentially be highly permeable. An escalated foundation factor was included in the cost estimate to help account for potential seepage remedies, but further investigations to address seepage cutoff requirements would be required during future phases of this study. Exhibit 3-7 presents a geologic profile along the dam axis to highlight geologic features that could affect the foundation.

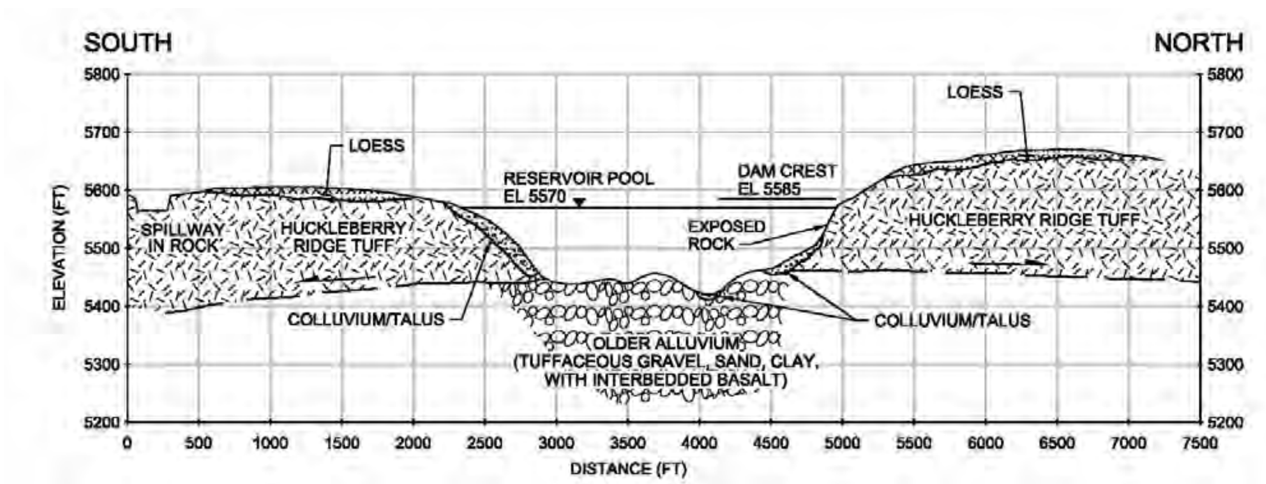
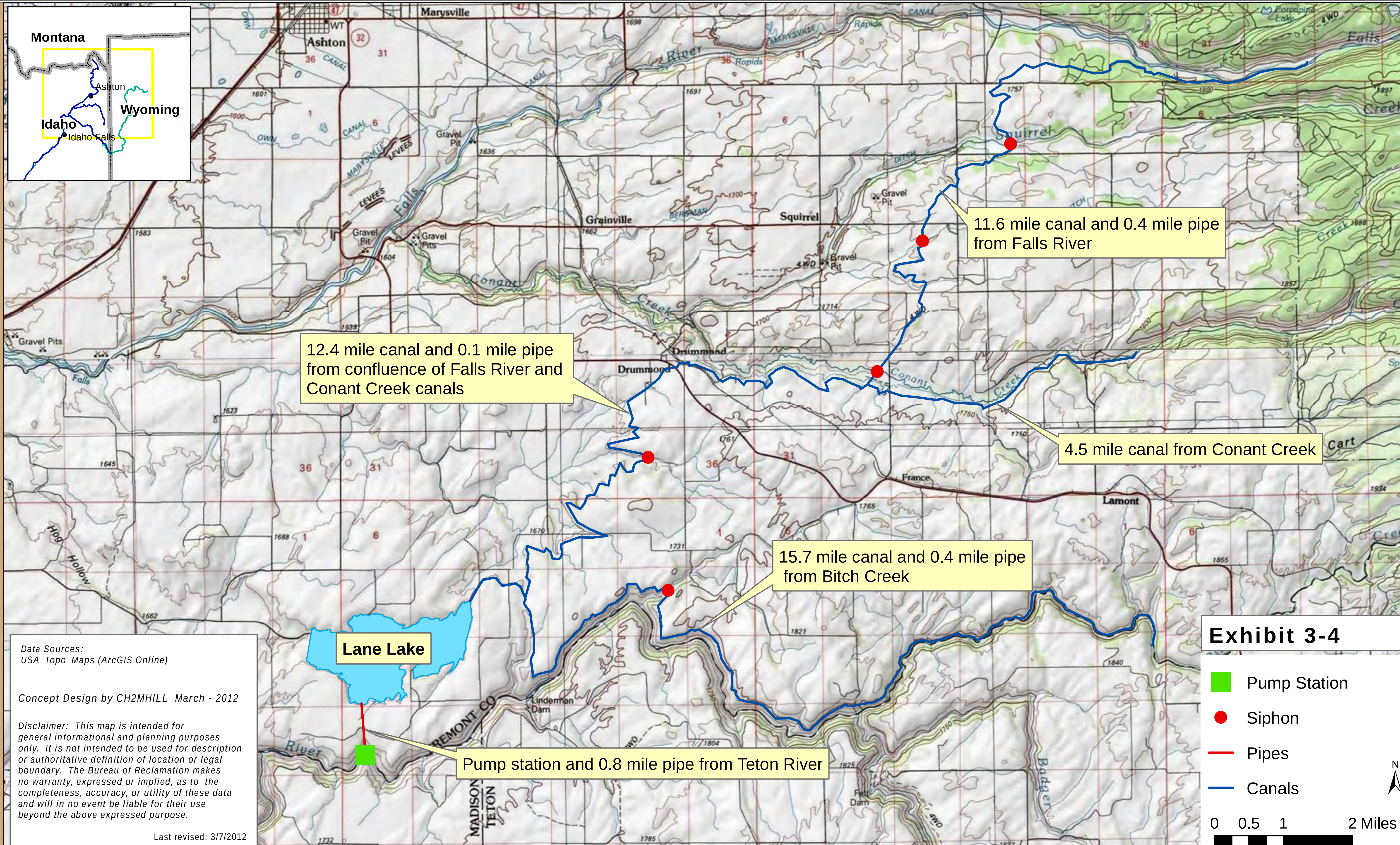


EXHIBIT 3-7
Lane Lake Dam Geologic Profile



Data Sources:
USA_Topo_Maps (ArcGIS Online)

Concept Design by CH2MHILL March - 2012

Disclaimer: This map is intended for general informational and planning purposes only. It is not intended to be used for description or authoritative definition of location or legal boundary. The Bureau of Reclamation makes no warranty, expressed or implied, as to the completeness, accuracy, or utility of these data and will in no event be liable for their use beyond the above expressed purpose.

Last revised: 3/7/2012

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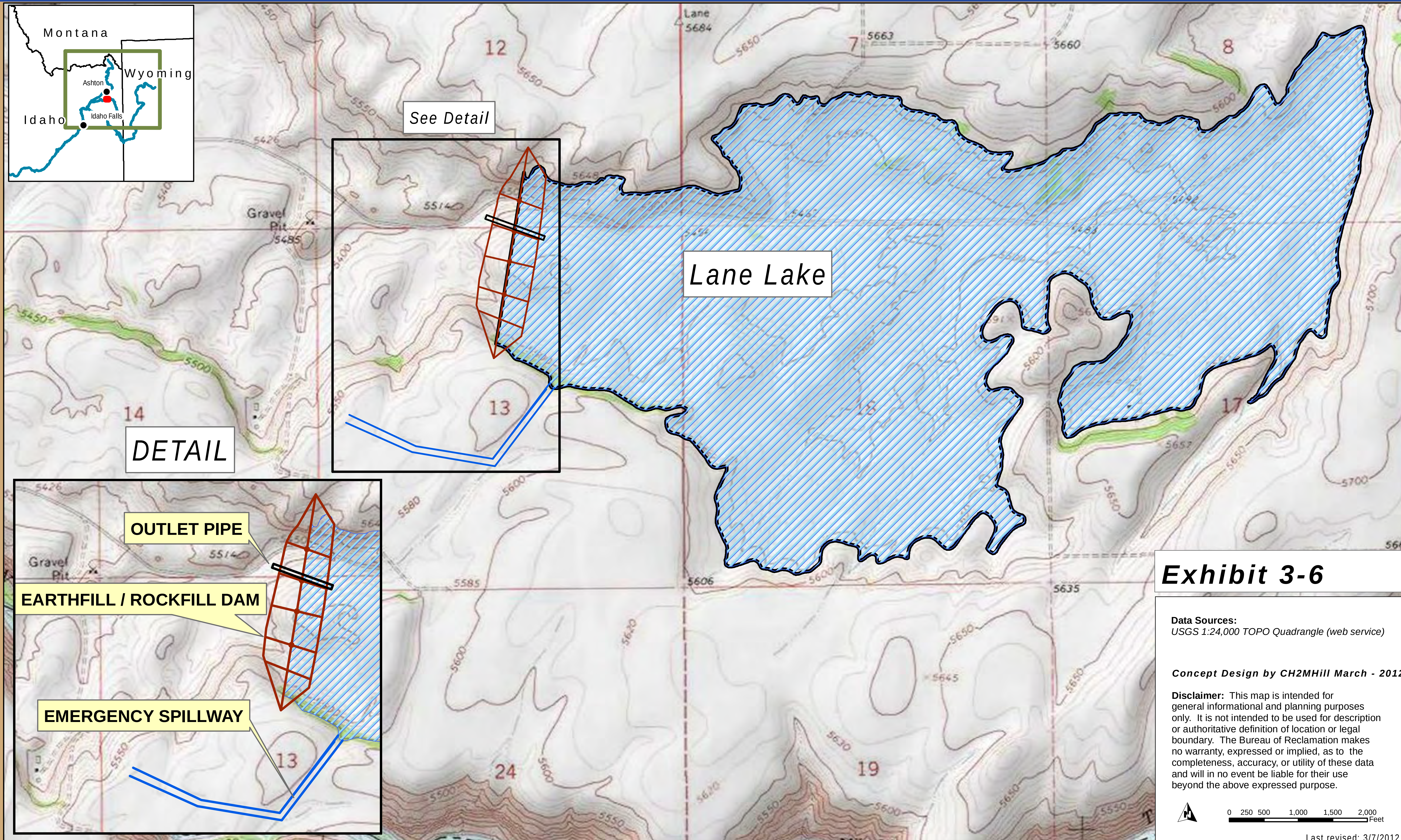
RECLAMATION
Managing Water in the West

Henrys Fork Basin Study, Idaho and Wyoming
Lane Lake Dam Alternative: Dam and Appurtenant Structures



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3.3.4 Hydropower Potential

As presented in Exhibit 3-8, hydropower potential associated with Lane Lake would be approximately 3,100 kW.

EXHIBIT 3-8
Lane Lake Hydropower Potential

Sub-Alternative	Design Flow (cfs)	Penstock Length (mi)	Head (ft)	Power Potential (kW)
All	101	2.9	500	3,100

3.4 Cost Estimate

A summary of the cost per acre-foot of water stored for each sub-alternative is presented in Exhibit 3-9. These costs include hydropower facilities. The site may also be prone to high seepage rates, so an escalated foundation factor was included in the cost estimate to help account for measures intended to limit seepage.

EXHIBIT 3-9
Lane Lake Sub-Alternative Cost Estimates[1]

Sub-Alternative	Storage Volume (af)	Total Construction Cost	Cost Per Unit Yield ($/af)
LL-T	68,000	$345,100,000	5,100
LL-CoF	68,000	$315,650,000	4,600
LL-B	67,820	$266,820,000	3,900
LL-F	68,000	$307,790,000	4,500

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

3.5 Basin Water Needs

The storage provided by Lane Lake would enhance the in-basin water budget by diverting 68,000 af during the annual high flow period and storing that water until more critical, higher demand periods during the summer and early fall. Water stored in the reservoir could help satisfy unmet irrigation demands in the Egin Bench (more water available in the Henrys Fork because of reduced need for diversions into the Crosscut Canal) and Lower Watershed irrigated regions (Reclamation, 2012). Reservoir releases would also be used to enhance ecological in-stream flows (see Section 3.7.2 – *Change in Connectivity*).

The out-of-basin water budget would be temporarily reduced by up to 68,000 af during the annual high flow period when water is diverted to the reservoir, but some or all of that quantity may be available at a later time for numerous out-of-basin uses, including needs resulting from climate change; agricultural needs; domestic, municipal, and industrial needs; ecological needs; and for recharge of the ESPA (Reclamation, 2012).

3.6 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*.

3.7 Environmental Benefits and Impacts

3.7.1 Impacted River Segments

River segments potentially impacted by various sub-alternatives include the Teton River, Conant Creek, Falls River, and Bitch Creek, as identified in Exhibit 3-10.

3.7.2 Change in Connectivity

Potential impacts to river connectivity consist of decreased flow (diversions to the reservoir) for river segments providing reservoir supply and increased flow for river segments receiving reservoir releases. As described in Section 2.2.1.3 – *Potentially Available Water*, diversions would likely occur during the excess spring runoff period and reservoir releases would likely occur during more critical low flow periods. Potential impacts to connectivity of each impacted river segment are identified in Exhibit 3-10. In addition to the segments listed in Exhibit 3-10, enhanced connectivity would be experienced in other downstream river segments, including the North Fork Teton River, South Fork Teton River, and the Lower Henrys Fork River, which have all been identified as having additional ecological streamflow needs (Van Kirk et al., 2011).

3.7.3 State Aquatic Species of Special Concern

The reservoir inundation area is not in Yellowstone cutthroat trout habitat. However, potential modifications to the hydrology of Bitch Creek would impact a core conservation population, which is defined as a population with greater than 99 percent Yellowstone cutthroat trout genes, and potential modifications to the hydrology of Conant Creek, Falls River, and the Teton River would impact conservation populations, which are defined as having less than 10 percent genetic introgression from other species. State Aquatic Species of Special Concern in potentially impacted river segments are indicated in Exhibit 3-10.

3.7.4 Other Environmental Factors

The proposed Lane Lake inundation area contains both winter range and migration corridors for big game, according to Trout Unlimited (TU), Friends of the Teton River (FTR), American Rivers (AR), and the Idaho Department of Fish and Game (IDFG). The United States Fish and Wildlife Service (USFWS) tracks one federally listed threatened species, the grizzly bear, and one candidate species, the wolverine, in the area. The bald eagle, sandhill crane, sharp-tailed grouse, and trumpeter swan, considered at-risk by the Bureau of Land Management (BLM) and the United States Forest Service (USFS), also make their homes here. Data from the National Wetlands Inventory (NWI) indicate construction at this 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. Hydrologic changes to the water source brought about by the proposed construction would also have indirect impacts on a stretch of Teton River that is eligible for Wild and Scenic River status designation and on Conant Creek that is designated as a State Natural and Recreational River.

Potential wildlife habitat impacts, federally listed species, and wetlands habitat impacts within the reservoir inundation area are also summarized in Exhibit 3-11, while State of Idaho aquatic species of special concern (Yellowstone cutthroat trout and rainbow trout) and special river designations for all potentially impacted river segments are summarized in Exhibit 3-10.

3.8 Land Management, Recreation and Infrastructure impacts and benefits

Lane Lake is located on private land, has a low recreation and economic rating, and is rated as having few potential infrastructure impacts, as summarized in Exhibit 3-12.

Exhibit 3-10

Impacts to Connectivity, State Aquatic Species of Special Concern, and Special River Designations for Affected River Reaches

Surface Storage Site	Sub-Alternative	Impacted River Segments	Connectivity: Flow Decrease (Supply Source)	Connectivity: Flow Increase (Receives Reservoir Releases)	State Aquatic Species of Special Concern: Yellowstone Cutthroat Trout (YCT) Presence	Rainbow Trout (RBT) Priority Fishery[b]	YCT Conservation and Management Tier[c] and RBT Fishery Rating	Special Designation[a]: BLM/USFS Eligible Stream	State Natural River	State Recreational River	Designated Wilderness[d]	Rating
Lane Lake	LL-T	Teton River	•	•	•		YCT Conservation	•				Eligible Federal
Lane Lake	LL-CoF	Conant Creek	•		•		YCT Conservation		•	•		State
		Falls River	•		•		YCT Conservation	•		•		State/ Eligible Federal
		Teton River		•	•		YCT Conservation	•				Eligible Federal
Lane Lake	LL-B	Bitch Creek	•		•		YCT Core	•	•	•		State/ Eligible Federal
		Teton River		•	•		YCT Conservation	•				Eligible Federal
Lane Lake	LL-F	Falls River	•		•		YCT Conservation	•		•		State/ Eligible Federal
		Teton River		•	•		YCT Conservation	•				Eligible Federal

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

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Exhibit 3-11

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

Surface Storage Site	Wildlife Habitat[a]			Federally Listed Species			Wetland/Habitat Value	
	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
Lane Lake	•[1]	•[2]	Winter Range	bald eagle, sandhill crane, sharp-tailed grouse, trumpeter swan	grizzly bear, wolverine[b]	Federal Terrestrial/ Sensitive	•	Minimal

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) and personal communications with the Henrys Fork Foundation.

[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
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	<1 Acre

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Exhibit 3-12

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

	Land Management Data[a]					Recreation/Economic Value								Infrastructure[d]				
Surface Storage 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
Lane Lake	•				Private								Low	•		•		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

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3.9 Assumptions and Limitations

General assumptions and limitations applicable to all of the surface-storage alternatives are described in Section 2.8 – *Key Assumptions and Limitations*. Additional assumptions and limitations specific to this alternative are listed below:

- Excavation for the open spillway would likely be in colluvial soils and/or rock. It is possible that the spillway may be in soft erodible materials and if an open channel spillway is used, it may require concrete or rock linings that are suitable to match the intended spillway flows. A lined concrete spillway was assumed for costing purposes. Alternative spillway approaches should also be investigated once the inflow design flow has been established and local site conditions are better understood.
- Since the natural watershed is only slightly larger than the reservoir itself, natural runoff from the watershed would be very low.

3.10 Evaluation Criteria

3.10.1 Stakeholder Group Measurable Criteria

There are four Stakeholder Group Measurable Criteria, with results summarized in Exhibit 3-13:

- Water Supply: The net change for in basin and out of basin water budgets in af 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 3.6.
- Environmental Considerations: Environmental benefits and impacts are summarized above in Section 3.7.
- Economics: The estimated reconnaissance-level field cost to construct the project is summarized in Section 3.4.

EXHIBIT 3-13
Stakeholder Group Measurable Criteria Summary

Stakeholder Group Measurable Criteria	Criteria Characterization
Water Supply (in-basin water transfer potential)	68,000 af/yr
Water Supply (out-of-basin water transfer potential)	68,000 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)	$266,820,000 - $345,100,000

[1] – Net environmental impact would depend on water sources and reservoir operations; further analysis required in future phase of study.

3.10.2 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.

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SECTION 4
Spring Creek Dam

4.1 Alternative Description

4.1.1 Overview

The Spring Creek alternative features a proposed new 180-foot-tall dam and a 20,000 af reservoir. The dam site is located in the Teton watershed on the Spring Creek headwater tributary where it joins Canyon Creek. Water for the reservoir could be supplied from several sources, including Spring Creek, Canyon Creek, the Teton River, and Bitch Creek. Pumping from the Teton River or Bitch Creek would be required to satisfy storage objectives. When full, Spring Creek Reservoir could provide a roughly 160-foot drop to a proposed new hydropower facility on Spring Creek at the base of the dam.

4.1.2 Alternative Variations

The following sub-alternatives were identified by varying potential water-supply sources. Conveyance routes for the sub-alternatives are collectively shown on Exhibits 4-2 and 4-4. Specific conveyance lengths and features are summarized below in Section 4.3.2 – *Conveyance.*

- S-Ca: Spring Creek Reservoir supplied by Spring Creek (natural inflow to reservoir) and Canyon Creek (gravity-flow canal). Water sources for this sub-alternative would not provide the full 20,000 af annual storage objective (see Exhibits 4-5 and 4-9).
- S-CaT: Spring Creek Reservoir supplied by Spring Creek (natural inflow to reservoir), Canyon Creek (gravity-flow canal), and the Teton River (combination pump station, pipe, and gravity-flow canal)
- S-T: Spring Creek Reservoir supplied by Spring Creek (natural inflow to reservoir) and the Teton River (combination pump station, pipe, and gravity-flow canal)
- S-B: Spring Creek Reservoir supplied by Spring Creek (natural inflow to reservoir) and Bitch Creek via the Teton River (combination pump stations, pipe, and gravity-flow canal)

4.1.3 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 evaluate potential water availability and design flow to identify sub-alternatives and develop relative costs.

4.2 Key Findings

Spring Creek Reservoir would provide additional storage water for the Teton watershed, effectively enhancing water supply by capturing excess peak flows and redistributing that water during periods of higher demand. The available storage would enhance the in-basin water budget by diverting 20,000 af during the annual high flow period and storing that water until more critical, higher demand periods. This storage water could help satisfy unmet irrigation demands in the Lower Watershed and Egin Bench irrigated regions. Reservoir releases during low flow periods would improve connectivity in downstream river segments, including Canyon Creek, North Fork Teton River, South Fork Teton River, and the Lower Henrys Fork River, which have all been identified as having additional ecological streamflow needs. Diversions would typically occur during periods when connectivity is not an issue, but nonetheless withdrawals may be expected to impact a core conservation population of Yellowstone cutthroat trout in Bitch Creek and conservation populations in Canyon Creek and the Teton River. The impoundment may also be expected to impact a conservation population in Spring Creek. The out-of-basin water budget would be temporarily reduced by up to 20,000 af during the annual high flow period when water is diverted to the reservoir, but some or all of that quantity may be available at a later time for numerous out-of-basin uses, including needs resulting from climate change; agricultural needs; domestic, municipal, and industrial needs; ecological needs; and for recharge of the ESPA. Exhibit 4-1 provides a tabular summary of the key findings.

EXHIBIT 4-1
Key Findings from the Reconnaissance Evaluation

Estimated Cost per af	Impact on In-Basin Water Budget	Impact on Out-of-Basin Water Budget	Change in Connectivity of Impacted River Segment
$3,900 - $11,500	20,000 af, to be diverted during the annual high flow period and released during high demand periods.	20,000 af reduction during the annual high flow period, in accordance with priority rights. Part or all of this quantity would be available later for out-of-basin needs.	Improvement in connectivity of downstream river segments, including Canyon Creek, North Fork Teton River, South Fork Teton River, and the Lower Henrys Fork River. Potential impacts to supply sources, including Bitch Creek, which contains a core conservation population of Yellowstone cutthroat trout, and the Spring Creek, Canyon Creek, and the Teton River, which contain conservation populations.

4.3 Engineering Results

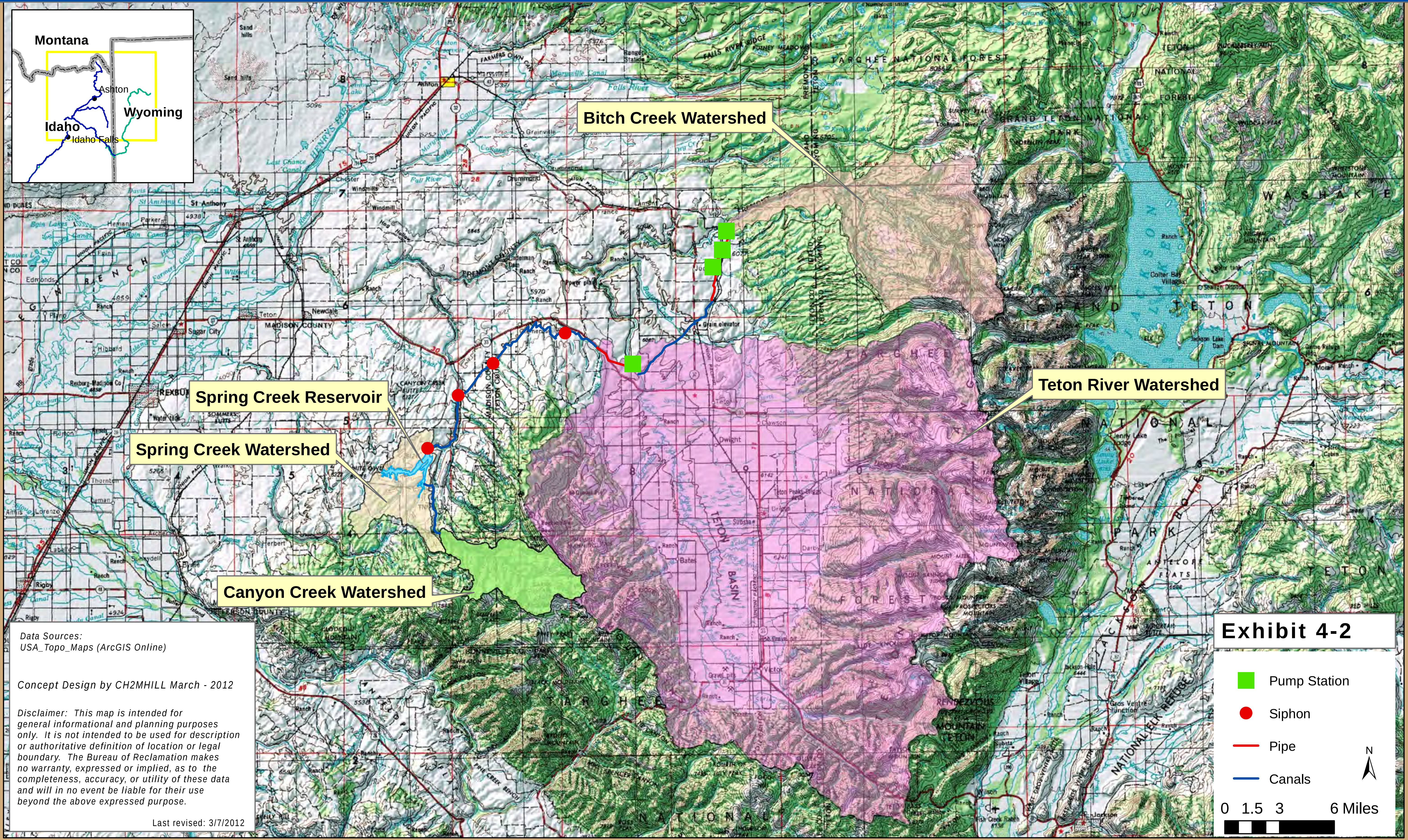
4.3.1 Hydrology

Four potential water supply sources were identified: Spring Creek, Teton River, Canyon Creek, and Bitch Creek (Exhibit 4-2). Exhibit 4-3 presents a summary of potentially available water from each source based on analyses using StreamStats (USGS, 2011; see Section 2.2.1 – *Hydrology*).

RECLAMATION
Managing Water in the West

Henrys Fork Basin Study, Idaho and Wyoming

Spring Creek Dam Alternative: Hydrology



Data Sources:
USA_Topo_Maps (ArcGIS Online)

Concept Design by CH2MHILL March - 2012

Disclaimer: This map is intended for general informational and planning purposes only. It is not intended to be used for description or authoritative definition of location or legal boundary. The Bureau of Reclamation makes no warranty, expressed or implied, as to the completeness, accuracy, or utility of these data and will in no event be liable for their use beyond the above expressed purpose.

Last revised: 3/7/2012

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EXHIBIT 4-3
Water Potentially Available for Storage at Spring Creek

Source	Watershed Area (sq. mi)	Quantity (af/year)
Spring Creek	13.8	2,073
Teton River[1]	479.9	469,464
Canyon Creek	19.5	8,705
Bitch Creek	65.9	67,820

[1] – Quantity reported for regulated systems is total estimated water in system. Excess spring runoff calculation was considered invalid for these systems because of upstream dam regulation.

4.3.2 Conveyance

Water supply routes were established from each source using a combination of pressurized pipelines, canals, and siphons, as depicted in Exhibit 4-4. Conveyance routes are conceptual, and are intended only to provide a basis for relative cost comparison, rather than reflect actual alignments and features for design. Exhibit 4-5 summarizes the key physical characteristics of each sub-alternative.

EXHIBIT 4-5
Spring Creek Sub-Alternative Characteristics

Sub-Alternative	Source	Volume Diverted (acre-ft/year)	Conveyance Length (mi)	
			Canal	Pipe[1]
S-Ca	Spring Creek	2,073	0.0	0.0
	Canyon Creek	8,705	3.5	0.0
S-CaT	Spring Creek	2,073	0.0	0.0
	Canyon Creek	8,705	3.5	0.0
	Teton River	9,222	15.7	3.3
S-T	Spring Creek	2,073	0.0	0.0
	Teton River	17,927	15.7	3.3
S-B	Spring Creek	2,073	0.0	0.0
	Bitch Creek[2]	17,927	23.0	6.5

[1] – Pipe length includes siphons and pressurized pipe from pump stations, if applicable.
[2] – Water is conveyed from Bitch Creek to the Teton River. The Teton River is used to convey the Bitch Creek water to a diversion location downstream where a pump station will divert water to the Spring Creek Reservoir using the same route as the S-CaT and S-T sub-alternatives. No additional volume from the Teton River is assumed for this sub-alternative.

Other conveyance features were also assessed during the evaluation including stream diversions, intake and fish screen structures, pump stations, and siphons. Those features are accounted for in the cost estimate, and the procedures used to identify and size those features are documented in Section 2.3.4 – *Cost Basis*.

4.3.3 Dam Configuration

A rockfill or granular earthfill dam would be constructed to impound Spring Creek Reservoir. The cross-section presented in Exhibit 2-3 shows a typical configuration for the proposed dam at this location, which features a central core with filter blanket drains and earthfill/rockfill shells. A concrete grout curtain/cutoff would also be required to limit seepage through the dam foundation. The bottom of the valley at the proposed dam location is at an approximate elevation of 5,965 feet and the top of the dam would be at an approximate elevation of 6,145 feet for a maximum height of about 180 feet. The length of the dam at this elevation would be about 1,200 feet. The resulting reservoir would have about 20,000 af of storage with a maximum surface area of 540 acres. Exhibit 4-6 shows potential locations for the dam, appurtenant structures, and emergency spillway.

A potential spillway alignment has been identified on the left abutment, and the dam would require a low-level outlet that provides a safe way to drain the reservoir and integrate with ultimate water distribution and hydropower schemes. An outlet pipeline would be constructed at the base of the dam and is assumed to be founded in bedrock. The depth to rock along this alignment is unknown but rock exposures in the valley walls and generally shallow depth to rock in well logs suggest that rock depths could be relatively shallow.

The dam foundation is expected to consist of alluvium and/or colluvium overlying bedrock. Bedrock under the dam site within the valley bottom is expected to consist of rhyolite tuff. The depth of overburden is unknown; however, steep slopes and rock outcrops in some areas along the sides of the valley suggest that rock could be encountered at relatively shallow depths. Exhibit 4-7 presents a profile of the dam axis and highlights geologic features that could affect the foundation.

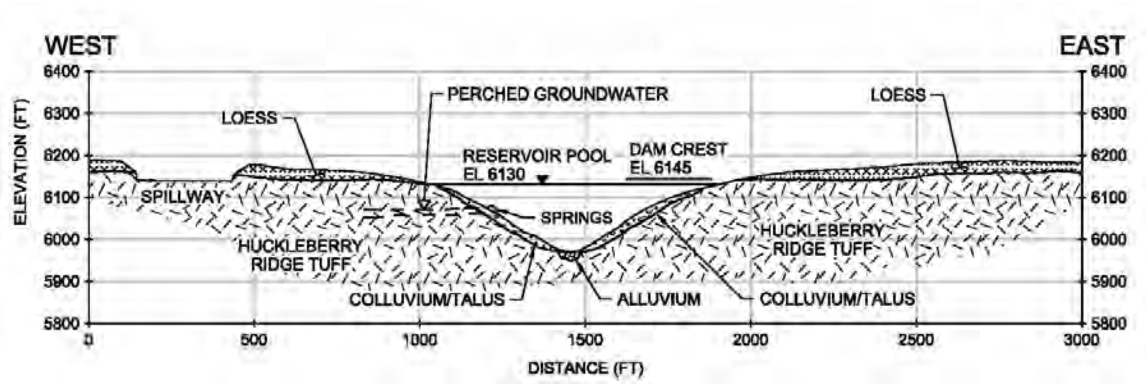


EXHIBIT 4-7
Spring Creek Dam Geologic Profile

4.3.4 Hydropower Potential

As presented in Exhibit 4-8, hydropower potential associated with Spring Creek would be approximately 193 kW for the S-Ca sub-alternative or 358 kW for all other sub-alternatives.

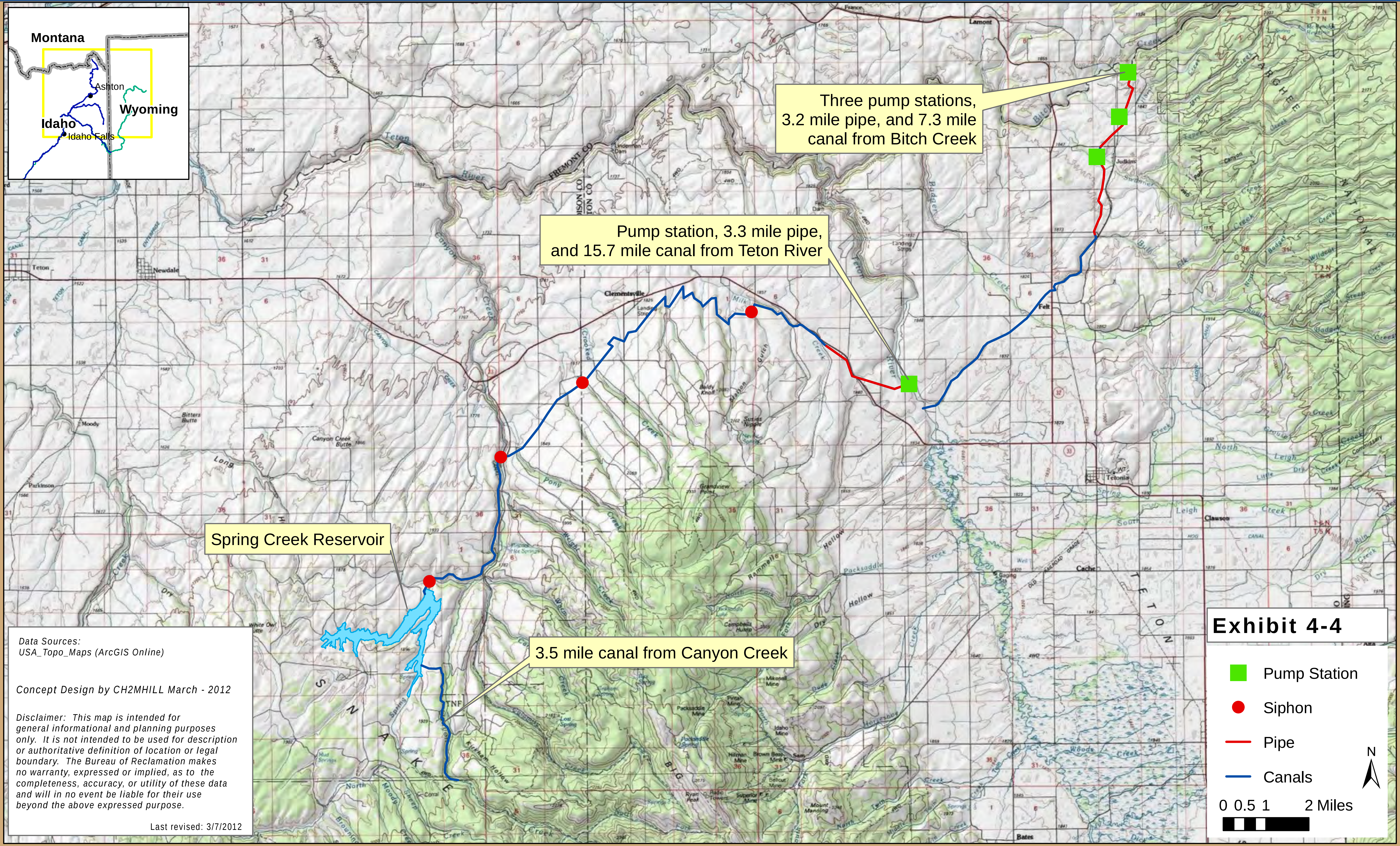
EXHIBIT 4-8
Spring Creek Hydropower Potential

Sub-Alternative	Design Flow (cfs)	Penstock Length (mi)	Head (ft)	Power Potential (kW)
S-Ca	16.1	0[1]	160	177
S-CaT; S-T; S-B	29.9	0[1]	160	328

[1] – It is assumed that turbines are located at the bottom of the outlet works. Therefore, no penstocks are needed.

Henrys Fork Basin Study, Idaho and Wyoming

Spring Creek Dam Alternative: Conveyance



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Henrys Fork Basin Study, Idaho and Wyoming

Spring Creek Dam Alternative: Dam and Appurtenant Structures

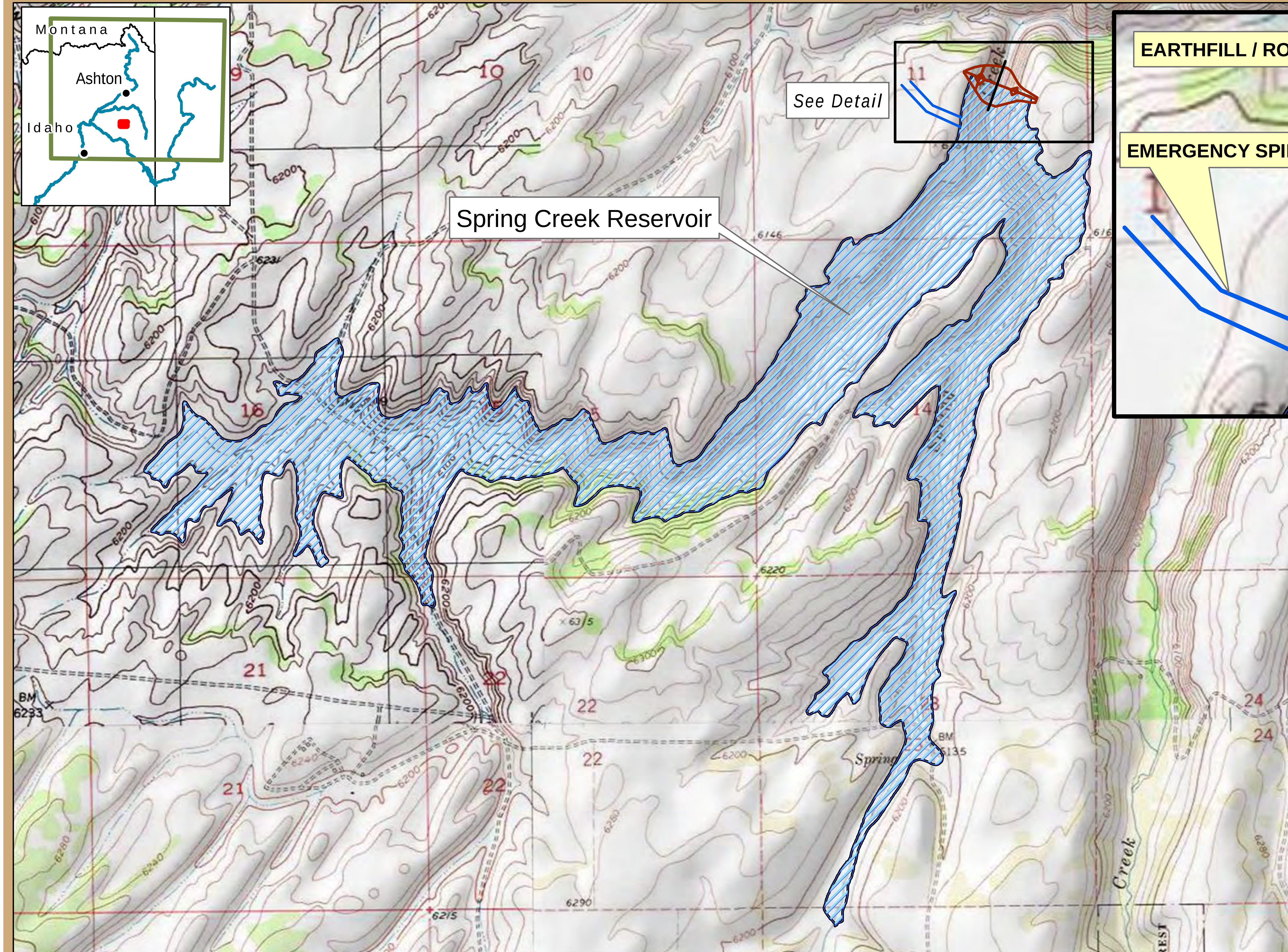

Exhibit 4-6

Data Sources:
USGS 1:24,000 TOPO QUAD (web service)

Concept Design by CH2MHill March - 2012

Disclaimer: This map is intended for general informational and planning purposes only. It is not intended to be used for description or authoritative definition of location or legal boundary. The Bureau of Reclamation makes no warranty, expressed or implied, as to the completeness, accuracy, or utility of these data and will in no event be liable for their use beyond the above expressed purpose.

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0 0.25 0.5 Miles

Last revised: 3/7/2012

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4.4 Cost Estimate

A summary of the cost per acre-foot of water stored for each sub-alternative are presented in Exhibit 4-9. These costs include hydropower facilities.

EXHIBIT 4-9
Spring Creek Sub-Alternative Cost Estimates[1]

Sub-Alternative	Storage Volume (af)	Total Construction Cost	Cost Per Unit Yield ($/acre-foot)
S-Ca	10,778	$41,760,000	3,900
S-CaT	20,000	$118,270,000	5,900
S-T	20,000	$140,090,000	7,000
S-B	20,000	$230,720,000	11,500

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

4.5 Basin Water Needs

The storage provided by Spring Creek Reservoir would enhance the in-basin water budget by diverting 20,000 af during the annual high flow period and storing that water until more critical, higher demand periods during the summer and early fall. Water stored in the reservoir would help satisfy unmet irrigation demands in the Egin Bench (more water available in the Henrys Fork because of reduced need for diversions into the Crosscut Canal) and Lower Watershed irrigated regions (Reclamation, 2012). Reservoir releases would also be used to enhance ecological in-stream flows (see Section 4.7.2 – *Change in Connectivity*).

The out-of-basin water budget would be temporarily reduced by up to 20,000 af during the annual high flow period when water is diverted to the reservoir, but some or all of that quantity may be available at a later time for numerous out-of-basin uses, including needs resulting from climate change; agricultural needs; domestic, municipal, and industrial needs; ecological needs; and for recharge of the ESPA (Reclamation, 2012).

4.6 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*.

4.7 Environmental Benefits and Impacts

4.7.1 Impacted River Segments

River segments potentially impacted by various sub-alternatives include Spring Creek, Canyon Creek, the Teton River, and Bitch Creek, as identified in Exhibit 4-10.

4.7.2 Change in Connectivity

Potential impacts to river connectivity consist of decreased flow (diversions to the reservoir) for river segments providing reservoir supply and increased flow for river segments receiving reservoir releases. As described in Section 2.2.1.3 – *Potentially Available Water*, diversions would likely occur during the excess spring runoff period and reservoir releases would likely occur during more critical low flow periods in the summer and fall. Potential impacts to connectivity of each impacted river segment are identified in Exhibit 4-10. In addition to the segments listed in Exhibit 4-10, enhanced connectivity would be experienced in other downstream river segments, including Canyon Creek, North Fork Teton River, South Fork Teton River, and the Lower Henrys Fork River, which have all been identified as having additional ecological streamflow needs (Van Kirk et al., 2011).

4.7.3 State Aquatic Species of Special Concern

Yellowstone cutthroat trout are present in the proposed reservoir inundation area. The reservoir would impact Spring Creek's conservation population, which is defined as having less than 10 percent genetic introgression from other species. Potential modifications to the hydrology of Bitch Creek would impact a core conservation population, which is defined as a population with greater than 99 percent Yellowstone cutthroat trout genes, and potential modifications to the hydrology of Canyon Creek and the Teton River would impact conservation populations, which are defined as having less than 10 percent genetic introgression from other species. State Aquatic Species of Special Concern in potentially impacted river segments are indicated in Exhibit 4-10.

4.7.4 Other Environmental Factors

The proposed Spring Creek Reservoir inundation area contains both winter range and migration corridors for big game, according to Trout Unlimited (TU), Friends of the Teton River (FTR), American Rivers (AR), the Idaho Department of Fish and Game (IDFG), and the Henrys Fork Foundation. The United States Fish and Wildlife Service (USFWS) tracks one candidate for federally listed threatened species, the wolverine, in the area. Sandhill crane and sharp-tailed grouse, considered at-risk by the Bureau of Land Management (BLM) and the United States Forest Service (USFS), also make their homes here. Data from the National Wetlands Inventory (NWI) indicate that there are no NWI designated wetlands at this site. 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. Hydrologic changes to the water source brought about by the proposed construction would also have indirect impacts on a stretch of Teton River that is eligible for Wild and Scenic River status designation.

Potential wildlife habitat impacts, federally listed species, and wetlands habitat impacts within the reservoir inundation area are also summarized in Exhibit 4-11, while State of Idaho aquatic species of special concern (Yellowstone cutthroat trout and rainbow trout) and special river designations for all potentially impacted river segments are summarized in Exhibit 4-10.

4.8 Land Management, Recreation and Infrastructure impacts and benefits

Spring Creek Reservoir is located on private and state land, has a moderate recreation and economic rating due to land-based recreation (hunting and ATV use), and is rated as having few potential infrastructure impacts, as summarized in Exhibit 4-12.

4.9 Assumptions and Limitations

General assumptions and limitations applicable to all of the surface-storage alternatives are described in Section 2.8 – *Key Assumptions and Limitations*. Additional assumptions and limitations specific to this alternative are listed below:

- For sub-alternative S-B, it is assumed that the Teton River has sufficient capacity to route diverted Bitch Creek water prior to diversion to Spring Creek Reservoir.
- Excavation for the open spillway would likely be in colluvial soils and/or rock. It is possible that the spillway may be in soft erodible materials and if an open channel spillway is used, it may require concrete or rock linings that are suitable to match the intended spillway flows. A lined concrete spillway was assumed for costing purposes. Alternative spillway approaches should also be investigated once the inflow design flow has been established and local site conditions are better understood.

Exhibit 4-10

Impacts to Connectivity, State Aquatic Species of Special Concern, and Special River Designations for Affected River Reaches

			Connectivity		State Aquatic Species of Special Concern			Special Designation[a]				
Surface Storage Site	Sub-Alternative	Impacted River Segments	Flow Decrease (Supply Source)	Flow Increase (Receives Reservoir Releases)	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
Spring Creek	S-Ca	Spring Creek	•	•	•		YCT Conservation	•				Eligible Federal
		Canyon Creek	•	•	•		YCT Conservation	•				Eligible Federal
		Teton River		•	•		YCT Conservation	•				Eligible Federal
Spring Creek	S-CaT	Spring Creek	•	•	•		YCT Conservation	•				Eligible Federal
		Canyon Creek	•	•	•		YCT Conservation	•				Eligible Federal
		Teton River	•	•	•		YCT Conservation	•				Eligible Federal
Spring Creek	S-T	Spring Creek	•	•	•		YCT Conservation	•				Eligible Federal
		Teton River	•	•	•		YCT Conservation	•				Eligible Federal
		Canyon Creek		•	•		YCT Conservation	•				Eligible Federal
Spring Creek	S-B	Spring Creek	•	•	•		YCT Conservation	•				Eligible Federal
		Bitch Creek	•		•		YCT Core	•	•	•		State/ Eligible Federal
		Canyon Creek		•	•		YCT Conservation	•				Eligible Federal
		Teton River		•	•		YCT Conservation	•				Eligible Federal

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

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Exhibit 4-11
Impacts to Wildlife Habitat, Federally Listed Species, and Wetland Habitat at the Reservoir Site

Surface Storage Site	Wildlife Habitat[a]			Federally Listed Species			Wetland/Habitat Value	
	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
Spring Creek	•[1,2]	•[4]	Winter Range	sandhill crane, sharp-tailed grouse	wolverine	Federal Terrestrial		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 the Henrys Fork Foundation.

[b]Per IDFG special species February 2011 GIS dataset (1-mile buffer area) and personal communications with the Henrys Fork Foundation.

[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, American Rivers, the IDFG February 2011 dataset, and personal communications with IDFG, BLM, and the Henrys Fork Foundation.

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
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	<1 Acre

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Exhibit 4-12

	Land Management Data[a]					Recreation/Economic Value								Infrastructure[e]				
Surface Storage 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[d]	Rating	Roads	Structures	Habitation	Additional Infrastructure Notes	Rating
Spring Creek	•		•		State							•	Moderate					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]Per personal communications with the Henrys Fork Foundation.

[e]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

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4.10 Evaluation Criteria

4.10.1 Stakeholder Group Measurable Criteria

There are four Stakeholder Group Measurable Criteria, with results summarized in Exhibit 4-13:

- Water Supply: The net change for in basin and out of basin water budgets in af 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 4.6.
- Environmental Considerations: Environmental benefits and impacts are summarized above in Section 4.7.
- Economics: The estimated reconnaissance-level field cost to construct the project is summarized in Section 4.4.

EXHIBIT 4-13
Stakeholder Group Measurable Criteria Summary

Stakeholder Group Measurable Criteria	Criteria Characterization
Water Supply (in-basin water transfer potential)	20,000 af/yr
Water Supply (out-of-basin water transfer potential)	20,000 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)	$41,760,000 - $230,720,000

[1] – Net environmental impact would depend on water sources and reservoir operations; further analysis required in future phase of study.

4.10.2 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.

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SECTION 5

Moody Creek Dam

5.1 Alternative Description

5.1.1 Overview

The Moody Creek alternative features a proposed new 220-foot-tall dam and a 37,000 af reservoir. The dam site is located in the Teton watershed on Moody Creek, just downstream of the Dry Canyon Creek confluence. Water for the reservoir could be supplied from several sources, including Moody Creek, Canyon Creek, and the Teton River. Pumping or gravity flow from the Teton River would be required to satisfy storage objectives. When full, Moody Creek Reservoir could provide a roughly 200-foot drop to a proposed new hydropower facility on Moody Creek at the base of the dam.

5.1.2 Alternative Variations

The following sub-alternatives were identified by varying potential water-supply sources. Conveyance routes for the sub-alternatives are collectively shown on Exhibits 5-2 and 5-4. Specific conveyance lengths and features are summarized below in Section 5.3.2 – *Conveyance.* Only the two sub-alternatives that draw source water from the Teton River satisfy the full annual storage objective of 37,000 af (see Exhibits 5-5 and 5-9).

- My: Moody Creek Reservoir supplied by Moody Creek (natural inflow to reservoir)
- My-Ca: Moody Creek Reservoir supplied by Moody Creek (natural inflow to reservoir) and Canyon Creek (gravity-flow canal)
- My-Ca_P: Moody Creek Reservoir supplied by Moody Creek (natural inflow to reservoir) and Canyon Creek (combination pump station, pipe, and gravity-flow canal)
- My-T: Moody Creek Reservoir supplied by Moody Creek (natural inflow to reservoir) and the Teton River (gravity-flow canal)
- My-T_P: Moody Creek Reservoir supplied by Moody Creek (natural inflow to reservoir) and the Teton River (combination pump station, pipe, and gravity-flow canal)

5.1.3 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 evaluate potential water availability and design flow to identify sub-alternatives and develop relative costs.

5.2 Key Findings

Moody Creek Reservoir would provide additional storage water for the Teton Basin, effectively enhancing water supply by capturing excess peak flows and redistributing that water during periods of higher demand. The available storage would enhance the in-basin water budget by diverting 37,000 af during the annual high flow period and storing that water until more critical, higher demand periods. This storage water could help satisfy unmet irrigation demands in the Lower Watershed and Egin Bench irrigated regions. Reservoir releases during low flow periods would improve connectivity in downstream river segments, including Moody Creek, North Fork Teton River, South Fork Teton River, and the Lower Henrys Fork River, which have all been identified as having additional ecological streamflow needs. 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 Canyon Creek and the Teton River and the impoundment may be expected to impact a conservation population in Moody Creek. The out-of-basin water budget would be temporarily reduced by up to 37,000 af during the annual high flow period, but some or all of that quantity may be available at a later time for numerous out-of-basin uses, including needs resulting from climate change; agricultural needs; domestic, municipal, and industrial needs; ecological needs; and for recharge of the ESPA. Exhibit 5-1 provides a tabular summary of the key findings.

EXHIBIT 5-1
Key Findings from the Reconnaissance Evaluation

Estimated Cost per af	Impact on In-Basin Water Budget	Impact on Out-of-Basin Water Budget	Change in Connectivity of Impacted River Segment
$3,600 - $4,500	37,000 af, to be diverted during the annual high flow period and released during high demand periods.	37,000 af reduction during the annual high flow period, in accordance with priority rights. Part or all of this quantity would be available later for out-of-basin needs.	Improvement in connectivity of downstream river segments, including Moody Creek, North Fork Teton River, South Fork Teton River, and the Lower Henrys Fork River. Potential impacts to supply sources, including Moody Creek, Canyon Creek, and the Teton River, which contain conservation populations of Yellowstone cutthroat trout.

5.3 Engineering Results

5.3.1 Hydrology

Three potential water supply sources were identified: Moody Creek, Teton River, and Canyon Creek (Exhibit 5-2). Exhibit 5-3 presents a summary of potentially available water from each source based on analyses using StreamStats (USGS, 2011; see Section 2.2.1 – *Hydrology*).

Henrys Fork Basin Study, Idaho and Wyoming

Moody Creek Dam Alternative: Hydrology

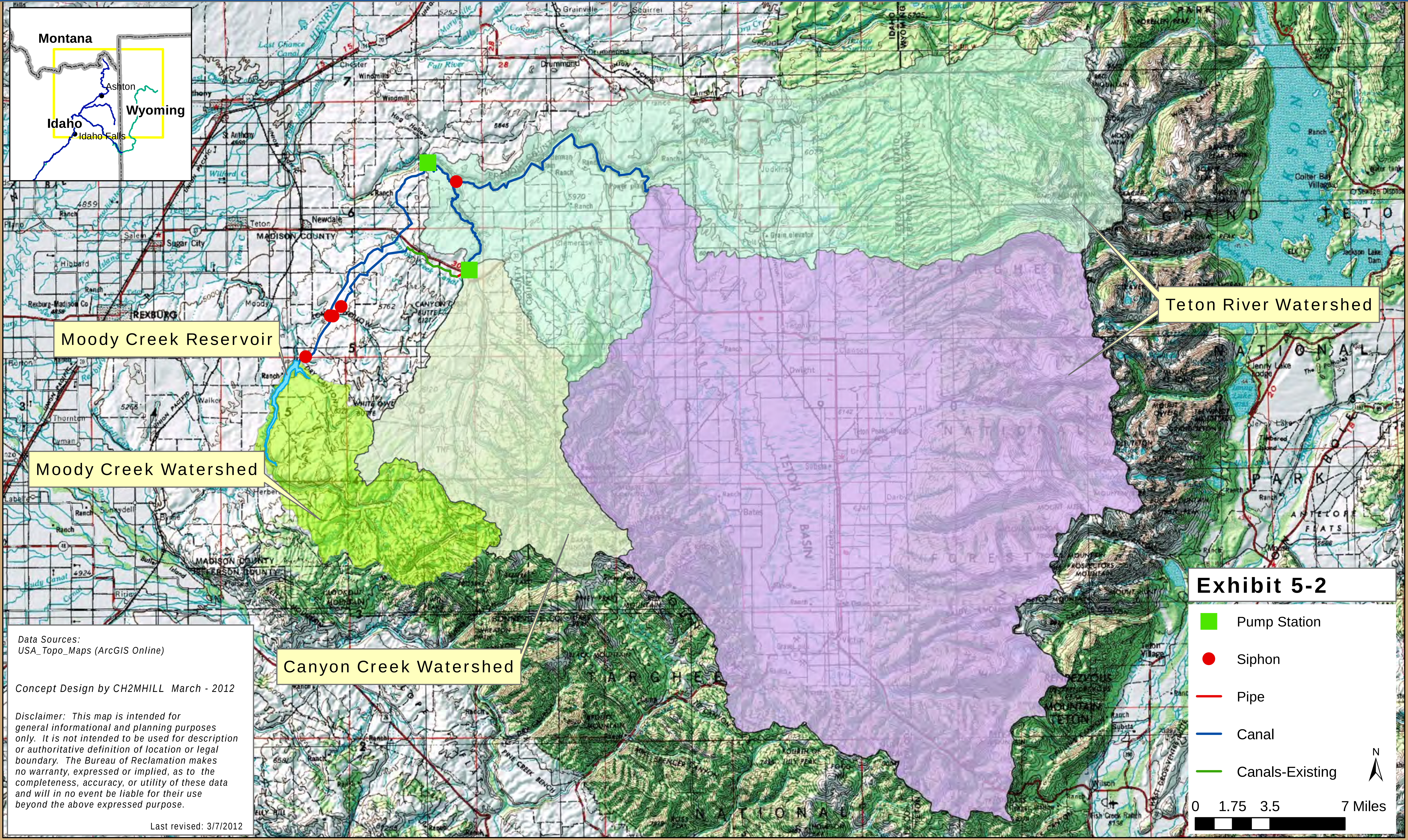

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EXHIBIT 5-3
Water Potentially Available for Storage at Moody Creek

Source	Watershed Area (sq. mi)	Quantity (af/year)
Moody Creek	58.4	14,993
Teton River[1,2]	489.1	469,007
Teton River[1,3]	834.7	691,704
Canyon Creek	85.7	19,438

[1] – Quantity reported for regulated systems is total estimated water in system. Excess spring runoff calculation was considered invalid for these systems because of upstream dam regulation.
[2] – My-T sub-alternative (gravity-flow canal).
[3] – My-T_P sub-alternative (pump station).

5.3.2 Conveyance

Water supply routes were established from each source, using a combination of pressurized pipelines, canals, and siphons, as depicted in Exhibit 5-4. Conveyance routes are conceptual, and are intended only to provide a basis for relative cost comparison, rather than reflect actual alignments and features for design. Exhibit 5-5 summarizes the key physical characteristics of each sub-alternative.

EXHIBIT 5-5
Moody Creek Sub-Alternative Characteristics

Sub-Alternative	Source	Volume Diverted (acre-ft/year)	Conveyance Length (mi)	
			Canal	Pipe[1]
My	Moody Creek	14,993	0.0	0.0
My-Ca	Moody Creek	14,993	0.0	0.0
	Canyon Creek	19,438	20.8	0.3
My-Ca_P	Moody Creek	14,993	0.0	0.0
	Canyon Creek[2]	19,438	7.7[1]	1.2
My-T	Moody Creek	14,993	0.0	0.0
	Teton River	22,007	28.3	1.1
My-T _P	Moody Creek	14,993	0.0	0.0
	Teton River	22,007	12.6	0.6

[1] – Pipe length includes siphons and pressurized pipe from pump station, if applicable s.
[2] – Route also utilizes 3.0 miles of the existing Canyon Creek Canal, which is assumed to have sufficient capacity.

Other conveyance features were also assessed during the evaluation including stream diversions, intake and fish screen structures, pump stations, and siphons. Those features are accounted for in the cost estimate, and the procedures used to identify and size those features are documented in Section 2.3.4 – *Cost Basis*.

5.3.3 Dam Configuration

A rockfill or granular earthfill dam would be constructed to impound Moody Creek Reservoir. The cross-section presented in Exhibit 2-3 shows a typical configuration for the proposed dam at this location, which features a central core with filter blanket drains and earthfill/rockfill shells. A concrete grout curtain/cutoff would also be required to limit seepage through the dam foundation. The bottom of the valley at the proposed dam location is at an approximate elevation of 5,185 feet and the top of the dam would be at an approximate elevation of 5,405 feet for a maximum height of about 220 feet. The length of the dam at this elevation would be about 1,300 feet. The resulting reservoir would have about 37,000 af of storage with a maximum surface area of 520 acres. Exhibit 5-6 shows potential locations for the dam, appurtenant structures, and emergency spillway.

A potential spillway alignment has been identified on the left abutment, and the dam would require a low-level outlet that provides a safe way to drain the reservoir and integrate with ultimate water distribution and hydropower schemes. Excavation for the open spillway would likely be in colluvial soils and/or rock. It is possible that the spillway may be in soft erodible materials if an open channel spillway is used. This may require concrete or rock linings that are suitable to match the intended spillway flows. The depth to rock along this alignment is unknown but steep slopes and rock mapping along the sides of the valley suggest that rock could be encountered at relatively shallow depths.

The dam foundation is expected to consist of alluvium and/or colluvium overlying bedrock. Bedrock under the dam site within the valley bottom is expected to consist of rhyolite tuff. The depth of overburden is unknown; however, steep slopes and rock outcrops in some areas along the sides of the valley suggest that rock could be encountered at relatively shallow depths. The abutments of the dam are expected to encounter colluvium and talus overlying rhyolite tuff including pumice and volcanic ash. Exhibit 5-7 presents a profile of the dam axis and highlights geologic features that could affect the foundation.

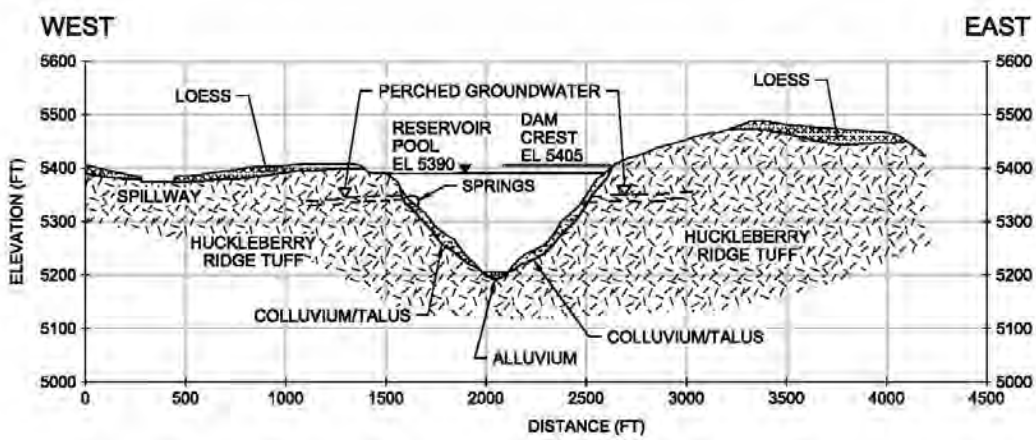


EXHIBIT 5-7
Moody Creek Dam Geologic Profile

5.3.4 Hydropower Potential

As presented in Exhibit 5-8, hydropower potential associated with Moody Creek would vary from approximately 307 kW to 758 kW.

EXHIBIT 5-8
Moody Creek Hydropower Potential

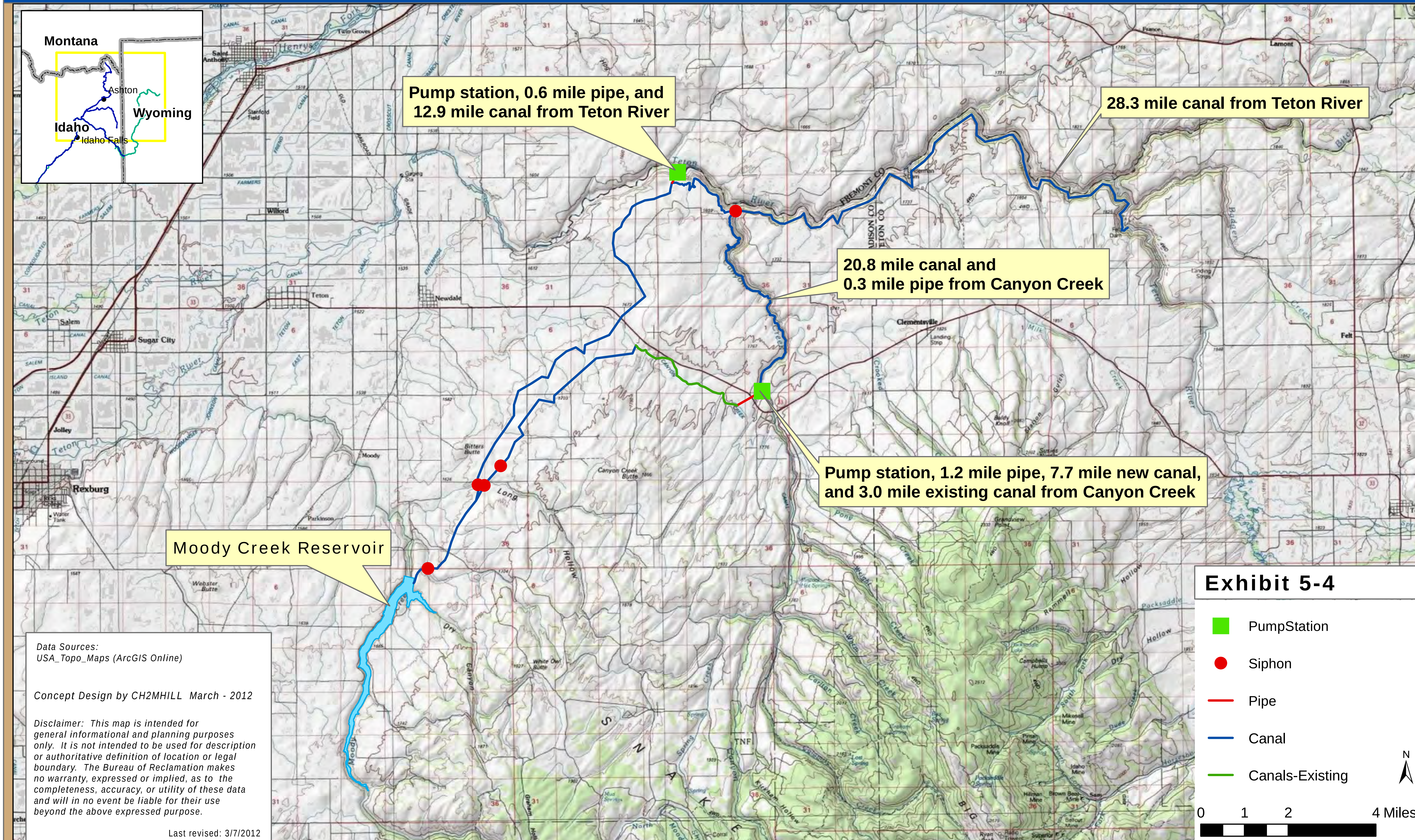
Sub-Alternative	Design Flow (cfs)	Penstock Length (mi)	Head (ft)	Power Potential (kW)
My	22.4	0[1]	200	307
My-Ca; My-Ca_P	51.4	0[1]	200	705
My-T; My-T_P	55.3	0[1]	200	758

[1] – It is assumed that turbines are located at the bottom of the outlet works. Therefore, no penstocks are needed.

RECLAMATION
Managing Water in the West

Henrys Fork Basin Study, Idaho and Wyoming

Moody Creek Dam Alternative: Conveyance



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RECLAMATION
Managing Water in the West

Henrys Fork Basin Study, Idaho and Wyoming

Moody Creek Dam Alternative: Dam and Appurtenant Structures

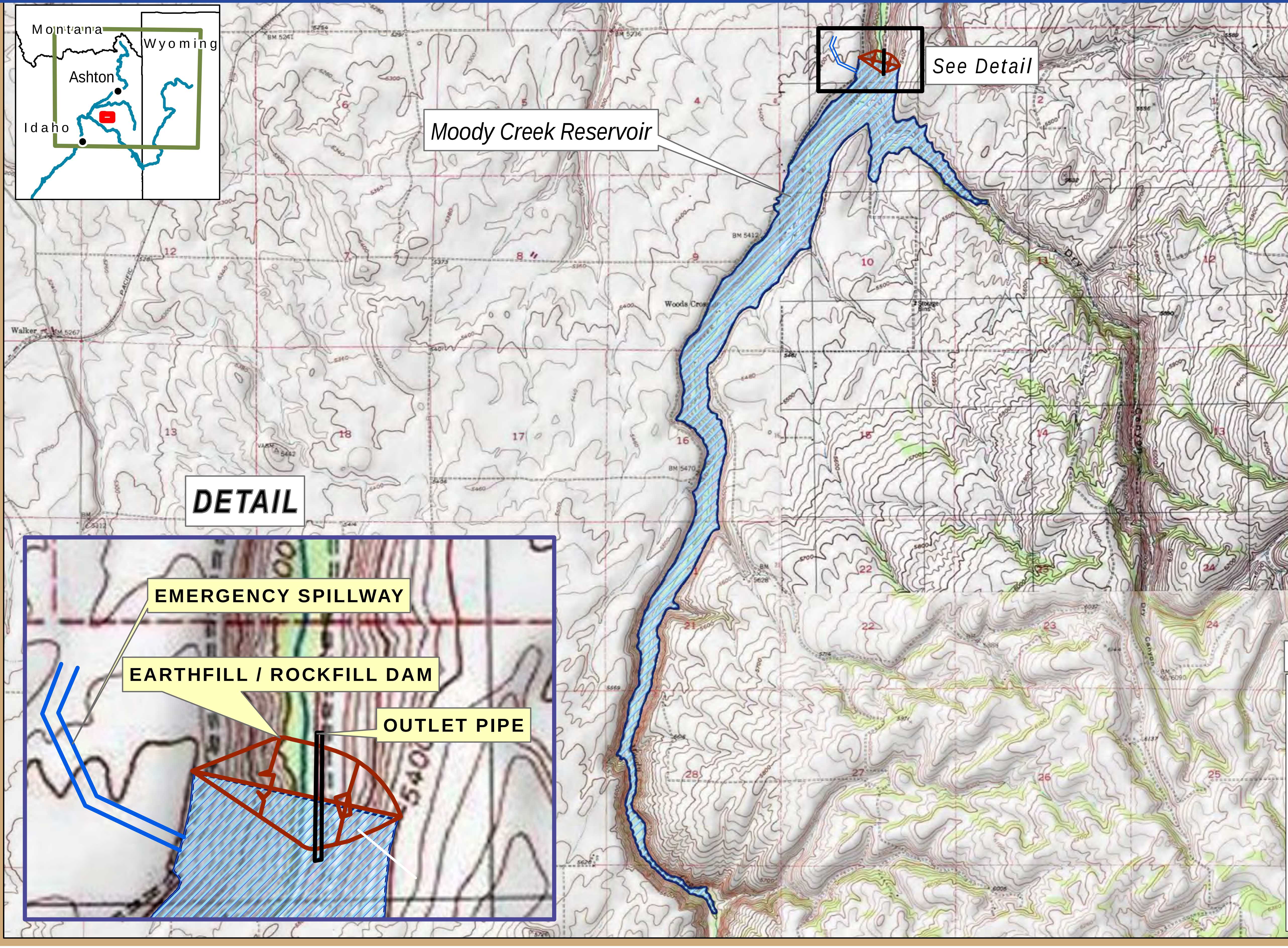

Exhibit 5-6

Data Sources:
USGS Topographic Quadrangles (web services)

Concept Design by CH2MHILL March - 2012

Disclaimer: This map is intended for general informational and planning purposes only. It is not intended to be used for description or authoritative definition of location or legal boundary. The Bureau of Reclamation makes no warranty, expressed or implied, as to the completeness, accuracy, or utility of these data and will in no event be liable for their use beyond the above expressed purpose.

0 0.5 1 Miles

Last revised: 3/7/2012

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5.4 Cost Estimate

A summary of the cost per acre-foot of water stored for each sub-alternative are presented in Exhibit 5-9. These costs include hydropower facilities.

EXHIBIT 5-9
Moody Creek Sub-Alternative Cost Estimates[1]

Sub-Alternative	Storage Volume (af)	Total Construction Cost	Cost Per Unit Yield ($/acre-foot)
My	14,993	$55,230,000	3,700
My-Ca	34,431	$132,400,000	3,800
My-Ca_P	34,431	$123,920,000	3,600
My-T	37,000	$167,040,000	4,500
My-T_P	37,000	$155,390,000	4,200

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

5.5 Basin Water Needs

The storage provided by Moody Creek Reservoir would enhance the in-basin water budget by diverting 37,000 af during the annual high flow period and storing that water until more critical, higher demand periods during the summer and early fall. Water stored in the reservoir would help satisfy unmet irrigation demands in the Egin Bench (more water available in the Henrys Fork because of reduced need for diversions into the Crosscut Canal) and Lower Watershed irrigated regions (Reclamation, 2012). Reservoir releases would also be used to enhance ecological in-stream flows (see Section 5.7.2 – *Change in Connectivity*).

The out-of-basin water budget would be temporarily reduced by up to 37,000 af during the annual high flow period when water is diverted to the reservoir, but some or all of that quantity may be available at a later time for numerous out-of-basin uses, including needs resulting from climate change; agricultural needs; domestic, municipal, and industrial needs; ecological needs; and for recharge of the ESPA (Reclamation, 2012).

5.6 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*.

5.7 Environmental Benefits and Impacts

5.7.1 Impacted River Segments

River segments potentially impacted by various sub-alternatives include Moody Creek, Canyon Creek, and the Teton River, as identified in Exhibit 5-10.

5.7.2 Change in Connectivity

Potential impacts to river connectivity consist of decreased flow (diversions to the reservoir) for river segments providing reservoir supply and increased flow for river segments receiving reservoir releases. As described in Section 2.2.1.3 – *Potentially Available Water*, diversions would likely occur during the excess spring runoff period and reservoir releases would likely occur during more critical low flow periods in the summer and fall. Potential impacts to connectivity of each impacted river segment are identified in Exhibit 5-10. In addition to the segments listed in Exhibit 5-10, enhanced connectivity would be experienced in other downstream river segments, including Moody Creek, North Fork Teton River, South Fork Teton River, and the Lower Henrys Fork River, which have all been identified as having additional ecological streamflow needs (Van Kirk et al., 2011).

5.7.3 State Aquatic Species of Special Concern

Yellowstone cutthroat trout are present in the proposed reservoir inundation area. The reservoir would impact Moody Creek's conservation population, which is defined as having less than 10 percent genetic introgression from other species, and potential modifications to the hydrology of Canyon Creek and the Teton River would also impact conservation populations. State Aquatic Species of Special Concern in potentially impacted river segments are indicated in Exhibit 5-10.

5.7.4 Other Environmental Factors

The proposed Moody Creek Reservoir inundation area is utilized by big game as a winter range area according to Trout Unlimited (TU), Friends of the Teton River (FTR), American Rivers (AR), the Idaho Department of Fish and Game (IDFG), and the Henrys Fork Foundation. No threatened species tracked by the USFWS, BLM, USFS, or IDFG are known to occur in the area. Sandhill crane and sharp-tailed grouse, considered at-risk by the Bureau of Land Management (BLM) and the United States Forest Service (USFS), also make their homes here. Data from the National Wetlands Inventory (NWI) indicate construction at this site would have moderate impact on mapped wetlands, affecting an area between 1 and 200 acres. 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. Hydrologic changes to the water source brought about by the proposed construction would also have indirect impacts on stretches of the Teton River that are eligible for Wild and Scenic River status designation.

Potential wildlife habitat impacts, federally listed species, and wetlands habitat impacts within the reservoir inundation area are also summarized in Exhibit 5-11, while State of Idaho aquatic species of special concern (Yellowstone cutthroat trout and rainbow trout) and special river designations for all potentially impacted river segments are summarized in Exhibit 5-10.

5.8 Land Management, Recreation and Infrastructure impacts and benefits

Moody Creek Reservoir is located on private land, has a low recreation and economic rating, and is rated as having few potential infrastructure impacts, as summarized in Exhibit 5-12.

5.9 Assumptions and Limitations

General assumptions and limitations applicable to all of the surface-storage alternatives are described in Section 2.8 – *Key Assumptions and Limitations*. Additional assumptions and limitations specific to this alternative are listed below:

- For sub-alternative My-Ca_P it is assumed that the existing Canyon Creek Canal (3.0 miles) has sufficient capacity to route flows from Canyon Creek.
- Excavation for the open spillway would likely be in colluvial soils and/or rock. It is possible that the spillway may be in soft erodible materials and if an open channel spillway is used, it may require concrete or rock linings that are suitable to match the intended spillway flows. A lined concrete spillway was assumed for costing purposes. Alternative spillway approaches should also be investigated once the inflow design flow has been established and local site conditions are better understood.

Exhibit 5-10

Impacts to Connectivity, State Aquatic Species of Special Concern, and Special River Designations for Affected River Reaches

			Connectivity		State Aquatic Species of Special Concern			Special Designation[a]				
Surface Storage Site	Sub-Alternative	Impacted River Segments	Flow Decrease (Supply Source)	Flow Increase (Receives Reservoir Releases)	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
Moody Creek	My-T_P	Moody Creek	•	•	•		YCT Conservation	•				Eligible Federal
		Teton River	•	•	•		YCT Conservation	•				Eligible Federal
Moody Creek	My-Ca	Moody Creek	•	•	•		YCT Conservation	•				Eligible Federal
		Canyon Creek	•				YCT Conservation	•				Eligible Federal
		Teton River		•	•		YCT Conservation	•				Eligible Federal
Moody Creek	My-Ca_P	Moody Creek	•	•	•		YCT Conservation	•				Eligible Federal
		Canyon Creek	•				YCT Conservation	•				Eligible Federal
		Teton River		•	•		YCT Conservation	•				Eligible Federal
Moody Creek	My-T	Moody Creek	•	•	•		YCT Conservation	•				Eligible Federal
		Teton River	•	•	•		YCT Conservation	•				Eligible Federal
Moody Creek	My	Moody Creek	•	•	•		YCT Conservation	•				Eligible Federal
		Teton River		•	•		YCT Conservation	•				Eligible Federal

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

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Exhibit 5-11

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

	Wildlife Habitat[a]			Federally Listed Species			Wetland/Habitat Value	
Surface Storage 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**
Moody Creek	•[4]		Winter Range	sandhill crane, sharp-tailed grouse		Federal Terrestrial	•	Moderate

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 the Henrys Fork Foundation.

[b]Per IDFG special species February 2011 GIS dataset (1-mile buffer area) and personal communications with the Henrys Fork Foundation.

[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
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	<1 Acre

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Exhibit 5-12

	Land Management Data[a]					Recreation/Economic Value								Infrastructure[d]				
Surface Storage 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
Moody Creek	•				Private								Low	•		•		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

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5.10 Evaluation Criteria

5.10.1 Stakeholder Group Measurable Criteria

There are four Stakeholder Group Measurable Criteria, with results summarized in Exhibit 5-13:

- Water Supply: The net change for in basin and out of basin water budgets in af is described above in Section 5.5 and summarized in Section 5.2.
- Water Rights: Water rights were not specifically addressed during this level of study, but known legal, institutional, and policy constraints are summarized in Section 5.6.
- Environmental Considerations: Environmental benefits and impacts are summarized above in Section 5.7.
- Economics: The estimated reconnaissance-level field cost to construct the project is summarized in Section 5.4.

EXHIBIT 5-13
Stakeholder Group Measurable Criteria Summary

Stakeholder Group Measurable Criteria	Criteria Characterization
Water Supply (in-basin water transfer potential)	37,000 af/yr
Water Supply (out-of-basin water transfer potential)	37,000 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)	$55,230,000 - $167,040,000

[1] – Net environmental impact would depend on water sources and reservoir operations; further analysis required in future phase of study.

5.10.2 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.

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SECTION 6

Upper Badger Creek Dam

6.1 Alternative Description

6.1.1 Overview

The Upper Badger Creek alternative features a proposed new 290-foot-tall dam and a 47,000 af reservoir. The dam site is located in the Teton watershed on Badger Creek approximately 5 miles upstream of the Teton River. Water for the reservoir could be supplied from Badger Creek and pumped from the Teton River. When full, Upper Badger Creek Reservoir could provide a roughly 590-foot drop to a proposed new hydropower facility on the Teton River.

6.1.2 Alternative Variations

The following sub-alternatives were identified by varying potential water-supply sources. Conveyance routes for the sub-alternatives are collectively shown on Exhibits 6-2 and 6-4. Specific conveyance lengths and features are summarized below in Section 6.3.2 – *Conveyance.*

- UB: Upper Badger Creek Reservoir supplied by Upper Badger Creek – natural inflow to reservoir. The water source for this sub-alternative would not provide the full 47,000 af annual storage objective (see Exhibits 6-5 and 6-9).
- UB-T-1_P: Upper Badger Creek Reservoir supplied by Upper Badger Creek (natural inflow to reservoir) and the Teton River (pump station and pipe)
- UB-T-2_P: Upper Badger Creek Reservoir supplied by Upper Badger Creek (natural inflow to reservoir) and the Teton River (pump station and pipe at a different point of diversion)

6.1.3 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 evaluate potential water availability and design flow to identify sub-alternatives and develop relative costs.

6.2 Key Findings

Upper Badger Creek Reservoir would provide additional storage water for the Teton Basin, effectively enhancing water supply by capturing excess peak flows and redistributing that water during periods of higher demand. The available storage would enhance the in-basin water budget by diverting 47,000 af during the annual high flow period and storing that water until more critical, higher demand periods. This storage water could help satisfy unmet irrigation demands in the Lower Watershed and Egin Bench irrigated regions. Reservoir releases during low flow periods would improve connectivity in other downstream river segments, including Badger Creek, North Fork Teton River, South Fork Teton River, and the Lower Henrys Fork River, which have all been identified as having additional ecological streamflow needs. Diversions would typically occur during periods when connectivity is not an issue, but nonetheless withdrawals may be expected to impact a conservation population of Yellowstone cutthroat trout in the Teton River and the impoundment may be expected to impact a core conservation population in Upper Badger Creek. The out-of-basin water budget would be temporarily reduced by up to 47,000 af during the annual high flow period when water is diverted to the reservoir, but some or all of that quantity may be available at a later time for numerous out-of-basin uses, including needs resulting from climate change; agricultural needs; domestic, municipal, and industrial needs; ecological needs; and for recharge of the ESPA. Exhibit 6-1 provides a tabular summary of the key findings.

EXHIBIT 6-1
Key Findings from the Reconnaissance Evaluation

Estimated Cost per af	Impact on In-Basin Water Budget	Impact on Out-of-Basin Water Budget	Change in Connectivity of Impacted River Segment
$2,700 - $5,300	47,000 af, to be diverted during the annual high flow period and released during high demand periods.	47,000 af reduction during the annual high flow period, in accordance with priority rights. Part or all of this quantity would be available later for out-of-basin needs.	Improvement in connectivity of downstream river segments, including Badger Creek, North Fork Teton River, South Fork Teton River, and the Lower Henrys Fork River. Potential impacts to supply sources, including Badger Creek, which contains a core conservation population of Yellowstone cutthroat trout, and the Teton River, which contains a conservation population.

6.3 Engineering Results

6.3.1 Hydrology

Two potential water supply sources were identified: Upper Badger Creek and the Teton River (Exhibit 6-2). Exhibit 6-3 presents a summary of potentially available water from each source based on analyses using StreamStats (USGS, 2011; see Section 2.2.1 – *Hydrology*).

EXHIBIT 6-3
Water Potentially Available for Storage at Upper Badger Creek

Source	Watershed Area (sq. mi)	Quantity (af/year)
Badger Creek	53.0	16,252
Teton River[1]	834.7	691,704

[1] – Quantity reported for regulated systems is total estimated water in system. Excess spring runoff calculation was considered invalid for these systems because of upstream dam regulation.

6.3.2 Conveyance

Water supply routes were established from each source using pressurized pipelines as depicted in Exhibit 6-4. Canals and siphons were not used for any of the sub-alternatives. Conveyance routes are conceptual, and are intended only to provide a basis for relative cost comparison, rather than reflect actual alignments and features for design. Exhibit 6-5 summarizes the key physical characteristics of each sub-alternative.

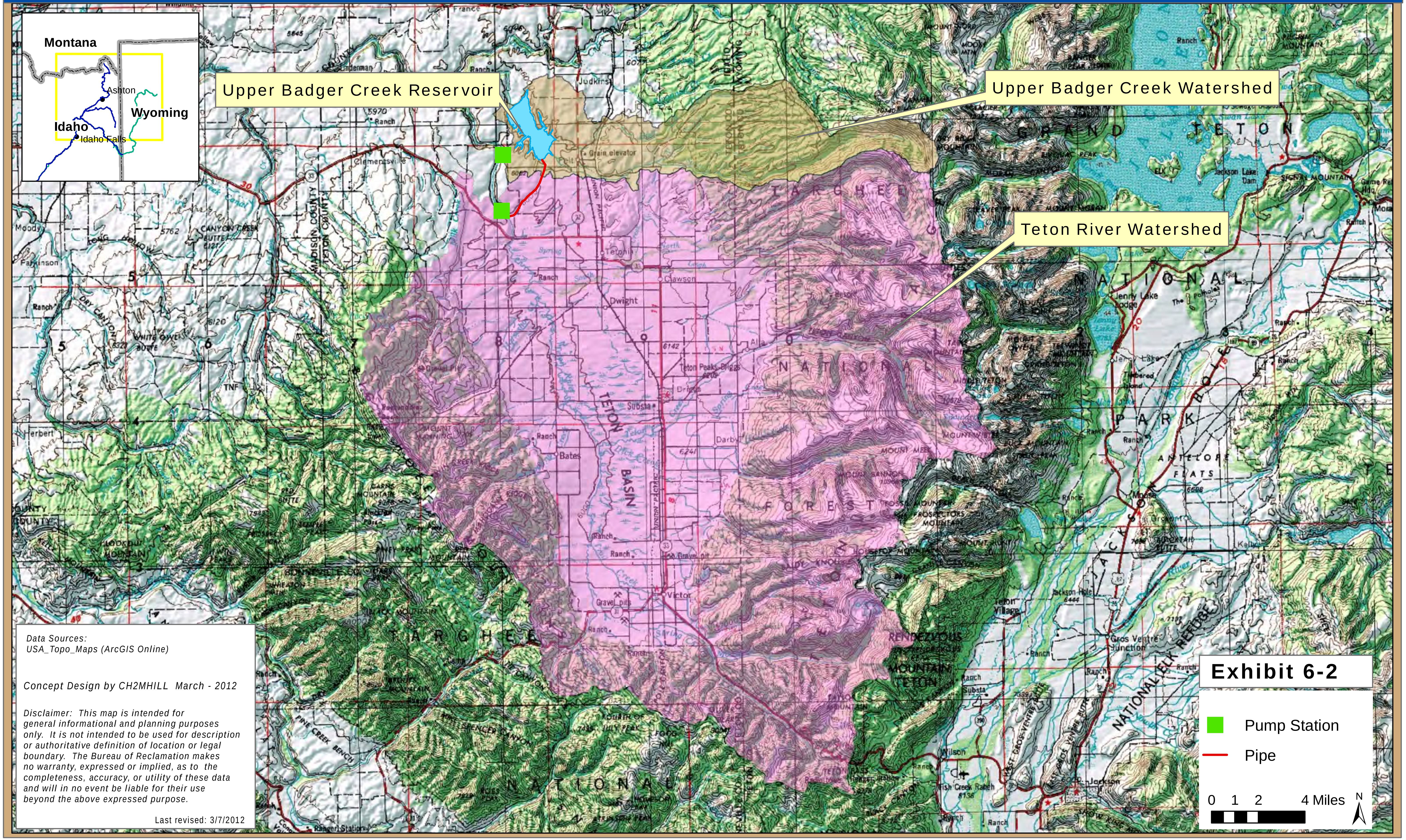
EXHIBIT 6-5
Upper Badger Creek Sub-Alternative Characteristics

Sub-Alternative	Source	Volume Diverted (acre-ft/year)	Conveyance Length (mi)	
			Canal	Pipe[1]
UB	Badger Creek	16,252	0.0	0.0
UB-T-1_P	Badger Creek	16,252	0.0	0.0
	Teton River	30,748	0.0	0.2
UB-T-2_P	Badger Creek	16,252	0.0	0.0
	Teton River	30,748	0.0	3.2

[1] – Pipe length includes siphons and pressurized pipe from pump stations, if applicable.

RECLAMATION
Managing Water in the West

Henrys Fork Basin Study, Idaho and Wyoming
Upper Badger Creek Dam Alternative: Hydrology



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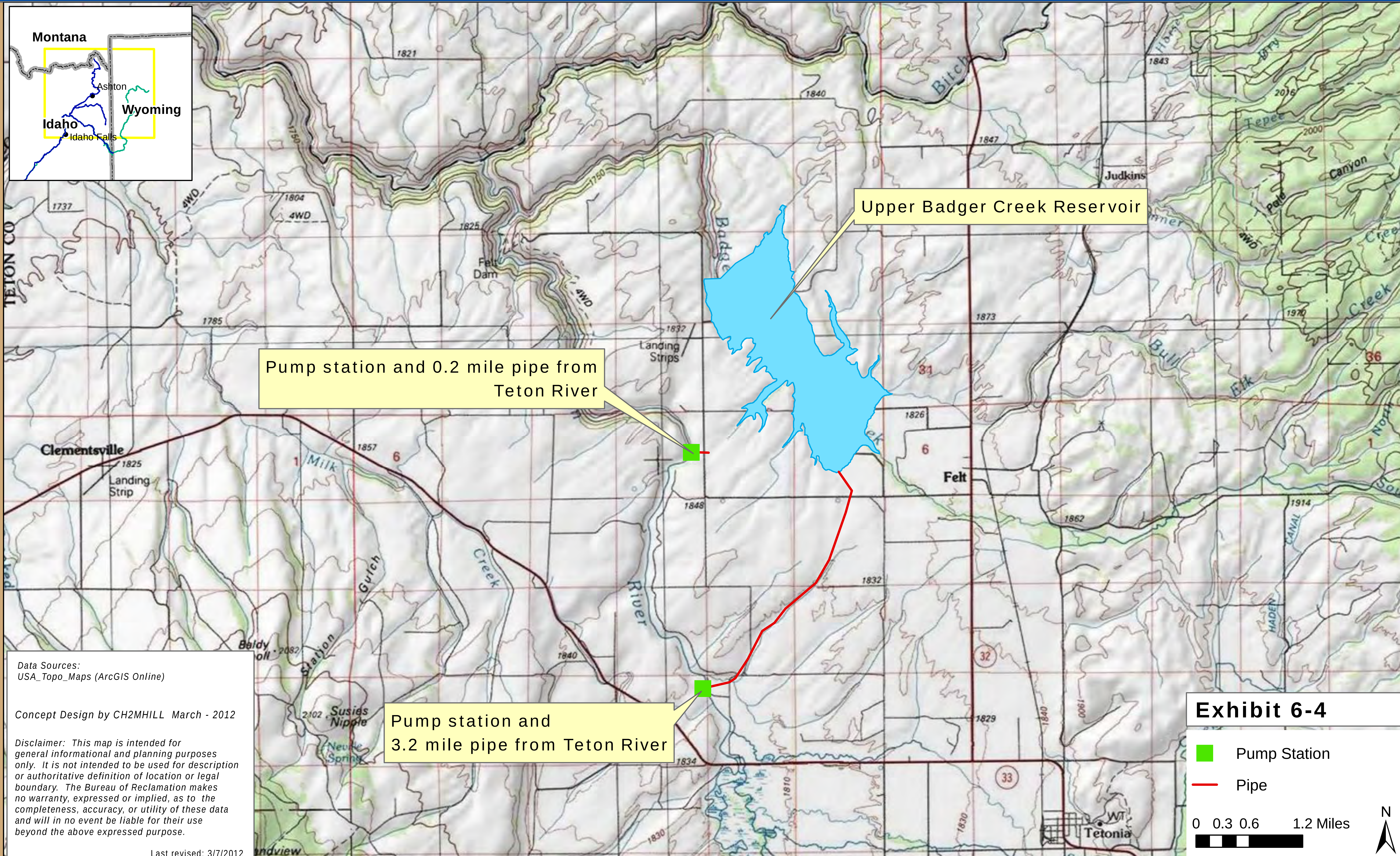

Data Sources:
USA_Topo_Maps (ArcGIS Online)

Concept Design by CH2MHILL March - 2012

Disclaimer: This map is intended for general informational and planning purposes only. It is not intended to be used for description or authoritative definition of location or legal boundary. The Bureau of Reclamation makes no warranty, expressed or implied, as to the completeness, accuracy, or utility of these data and will in no event be liable for their use beyond the above expressed purpose.

Last revised: 3/7/2012

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Other conveyance features were also assessed during the evaluation including stream diversions, intake and fish screen structures, pump stations, and siphons. Those features are accounted for in the cost estimate, and the procedures used to identify and size those features are documented in Section 2.3.4 – *Cost Basis*.

6.3.3 Dam Configuration

A rockfill or granular earthfill dam would be constructed to impound Upper Badger Creek Reservoir. The cross-section presented in Exhibit 2-3 shows a typical configuration for the proposed dam at this location, which features a central core with filter blanket drains and earthfill/rockfill shells. A concrete grout curtain/cutoff would also be required because of concern about seepage through the dam foundation. The bottom of the valley at the proposed dam location is at an approximate elevation of 5,695 feet and the top of the dam would be at an approximate elevation of 5,985 feet for a maximum height of about 290 feet. The length of the dam at this elevation would be about 2,400 feet. The resulting reservoir would have about 47,000 af of storage with a maximum surface area of 1,550 acres. The upstream watershed is approximately 53 square miles. Exhibit 6-6 shows potential locations for the dam, appurtenant structures, and emergency spillway.

A potential spillway alignment has been identified on the right side of the dam, and the dam would require a low-level outlet that provides a safe way to drain the reservoir and integrate with ultimate water distribution and hydropower schemes. An outlet pipeline would be constructed at the base of the dam and is assumed to be founded in bedrock. The depth to rock along this alignment is unknown but rock exposures in the valley walls and generally shallow depth to rock in well logs suggest that rock depths could be relatively shallow.

The dam foundation is expected to consist of alluvium and/or colluvium overlying bedrock. Bedrock under the dam site within the valley bottom is expected to consist of rhyolite tuff. The depth of overburden is unknown; however, steep slopes and rock outcrops in some areas along the sides of the valley suggest that rock could be encountered at relatively shallow depths. The abutments of the dam are expected to encounter colluvium and talus overlying rhyolite tuff including pumice and volcanic ash. Exhibit 6-7 presents a profile of the dam axis and highlights geologic features that could affect the foundation.

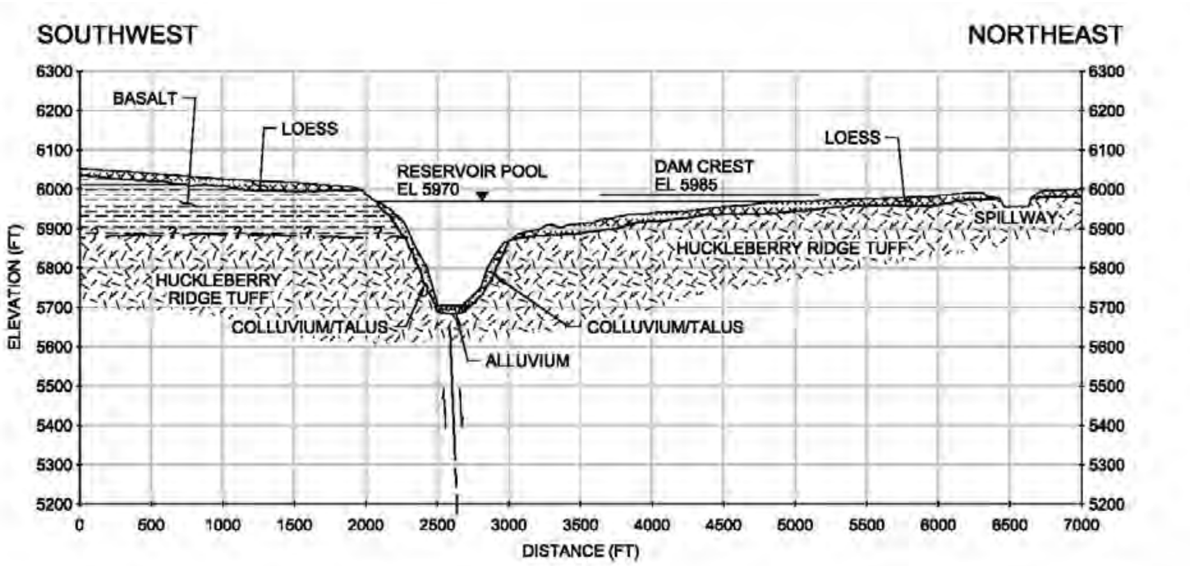

EXHIBIT 6-7
Upper Badger Creek Dam Geologic Profile

6.3.4 Hydropower Potential

As presented in Exhibit 6-8, hydropower potential associated with Upper Badger Creek would vary from approximately 840 kW to 2,430 kW.

EXHIBIT 6-8
Upper Badger Creek Hydropower Potential

Sub-Alternative	Design Flow (cfs)	Penstock Length (mi)	Head (ft)	Power Potential (kW)
UB	27.2	3.9	590	840
UB-T-1 _P; UB-T-2_P	70.2	3.9	590	2,430

6.4 Cost Estimate

A summary of the cost per acre-foot of water stored for each sub-alternative are presented in Exhibit 6-9. These costs include hydropower facilities.

EXHIBIT 6-9
Upper Badger Creek Sub-Alternative Cost Estimates[1]

Sub-Alternative	Storage Volume (af)	Total Construction Cost	Cost Per Unit Yield ($/acre-foot)
UB	16,252	$86,230,000	5,300
UB-T-1_P	47,000	$128,940,000	2,700
UB-T-2_P	47,000	$156,280,000	3,300

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

6.5 Basin Water Needs

The storage provided by Upper Badger Creek Reservoir would enhance the in-basin water budget by diverting 47,000 af during the annual high flow period and storing that water until more critical, higher demand periods during the summer and early fall. Water stored in the reservoir would help satisfy unmet irrigation demands in the Egin Bench (more water available in the Henrys Fork because of reduced need for diversions into the Crosscut Canal) and Lower Watershed irrigated regions (Reclamation, 2012). Reservoir releases would also be used to enhance ecological in-stream flows (see Section 6.7.2 – *Change in Connectivity*).

The out-of-basin water budget would be temporarily reduced by up to 37,000 af during the annual high flow period when water is diverted to the reservoir, but some or all of that quantity may be available at a later time for numerous out-of-basin uses, including needs resulting from climate change; agricultural needs; domestic, municipal, and industrial needs; ecological needs; and for recharge of the ESPA (Reclamation, 2012).

RECLAMATION
Managing Water in the West

Henrys Fork Basin Study, Idaho and Wyoming
Upper Badger Creek Dam Alternative: Dam and Appurtenant Structures

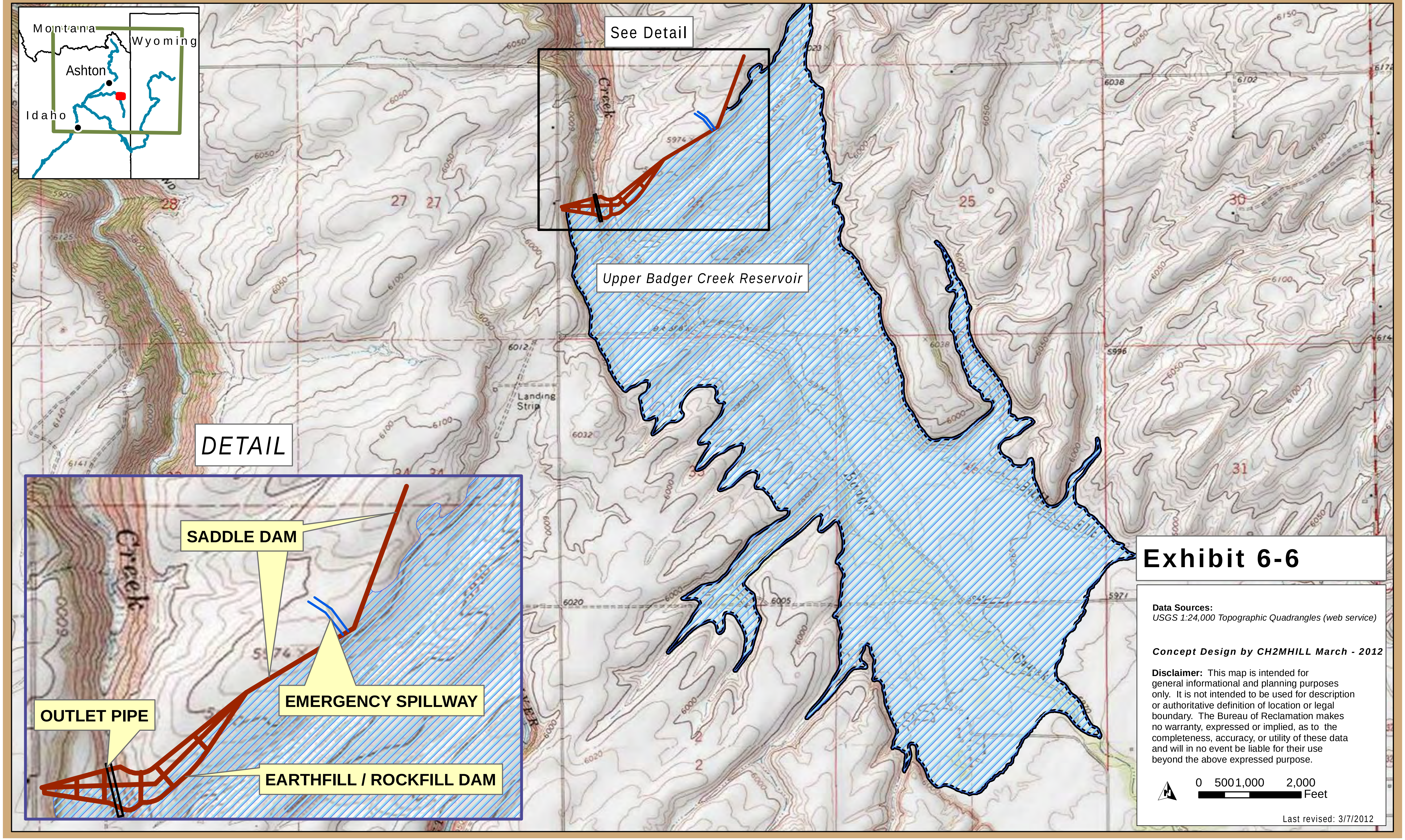

Exhibit 6-6

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6.6 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*.

6.7 Environmental Benefits and Impacts

6.7.1 Impacted River Segments

River segments potentially impacted by various sub-alternatives include Upper Badger Creek and the Teton River, as identified in Exhibit 6-10.

6.7.2 Change in Connectivity

Potential impacts to river connectivity consist of decreased flow (diversions to the reservoir) for river segments providing reservoir supply and increased flow for river segments receiving reservoir releases. As described in Section 2.2.1.3 – *Potentially Available Water*, diversions would likely occur during the excess spring runoff period and reservoir releases would likely occur during more critical low flow periods in the summer and fall. Potential impacts to connectivity of each impacted river segment are identified in Exhibit 6-10. In addition to the segments listed in Exhibit 6-10, enhanced connectivity would be experienced in other downstream river segments, including Badger Creek, North Fork Teton River, South Fork Teton River, and the Lower Henrys Fork River, which have all been identified as having additional ecological streamflow needs (Van Kirk et al., 2011).

6.7.3 State Aquatic Species of Special Concern

Upper Badger Creek has been identified as containing a core conservation population of Yellowstone cutthroat trout, which is defined as a population with greater than 99 percent Yellowstone cutthroat trout genes. The reservoir inundation area is in a reach that currently provides a dry barrier during periods of low flow that has successfully prevented invasion of rainbow trout upstream. A reservoir would provide a site for potential establishment of rainbow trout or other species that would have a negative impact on the population of Yellowstone cutthroat trout in Badger Creek. Potential modifications to the hydrology of the Teton River would also impact a conservation population, which is defined as having less than 10 percent genetic introgression from other species. State Aquatic Species of Special Concern in potentially impacted river segments are indicated in Exhibit 6-10.

6.7.4 Other Environmental Factors

The proposed Upper Badger Creek Reservoir inundation area contains both winter range and migration corridors for big game, according to Trout Unlimited (TU), Friends of the Teton River (FTR), American Rivers (AR), and the Idaho Department of Fish and Game (IDFG). The United States Fish and Wildlife Service (USFWS) tracks two federally listed threatened species, the grizzly bear and the Canadian lynx, and one candidate species, the wolverine, in the area. Sandhill crane and sharp-tailed grouse, considered at-risk by the Bureau of Land Management (BLM) and the United States Forest Service (USFS), also make their homes here. Data from the National Wetlands Inventory (NWI) indicate construction at this site would have moderate impact on mapped wetlands, affecting an area between 1 and 200 acres. 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. Badger Creek is designated as a State Recreational River, and the Teton River is eligible for Wild and Scenic River status designation.

Potential wildlife habitat impacts, federally listed species, and wetlands habitat impacts within the reservoir inundation area are also summarized in Exhibit 6-11, while State of Idaho species of concern (Yellowstone cutthroat trout) and special river designations for all potentially impacted river segments are summarized in Exhibit 6-10.

6.8 Land Management, Recreation and Infrastructure Impacts and Benefits

Upper Badger Creek Reservoir is located on private and conservation easement land, has a high recreation and economic rating due to boating and fishing activities, and is rated as having few potential infrastructure impacts, as summarized in Exhibit 6-12.

6.9 Assumptions and Limitations

General assumptions and limitations applicable to all of the surface-storage alternatives are described in Section 2.8 – *Key Assumptions and Limitations*. Additional assumptions and limitations specific to this alternative are listed below:

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

6.10 Evaluation Criteria

6.10.1 Stakeholder Group Measurable Criteria

There are four Stakeholder Group Measurable Criteria, with results summarized in Exhibit 6-13:

- Water Supply: The net change for in basin and out of basin water budgets in af is described above in Section 6.5 and summarized in Section 6.2.
- Water Rights: Water rights were not specifically addressed during this level of study, but known legal, institutional, and policy constraints are summarized in Section 6.6.
- Environmental Considerations: Environmental benefits and impacts are summarized above in Section 6.7.
- Economics: The estimated reconnaissance-level field cost to construct the project is summarized in Section 6.4.

EXHIBIT 6-13
Stakeholder Group Measurable Criteria Summary

Stakeholder Group Measurable Criteria	Criteria Characterization
Water Supply (in-basin water transfer potential)	47,000 af/yr
Water Supply (out-of-basin water transfer potential)	47,000 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)	\$86,230,000 - \$156,280,000

[1] – Net environmental impact would depend on water sources and reservoir operations; further analysis required in future phase of study.

6.10.2 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 6-10

Impacts to Connectivity, State Aquatic Species of Special Concern, and Special River Designations for Affected River Reaches

			Connectivity		State Aquatic Species of Special Concern			Special Designation[a]				
Surface Storage Site	Sub-Alternative	Impacted River Segments	Flow Decrease (Supply Source)	Flow Increase (Receives Reservoir Releases)	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
Upper Badger	UB-T-1_P	Badger Creek	•	•	•		YCT Core	•		•		State / Eligible Federal
		Teton River	•	•	•		YCT Conservation	•				Eligible Federal
Upper Badger	UB-T-2_P	Badger Creek	•	•	•		YCT Core	•		•		State / Eligible Federal
		Teton River	•	•	•		YCT Conservation	•				Eligible Federal
Upper Badger	UB	Badger Creek	•	•	•		YCT Core	•		•		State / Eligible Federal
		Teton River		•	•		YCT Conservation	•				Eligible Federal

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

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Exhibit 6-11

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

Surface Storage Site	Wildlife Habitat[a]			Federally Listed Species			Wetland/Habitat Value	
	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
Upper Badger Creek	•[1,2]	•[2]	Winter Range	sandhill crane, sharp-tailed grouse	Canadian lynx, grizzly bear, wolverine	Federal Terrestrial	•	Moderate

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) and personal communications with the Henrys Fork Foundation.

[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
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	<1 Acre

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Exhibit 6-12

	Land Management Data[a]					Recreation/Economic Value								Infrastructure[d]				
Surface Storage 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
Upper Badger Creek	•			•	Federal/ Conservation	•[b,c]	•[b,c]					camping, trails	High					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

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SECTION 7
Moose Creek Dam

7.1 Alternative Description

7.1.1 Overview

The Moose Creek alternative features a proposed new 160-foot-tall dam and a 60,000 af reservoir. The dam site is located in the Henrys Fork watershed at the headwaters of Moose Creek between Island Park Reservoir and Big Springs. Water for the reservoir must be pumped from the Henrys Fork River, or potentially Big Springs, depending on volumes and restrictions. When full, Moose Creek Reservoir could provide a roughly 140- to 260-foot drop to a proposed new hydropower facility on Moose Creek at the base of the dam or on the Henrys Fork River. Expansion of the Crosscut Canal would also allow water released from the reservoir to be transferred to the Lower Teton watershed.

7.1.2 Alternative Variations

The following sub-alternatives were identified by varying potential water-supply sources. Conveyance routes for the sub-alternatives are collectively shown on Exhibits 7-2 and 7-4. Specific conveyance lengths and features are summarized below in Section 7.3.2 – *Conveyance.*

- Ms-H-1_P: Moose Creek Reservoir supplied by Moose Creek (natural inflow to reservoir) and Henrys Fork River (pump station [PS1] and pipe)
- Ms-H-2_P: Moose Creek Reservoir supplied by Moose Creek (natural inflow to reservoir) and Henrys Fork River (combination of pump station [PS2], pipe, and gravity-flow canal)
- Ms-H-3_P: Moose Creek Reservoir supplied by Moose Creek (natural inflow to reservoir) and Henrys Fork River (combination of pump station [PS3], pipe, and gravity-flow canal)
- Ms-H-4_P: Moose Creek Reservoir supplied by Moose Creek (natural inflow to reservoir) and Henrys Fork River (combination of pump station [PS4], pipe, and gravity-flow canal)

7.1.3 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 evaluate potential water availability and design flow to identify sub-alternatives and develop relative costs.

7.2 Key Findings

Moose Creek Reservoir would provide additional water storage for the Henrys Fork Basin and for the Teton Basin via cross-basin transfer using the Crosscut Canal, effectively enhancing water supply by capturing excess peak flows and redistributing that water during periods of higher demand. The available storage would enhance the in-basin water budget by diverting 60,000 af during the annual high flow period and storing that water until more critical, higher demand periods. This storage water could help satisfy unmet irrigation demands in the North Fremont, Lower Watershed, and Egin Bench irrigated regions. Reservoir releases during low flow periods would improve connectivity in other downstream river segments, including the Middle Henrys Fork River, Lower Henrys Fork River, North Fork Teton River, and South Fork Teton River, which have all been identified as having additional ecological streamflow needs. Diversions would typically occur during periods when connectivity is not an issue, and withdrawals would not be expected to impact any populations of Yellowstone cutthroat trout, but a priority rainbow trout fishery in the Henrys Fork River could be impacted. The out-of-basin water budget would be temporarily reduced by up to 60,000 af during the annual high flow period when water is diverted to the reservoir, but some or all of that quantity may be available at a later time for numerous out-of-basin uses, including needs resulting from climate change; agricultural needs; domestic, municipal, and industrial needs; ecological needs; and for recharge of the ESPA. Exhibit 7-1 provides a tabular summary of the key findings.

EXHIBIT 7-1
Key Findings from the Reconnaissance Evaluation

Estimated Cost per af	Impact on In-Basin Water Budget	Impact on Out-of-Basin Water Budget	Change in Connectivity of Impacted River Segment
$2,800 - $4,200	60,000 af, to be diverted during the annual high flow period and released during high demand periods.	60,000 af reduction during the annual high flow period, in accordance with priority rights. Part or all of this quantity would be available later for out-of-basin needs.	Improvement in connectivity of downstream river segments, including Middle Henrys Fork River, Lower Henrys Fork River, North Fork Teton River, and South Fork Teton River. Potential impacts to supply sources, none of which contain conservation populations of Yellowstone cutthroat trout.

7.3 Engineering Results

7.3.1 Hydrology

7.3.1.1 Water Supply

Two potential water supply sources were identified: Moose Creek and the Henrys Fork River (Exhibit 7-2). Exhibit 7-3 presents a summary of potentially available water from each source based on analyses using StreamStats (USGS, 2011; see Section 2.2.1 – *Hydrology*).

EXHIBIT 7-3
Water Potentially Available for Storage at Moose Creek

Source	Watershed Area (sq. mi)	Quantity (af/year)
Moose Creek	9.1	7,943
Henrys Fork River[1]	171.0	144,614

[1] – Quantity reported for regulated systems is total estimated water in system. Excess spring runoff calculation was considered invalid for these systems because of upstream dam regulation.

7.3.1.2 Crosscut Canal

The Crosscut Canal is an existing conveyance feature that allows water from the Henrys Fork River to be diverted and routed to the Lower Teton River. This cross-basin water transfer enables storage projects in the Henrys Fork Basin to help meet demands in the Teton Basin.

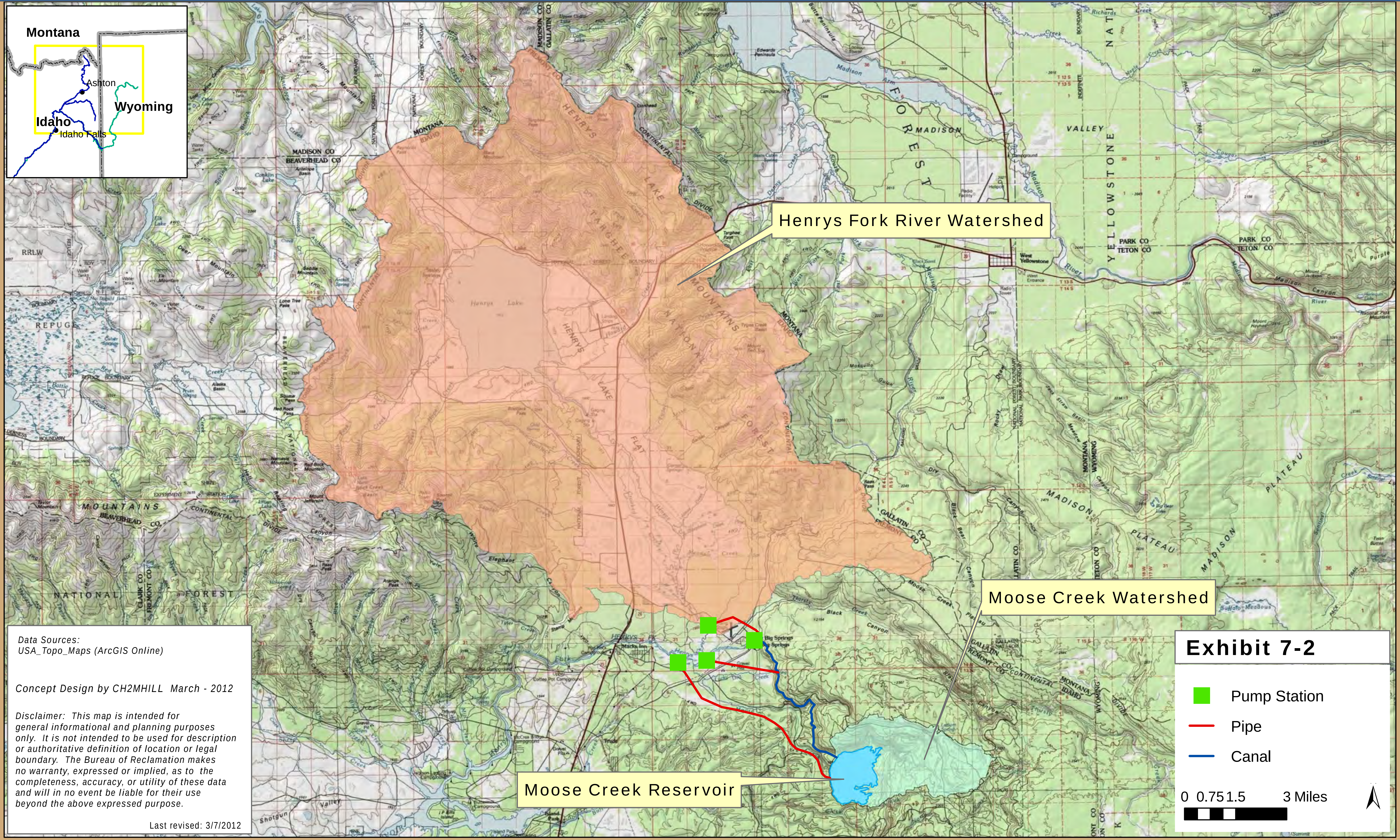
7.3.2 Conveyance

7.3.2.1 Reservoir Supply Routes

Water supply routes were established from each source, using a combination of pressurized pipelines and canals as depicted in Exhibit 7-4. Siphons were not used for any of the sub-alternatives. Conveyance routes are conceptual, and are intended only to provide a basis for relative cost comparison, rather than reflect actual alignments and features for design. Exhibit 7-5 summarizes the key physical characteristics of each sub-alternative.

Henrys Fork Basin Study, Idaho and Wyoming

Moose Creek Dam Alternative: Hydrology



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Henrys Fork Basin Study, Idaho and Wyoming

Moose Creek Dam Alternative: Conveyance

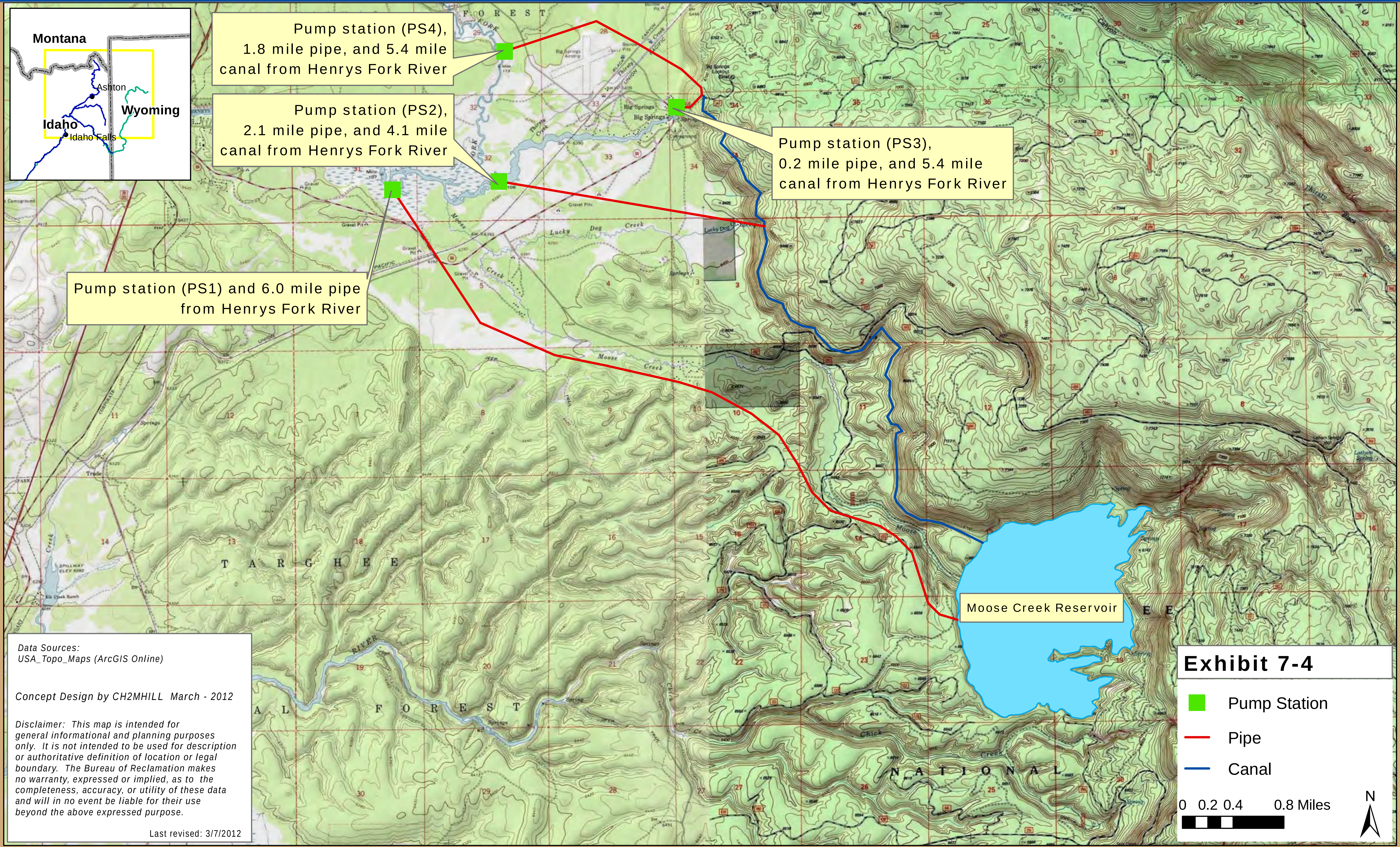

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EXHIBIT 7-5
Moose Creek Sub-Alternative Characteristics

Sub-Alternative	Source	Volume Diverted (acre-ft/year)	Conveyance Length (mi)	
			Canal	Pipe[1]
Ms-H-1_P	Moose Creek	7,943	0.0	0.0
	Henrys Fork River	52,057	0.0	6.0
Ms-H-2_P	Moose Creek	7,943	0.0	0.0
	Henrys Fork River	52,057	4.1	2.1
Ms-H-3_P	Moose Creek	7,943	0.0	0.0
	Henrys Fork River	52,057	5.4	0.2
Ms-H-4_P	Moose Creek	7,943	0.0	0.0
	Henrys Fork River	52,057	5.4	1.8

[1] – Pipe length includes siphons and pressurized pipe from pump stations, if applicable.

Other conveyance features were also assessed during the evaluation including stream diversions, intake and fish screen structures, pump stations, and siphons. Those features are accounted for in the cost estimate, and the procedures used to identify and size those features are documented in Section 2.3.4 – *Cost Basis*.

7.3.2.2 Crosscut Canal

The current capacity of the existing Crosscut Canal is approximately 600 cfs at the upstream end of the canal and approximately 400 cfs at the downstream end (FMID, personal communication, 2011). To better enable this alternative to help meet demands in the Lower Teton basin, an evaluation was conducted to expand the hydraulic capacity of the Crosscut Canal by an additional 400 cfs.

Dimensions for an expanded Crosscut 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"). Canal parameters for capacity iterations were generally in accordance with Reclamation's Canal Design Flowchart (Reclamation, 2010) for the five canal sections reported in the profile and section design drawings (Reclamation, 1936).

Exhibit 7-6 summarizes the key physical characteristics of the canal, and the differences between existing and proposed flow areas were used to determine excavation quantities and costs included in Section 7.4 – *Cost Estimate*.

EXHIBIT 7-6
Crosscut Canal Characteristics

Section	Length (mi)	Manning's Roughness (n)	Longitudinal Slope	Side Slope	Existing Condition		Proposed Expansion	
					Capacity (cfs)	Flow Area (sq. ft)	Capacity (cfs)	Flow Area (sq. ft)
1	2.0	0.0225	0.0003	1.5H:1V	589	197	1,000	286
2	0.6	0.0225	0.0003	1.5H:1V	754	241	1,000	293
3	0.6	0.0225	0.0009	1.5H:1V	562	143	1,000	246
4	1.1	0.0225	0.0005	1.5H:1V	407	132	1,000	262
5	2.3	0.0225	0.0004	1.5H:1V	399	140	1,000	282

7.3.3 Dam Configuration

A rockfill or granular earthfill dam would be constructed to impound Moose Creek Reservoir. The cross-section presented in Exhibit 2-3 shows a typical configuration for the proposed dam at this location, which features a central core with filter blanket drains and earthfill/rockfill shells. A concrete grout curtain/cutoff would also be required to limit seepage through the dam foundation. The bottom of the valley at the proposed dam location is at an approximate elevation of 6,495 feet and the top of the dam would be at an approximate elevation of 6,655 feet for a maximum height of about 160 feet. The length of the dam at this elevation would be about 1,300 feet. The resulting reservoir would have about 60,000 af of storage with a maximum surface area of 1,080 acres. The upstream watershed is approximately 9 square miles. Exhibit 7-7 shows potential locations for the dam, appurtenant structures, and emergency spillway.

A potential spillway alignment has been identified near the left abutment, and the dam would require a low-level outlet that provides a safe way to drain the reservoir and integrates with ultimate water distribution and hydropower schemes. Excavation for the open spillway would likely be in colluvial soils and/or rock. It is possible that the spillway may be in soft erodible materials if an open channel spillway is used. This may require concrete or rock linings that are suitable to match the intended spillway flows. The depth to rock along this alignment is unknown but steep slopes and rock mapping along the sides of the valley suggest that rock could be encountered at relatively shallow depths.

The dam foundation is expected to consist of alluvium and/or colluvium overlying bedrock. Bedrock under the dam site within the valley bottom is expected to consist of rhyolite tuff. The depth of overburden is unknown; however, steep slopes and rock outcrops in some areas along the sides of the valley suggest that rock could be encountered at relatively shallow depths. The abutments of the dam are expected to encounter colluvium and talus overlying rhyolite tuff including pumice and volcanic ash. Exhibit 7-8 presents a profile of the dam axis and highlights geologic features that could affect the foundation.

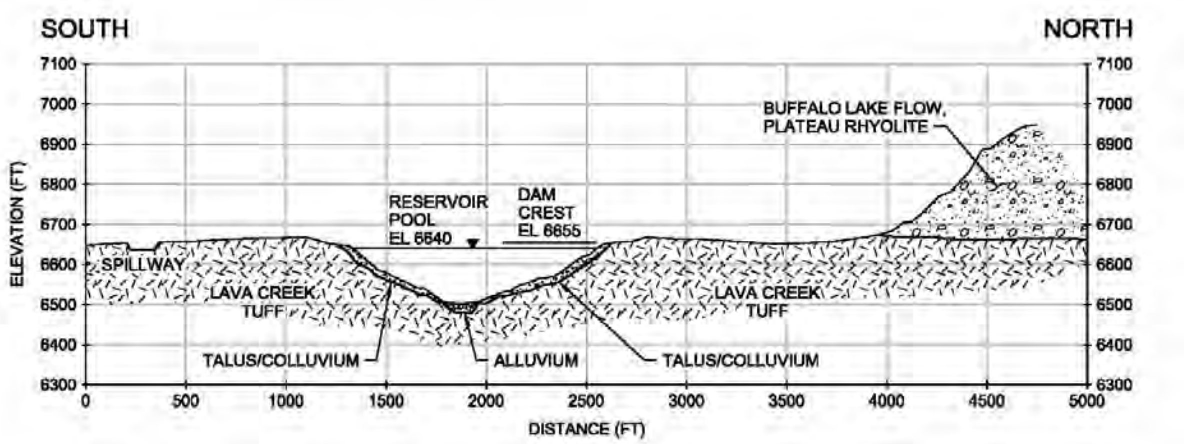

EXHIBIT 7-8
Moose Creek Dam Geologic Profile

RECLAMATION
Managing Water in the West

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Henrys Fork Basin Study, Idaho and Wyoming

Moose Creek Dam Alternative: Dam and Appurtenant Structures

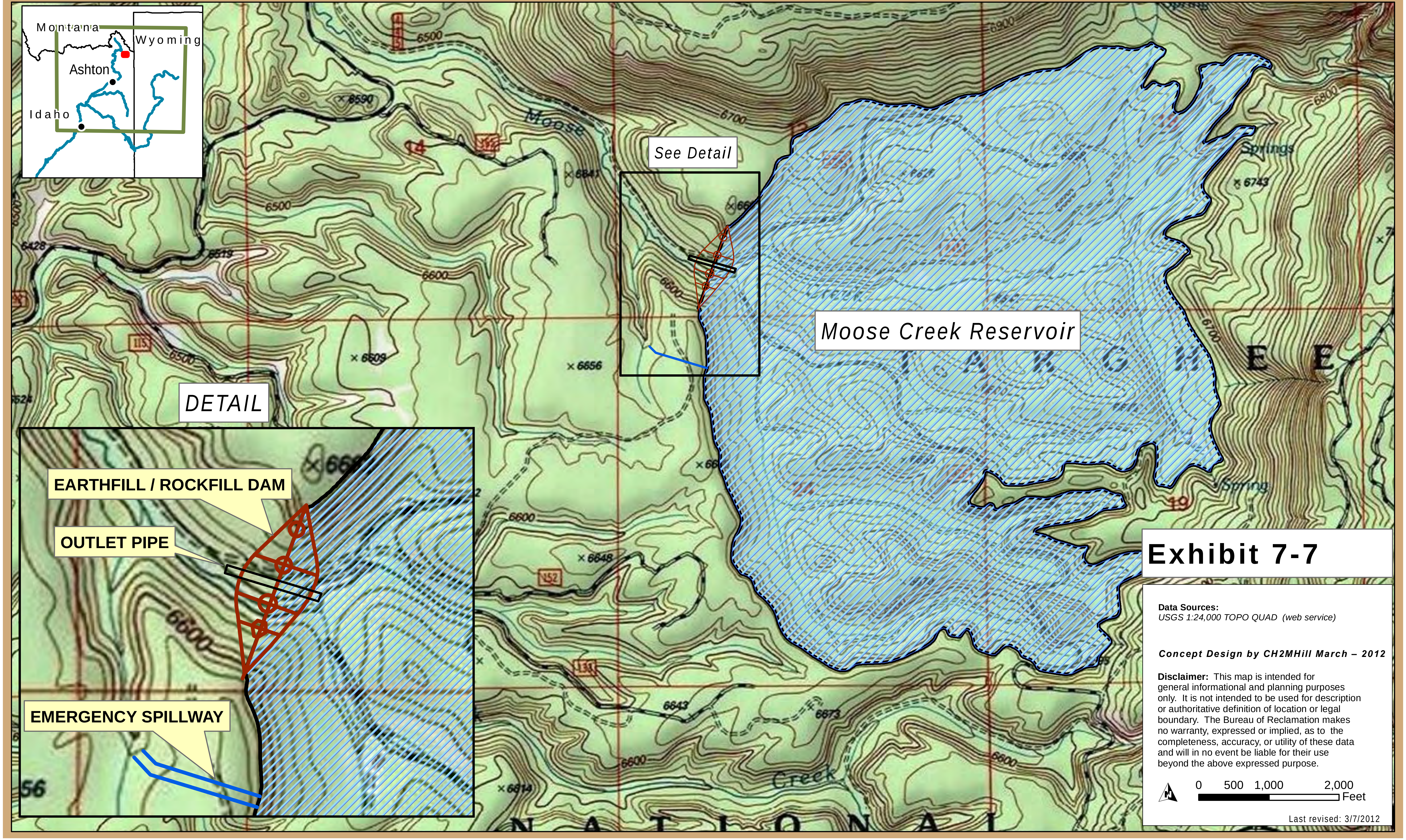

Exhibit 7-7

Data Sources:
USGS 1:24,000 TOPO QUAD (web service)

Concept Design by CH2MHill March – 2012

Disclaimer: This map is intended for general informational and planning purposes only. It is not intended to be used for description or authoritative definition of location or legal boundary. The Bureau of Reclamation makes no warranty, expressed or implied, as to the completeness, accuracy, or utility of these data and will in no event be liable for their use beyond the above expressed purpose.

Last revised: 3/7/2012

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7.3.4 Hydropower Potential

As presented in Exhibit 7-9, hydropower potential associated with Moose Creek would vary from approximately 860 kW to 1,598 kW.

EXHIBIT 7-9
Moose Creek Hydropower Potential

Sub-Alternative	Design Flow (cfs)	Penstock Length (mi)	Head (ft)	Power Potential (kW)
Ms-H-1_P	89.6	0[1]	260	1,598
Ms-H-2_P; Ms-H-3_P; Ms-H-4_P	89.6	0[2]	140	860

[1] – It is assumed that pumping delivery pipe will be operated in reverse flow direction during power generation. Therefore, no penstocks are needed. However, converting pump station to reversible turbines was assumed to increase the pump station cost by 10 percent.
[2] – It is assumed that turbines are located at the bottom of the outlet works. Therefore, no penstocks are needed.

7.4 Cost Estimate

A summary of the cost per acre-foot of water stored for each sub-alternative are presented in Exhibit 7-10. These costs include hydropower facilities and expansion of the Crosscut Canal.

EXHIBIT 7-10
Moose Creek Sub-Alternative Cost Estimates[1]

Sub-Alternative	Storage Volume (af)	Total Construction Cost	Cost Per Unit Yield ($/acre-foot)
Ms-H-1_P	60,000	$251,560,000	4,200
Ms-H-2_P	60,000	$198,500,000	3,300
Ms-H-3_P	60,000	$167,680,000	2,800
Ms-H-4_P	60,000	$198,370,000	3,300

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

7.5 Basin Water Needs

The storage provided by Moose Creek Reservoir would enhance the in-basin water budget by diverting 60,000 af during the annual high flow period and storing that water until more critical, higher demand periods during the summer and early fall. Water stored in the reservoir would help satisfy unmet irrigation demands in the North Fremont, Lower Watershed, and Egin Bench irrigated regions (Reclamation, 2012). Reservoir releases would also be used to enhance ecological in-stream flows (see Section 7.7.2 – *Change in Connectivity*).

The out-of-basin water budget would be temporarily reduced by up to 60,000 af during the annual high flow period when water is diverted to the reservoir, but some or all of that quantity may be available at a later time for numerous out-of-basin uses, including needs resulting from climate change; agricultural needs; domestic, municipal, and industrial needs; ecological needs; and for recharge of the ESPA (Reclamation, 2012).

7.6 Legal, Institutional, or Policy Constraints

Many legal, institutional, and policy constraints that may affect the implementation of this alternative are described in Section 2.5 – *Legal, Institutional, or Policy Constraints*. Additionally, development of a project at this site would need to comply with the 1997 Revised Targhee Forest Plan or would require an Environmental Impact Statement to evaluate amending the Forest Plan.

7.7 Environmental Benefits and Impacts

7.7.1 Impacted River Segments

River segments potentially impacted by various sub-alternatives include Moose Creek and the Henrys Fork River, as identified in Exhibit 7-11.

7.7.2 Change in Connectivity

Potential impacts to river connectivity consist of decreased flow (diversions to the reservoir) for river segments providing reservoir supply and increased flow for river segments receiving reservoir releases. As described in Section 2.2.1.3 – *Potentially Available Water*, diversions would likely occur during the excess spring runoff period and reservoir releases would likely occur during more critical low flow periods in the summer and fall. Potential impacts to connectivity of each impacted river segment are identified in Exhibit 7-11. In addition to the segments listed in Exhibit 7-11, enhanced connectivity would be experienced in other downstream river segments, including the Middle Henrys Fork River, Lower Henrys Fork River, North Fork Teton River, and South Fork Teton River, which have all been identified as having additional ecological streamflow needs (Van Kirk et al., 2011).

7.7.3 State Aquatic Species of Special Concern

The reservoir inundation area is not in crucial habitat for Yellowstone cutthroat trout. No Yellowstone cutthroat trout population has been identified in Moose Creek, and only a minimal population has been documented in the Henrys Fork River (including Big Springs). Wild cutthroat trout are found in the Henrys Lake area and tributaries, and it is common for cutthroat to move from these areas to their native habitat in the upper Henrys Fork. Population surveys have documented cutthroat in the Henrys Fork, although not in large abundance. 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 7-11.

7.7.4 Other Environmental Factors

The proposed Moose Creek Reservoir inundation area listed as a migration corridor for big game, according to Trout Unlimited (TU), Friends of the Teton River (FTR), American Rivers (AR), the Idaho Department of Fish and Game (IDFG), and the Henrys Fork Foundation. The United States Fish and Wildlife Service (USFWS) tracks two federally listed threatened species, the grizzly bear and the Canadian lynx, and one candidate species, the wolverine, in the area. This area has been designated as a core area for grizzly bears, and the primary emphasis for these lands is to provide secure habitat for grizzly bears. Per the 1997 Targhee Revised Forest Plan, management activities are not to occur during the period bears are active. The bald eagle, boreal owl, flammulated owl, northern three-toed woodpecker, and trumpeter swan, considered at-risk by the Bureau of Land Management (BLM) and the United States Forest Service (USFS) occur in the area. Data from the National Wetlands Inventory (NWI) indicate that there are no NWI designated wetlands at this site. 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. Moose Creek is eligible for Recreational River status designation. The reach of the Henrys Fork River where water would be diverted is designated as a State Recreational and Natural River and has been identified as having the following outstanding remarkable characteristics: fish, wildlife, and recreational opportunities. Big Springs, one of the potential diversion sites, was designated in 1981 as the first National Water Trail in the U.S and is also designated as a National Natural Landmark.

Potential wildlife habitat impacts, federally listed species, and wetlands habitat impacts within the reservoir inundation area are also summarized in Exhibit 7-12, while State of Idaho aquatic species of special concern (Yellowstone cutthroat trout and rainbow trout) and special river designations for all potentially impacted river segments are summarized in Exhibit 7-11.

Exhibit 7-11

Impacts to Connectivity, State Aquatic Species of Special Concern, and Special River Designations for Affected River Reaches

Surface Storage Site	Sub-Alternative	Impacted River Segments	Connectivity		State Aquatic Species of Special Concern			Special Designation[a]				
			Flow Decrease (Supply Source)	Flow Increase (Receives Reservoir Releases)	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
Moose Creek	MS-H-1_P, MS-H-2_P, MS-4_P	Moose Creek	•	•		•	YCT Sport / None	•				Eligible Federal
		Henrys Fork	•	•	•[e]	•	RBT Priority		•	•		State
Moose Creek	MS-H-3_P	Moose Creek	•	•		•	YCT Sport / None	•				Eligible Federal
		Henrys Fork	•	•	•[e]	•	RBT Priority		•	•		State
		Big Springs	•		•[e]	•	RBT Priority		•[f]			Federal

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 personal communications with IDFG, wild cutthroat trout are found in the Henrys Lake area and tributaries, and it is common for cutthroat to move from these areas to their native habitat in the upper Henrys Fork. Population surveys have documented cutthroat in the Henrys Fork, although not in large abundance.

[f]Big Springs, one of the potential diversion sites, is designated as a National Water Trail and National Natural Landmark.

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
None	None

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Exhibit 7-12
Impacts to Wildlife Habitat, Federally Listed Species, and Wetland Habitat at the Reservoir Site

Surface Storage Site	Wildlife Habitat[a]			Federally Listed Species			Wetland/Habitat Value	
	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
Moose Creek	•[4]	•[4]	Winter Range	bald eagle[d], boreal owl, flammulated owl, northern three-toed woodpecker, trumpeter swan[d]	Canadian lynx, grizzly bear, wolverine	Sensitive		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 the Henrys Fork Foundation and IDFG.

[b]Per IDFG special species February 2011 GIS dataset (1-mile buffer area) and personal communications with the Henrys Fork Foundation.

[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, American Rivers, the IDFG February 2011 dataset, and personal communications with IDFG, BLM, and the Henrys Fork Foundation.

[d]Physical location of site is not located on sensitive habitat or special river designations, rather modifications to the hydrology of the water supply source would cause indirect impacts.

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
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	<1 Acre

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7.8 Land Management, Recreation and Infrastructure impacts and benefits

Moose Creek Reservoir is located on federal land, has a high recreation and economic rating due to scenic value, cultural and historic resource potential, and land-based recreation (hunting, hiking, camping, and wildlife viewing), and is rated as having few potential infrastructure impacts, as summarized in Exhibit 7-13.

7.9 Assumptions and Limitations

General assumptions and limitations applicable to all of the surface-storage alternatives are described in Section 2.8 – *Key Assumptions and Limitations*. Additional assumptions and limitations specific to this alternative are listed below:

- Big Springs is a suitable and acceptable location for diversion of Henrys Fork River water to the reservoir.
- The hydropower scheme varies by alternative, as explained in the notes for Exhibit 10-9.
- Excavation for the open spillway would likely be in colluvial soils and/or rock. It is possible that the spillway may be in soft erodible materials and if an open channel spillway is used, it may require concrete or rock linings that are suitable to match the intended spillway flows. A lined concrete spillway was assumed for costing purposes. Alternative spillway approaches should also be investigated once the inflow design flow has been established and local site conditions are better understood.

7.10 Evaluation Criteria

7.10.1 Stakeholder Group Measurable Criteria

There are four Stakeholder Group Measurable Criteria, with results summarized in Exhibit 7-14:

- Water Supply: The net change for in basin and out of basin water budgets in af is described above in Section 7.5 and summarized in Section 7.2.
- Water Rights: Water rights were not specifically addressed during this level of study, but known legal, institutional, and policy constraints are summarized in Section 7.6.
- Environmental Considerations: Environmental benefits and impacts are summarized above in Section 7.7.
- Economics: The estimated reconnaissance-level field cost to construct the project is summarized in Section 7.4.

EXHIBIT 7-14
Stakeholder Group Measurable Criteria Summary

Stakeholder Group Measurable Criteria	Criteria Characterization
Water Supply (in-basin water transfer potential)	60,000 af/yr
Water Supply (out-of-basin water transfer potential)	60,000 af/yr
Legal, Institutional, or Policy Constraints (yes, no)	Yes
Environmental Considerations (net positive, negative or neutral)	Negative
Economics (reconnaissance-level field costs for implementation)	$167,680,000 - $251,560,000

7.10.2 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 7-13

	Land Management Data[a]					Recreation/Economic Value								Infrastructure[e]				
Surface Storage Site	**Private**	**Federal**	**State**	**Conservation Easements[b]**	**Rating**	**Boating**	**Fishing**	**Yellowstone National Park**	**Guiding/ Outfitting**	**Scenic/ Natural Features[d]**	**Cultural/ Historic Resources[c]**	**Land Recreation[d]**	**Rating**	**Roads**	**Structures**	**Habitation**	**Additional Infrastructure Notes**	**Rating**
Moose Creek		•			Federal					•	archeologic site	•	High					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]Per personal communications with the Henrys Fork Foundation.

[e]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

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#	Page	Line	Comment	Comment Category[a]	Response (if necessary)
1	9	20	City of Ashton, not Town	1	Comment addressed in final TM.
2	39	7	The additional areas that would be inundated around IP Reservoir are big game migration corridors.	1	Comment addressed in final TM.
3	39	11	Add sharp-tailed grouse	1	Comment addressed in final TM.
4	40		Add sharp-tailed grouse. The expanded area of IP Reservoir would impact wetlands in the lower reaches of Sheridan Creek, Icehouse Creek, Hotel Creek, and others.	1	Comment addressed in final TM.
5	41		IP Reservoir is a popular boating area. For the 8-foot dam raise, would impact the historic Trude Ranch, perhaps other historic sites, Nez Perce Trail? The 8-foot alternative would also impact considerable land-based recreation – hunting, hiking, camping, ATV riding, etc.	1	Comment addressed in final TM.
6	43	7	City of Ashton, not Town	1	Comment addressed in final TM.
7	44	9	Clarify that Ashton Reservoir is currently operated as a run-of the river facility, no water impounded for irrigation storage. There are 3 generating units, one if 2.85 MW, the other two are both 2.5MW, so total 7.85MW.	1	Comment addressed in final TM.
8	44	11	Existing Ashton Dam is 226 ft. long and 60 feet tall.	1/2	The existing spillway is approximately 226 feet long, but the length of the entire structure is approximately 450 feet. The final TM clarifies that the 57 foot dam height is the approximate height to the top of spillway.
9	44	18	Building a new dam bypass tunnel north of the dam was a major component of the Ashton Dam remediation project.	1	Comment addressed in final TM.
10	57		The additional area that would be inundated by Ashton Reservoir would back up into a State Designated Recreational River.	1	Comment addressed in final TM.
11	58	12	NO YCT??	2	YCT populations not documented in available literature in this reach of the Henrys Fork River.
12	58	15	The expanded Ashton Reservoir would inundate big game winter range in addition to migratory corridor.	1	Comment addressed in final TM.
13	58	19	Add sharp-tailed grouse, and probably all of the wading birds and waterfowl also listed for Island Park Reservoir.	1	Comment addressed in final TM.
14	58	21	The expanded Ashton Reservoir would inundate wetlands in the lower reaches of Baker Springs, Rattlesnake Creek, others…	1	Comment addressed in final TM.
15	59		Add big game winter range, add sharp-tailed grouse and other wading birds and waterfowl, add wetland impacts.	1	Comment addressed in final TM.

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Technical Memorandum

Henrys Fork Basin Study
Dam Raise Alternatives

Technical Series No. PN-HFS-003

Prepared by

CH2MHILL®

For

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

November 2012

Contents

Section			Page

Exhibits **Page**

Part I – Introduction and Methodology

SECTION 1

Alternatives Introduction

1.1 Alternatives Overview

A brief summary of each dam raise alternative is provided in the sections that follow, with dam and reservoir locations depicted in Exhibit 1-1. More detailed descriptions of each alternative and lists of their sub-alternatives (if applicable) are provided in the alternative-specific sections at the end of the report.

1.2 Island Park Dam Raise

The Island Park Dam Raise Alternative consists of raising Island Park Reservoir normal pool by one to eight feet to increase reservoir storage by 8,000 to 74,000 acre-feet (af). The one foot raise would be accomplished by replacing the rubber bladder on the spillway, and the eight foot raise would be accomplished by building up the entire embankment and raising the spillway. Island Park Reservoir is located directly on the Henrys Fork River at the Town of Island Park and would require no secondary water sources. When full, the proposed one foot reservoir raise could provide a roughly 44-foot drop to the existing hydropower facility on the Henrys Fork River at the base of the dam, and the eight foot dam raise would provide a roughly 51-foot drop to a proposed new hydropower facility. A variation of this alternative includes expansion of the Crosscut Canal, which would allow water released from the reservoir to be transferred to the Lower Teton Basin.

1.3 Ashton Dam Raise

The Ashton Dam Raise Alternative consists of raising Ashton Dam by approximately 43 feet to a total height of 100 feet to increase reservoir storage by 20,400 af to a total of 30,200 af. Ashton Reservoir is located directly on the Henrys Fork River at the City of Ashton, and would require no secondary water sources. When full, Ashton Reservoir could provide a roughly 80-foot drop to a proposed new hydropower facility at the base of the dam. A variation of this alternative includes expansion of the Crosscut Canal, which would allow water released from the reservoir to be transferred to the Lower Teton Basin.

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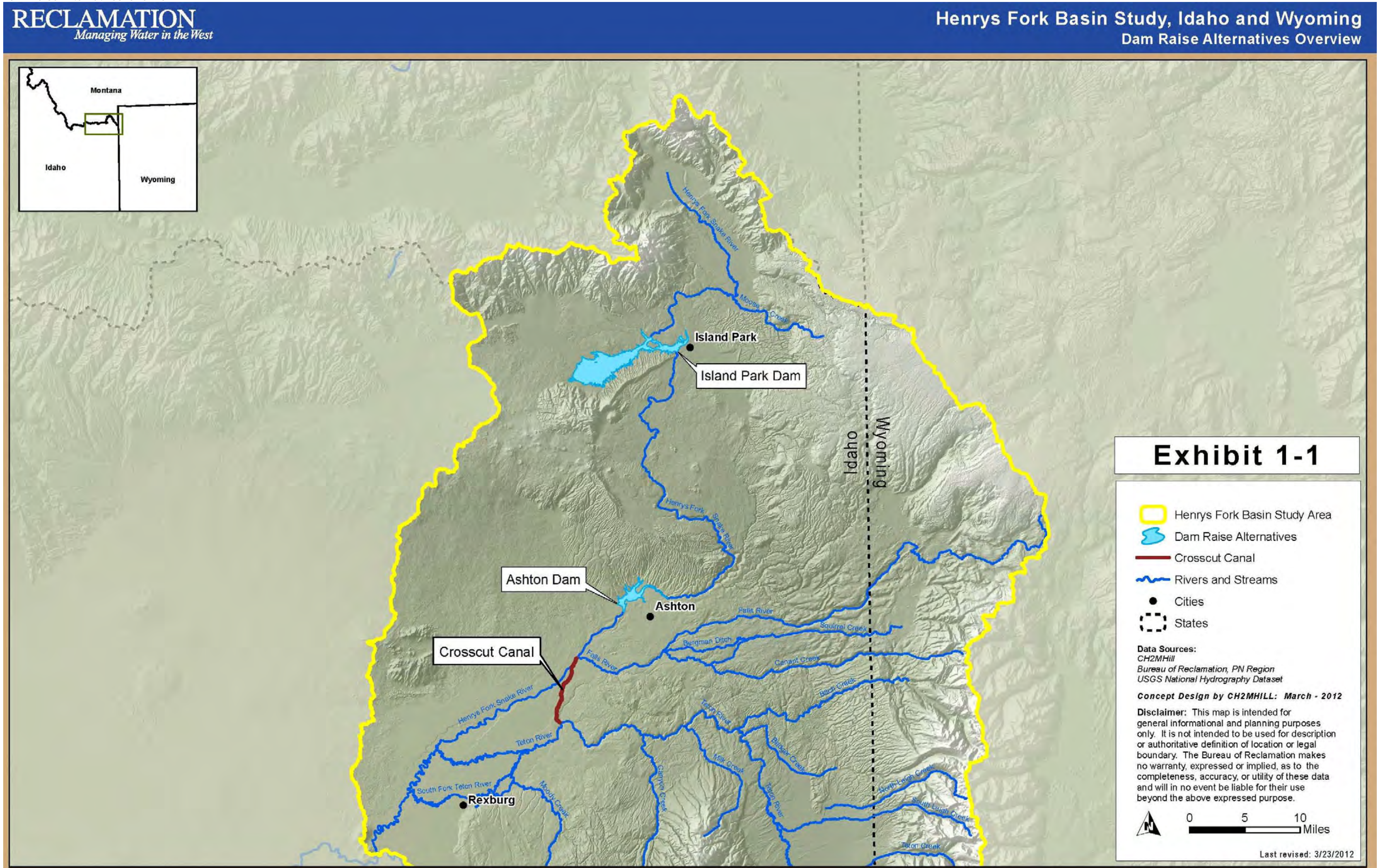
EXHIBIT 1-1
Dam Raise Alternatives Overview



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SECTION 2

Evaluation Approaches, Assumptions, and Limitations

2.1 Overview

This section 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 sections in Part II of this report.

2.2 Engineering Approaches

2.2.1 Hydrology

The hydrologic assessment was performed using StreamStats, a Web-based Geographic Information System (GIS) implemented by each state and managed by the USGS using ESRI GIS software tools. Users can obtain flow statistics, drainage-basin characteristics, and other information for user-selected sites on streams. If a user selects an ungaged site, StreamStats will delineate the drainage-basin boundary, measure basin characteristics, and estimate stream flow statistics using regional regression equations under the assumption of natural (unregulated) flow conditions.

2.2.1.1 StreamStats Output

Four primary types of data were downloaded and summarized from StreamStats for each watershed:

- Watershed Delineation: delineated in Web-based GIS and downloaded as shape files.
- Watershed Characteristics: area, mean annual precipitation and mean basin elevation.
- Regression-Based Estimates of Stream Flow: average annual flow rate and average percentile flow rates by month (exceeded 20 percent, 50 percent, or 80 percent of the time). These were converted to average runoff volumes.
- Standard Estimation Errors: The stream flow estimates are regression-based statistics. The standard estimation error is one standard deviation (+/-) from the best estimate, expressed as a percent. Roughly two-thirds (68.2 percent) of the indicated statistic for gaged sites fell within the standard error range indicated. Actual standard error for an ungaged site may or may not be comparable, depending on how similar the ungaged site is to regional gaged sites.

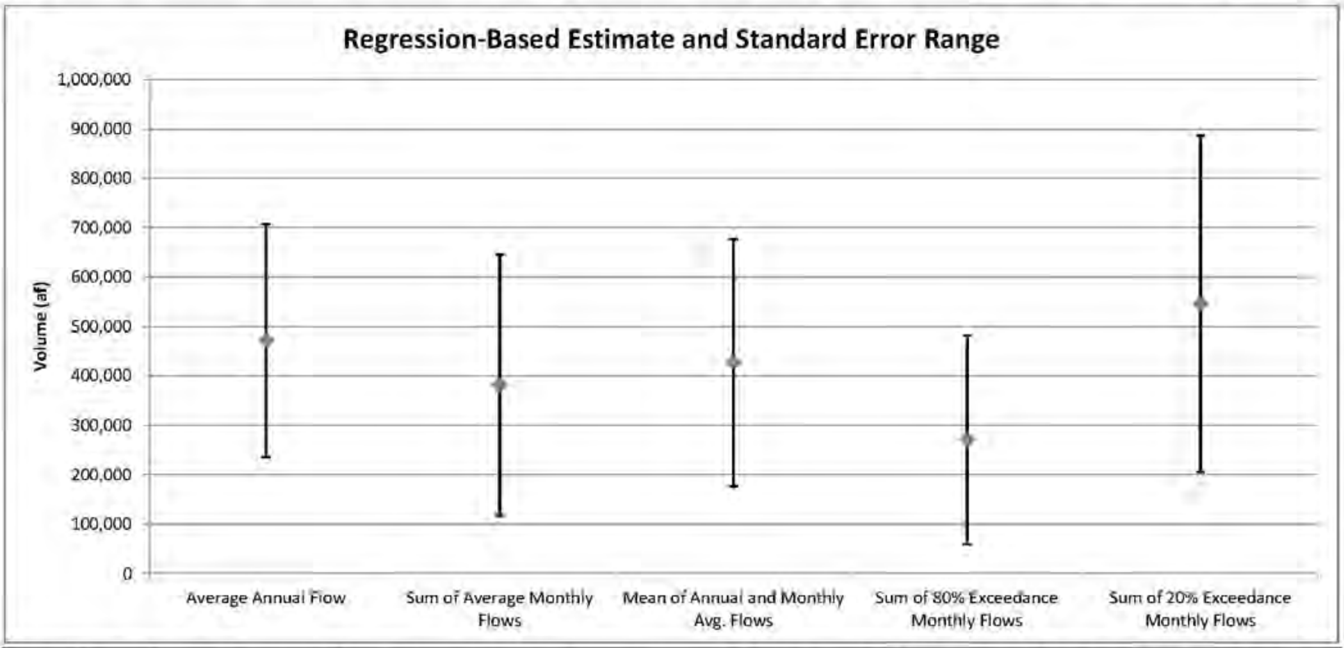
2.2.1.2 Hydrologic Summary

Using the Henrys Fork River at Island Park as an example, the StreamStats output is summarized in Exhibit 2-1. The primary table and associated chart in Exhibit 2-1 are intended to provide a high-level overview of the watershed hydrology and associated levels of uncertainty. Rows 1 to 3 of the table present the watershed characteristics, Rows 4 to 6 summarize average annual flow volumes, and Rows 7 and 8 summarize low-flow (80 percent exceedance) and high-flow (20 percent exceedance) conditions.

Column 4 indicates whether the statistic should be considered biased. Columns 5 to 7 present the standard estimation error for each statistic reported by StreamStats. StreamStats provided a single error statistic by month, which was summarized in the table as the lowest, mean, and highest standard error when monthly statistics were summed or averaged over longer periods. Columns 8 to 10 present a standard confidence interval based on reported standard estimation errors. It should be noted that results in Columns 8 to 10 do not derive directly from the summary statistics in Columns 5 to 7, but are rather calculated using standard errors and statistics for each individual month.

EXHIBIT 2-1
Hydrology for Island Park Reservoir (Henry's Fork River) Watershed

1	2	3	4	5	6	7	8	9	10
				Standard Estimation Error (%)			68% Confidence Interval		
No.	Statistic	Units	Bias	Low	Mean	High	Low	Best Estimate	High
1	Watershed Area	(sq. mi.)	None	----	----	----	----	500	----
2	Mean Annual Precipitation	(inches)	None	----	----	----	----	33.3	----
3	Mean Basin Elevation	(feet)	None	----	----	----	----	7,070	----
4	Average Annual Flow	(af)	None	----	50%	----	236,013	472,026	708,040
5	Sum of Average Monthly Flows	(af)	None	46%	73%	96%	117,540	381,650	645,760
6	Mean of Annual and Monthly Avg. Flows	(af)	None	----	----	----	**176,776**	**426,838**	**676,900**
7	Sum of 80% Exceedance Monthly Flows	(af)	Underestimates	57%	83%	100%	59,133	270,563	481,994
8	Sum of 20% Exceedance Monthly Flows	(af)	Overestimates	37%	64%	81%	206,081	546,331	886,581



DEFINITION: The **"standard error range"** is the regression-based estimate +/- one standard deviation. Roughly two-thirds (68.2%) of the indicated statistic for gaged sites fell within the standard error range indicated. Results for ungaged sites may or may not be comparable, depending on how similar they are to the gaged sites used to develop the regression equation.

There were three alternative approaches to estimating average annual runoff volumes in Rows 4 to 6: direct calculation, sum of average monthly flows, and the average of these two statistics. Direct calculation of mean annual flow is an unbiased statistic. The sum of average monthly flows should also be a relatively unbiased estimate of mean annual flows. Although average annual runoff volumes are not typically produced by 12 sequential average-runoff months, the resulting skew relative to calculating average annual runoff directly should be mostly random (approximately normally distributed). With no clear preference for one method of calculating the mean annual flow, the results of both methods were averaged.

Percentile estimates were only available on a monthly basis, so monthly estimates were summed in Rows 7 and 8. Although the percentile estimate for each month should be unbiased, the resulting annual sum is expected to be skewed relative to a direct estimate of percentile annual flows. The reason for the skew is that seasonally extreme weather conditions (wet or dry) rarely persist at the same percentile severity for 12 continuous months. Therefore, percentile annual estimates are typically less extreme than the sum of percentile monthly estimates.

The standard estimation error was used to calculate the low and high bounds for the standard (68.2 percent) confidence interval. The interpretation is that the true average annual runoff is not known for an ungaged site, but based on regression analysis of gaged sites, there is a range of values that likely captures the mean. There is a best estimate of the mean runoff, and low and high values that bracket the mean runoff for roughly two-thirds of regional gaged sites. This best estimate and bracketing range of estimates is shown graphically in Exhibit 2-1, and indicates that the level of uncertainty is fairly high. The actual flow volume available at the ungaged site is not known.

2.2.1.3 Potentially Available Water

The primary table in Exhibit 2-1 does not necessarily indicate how much water would be available for impoundment. To determine a design yield from each watershed, a number of factors need to be considered, including water rights, exchange rights, the storage concept (is the reservoir sized for carry-over storage from wet years, reliable yield during drought conditions, or average yield conditions), reservoir operations, instream-flow thresholds, requirements for flushing flows, and other factors. These analyses were not part of the study at this reconnaissance level.

For the new surface storage alternatives (Technical Series Number PN-HFS-002), the potential water available for storage from each watershed was defined as the average excess spring runoff. However, since both dam raise alternatives are located on regulated systems with upstream dams, the average unregulated excess spring runoff approach was invalid. At this stage of the study, lacking more detailed information, it was assumed that sufficient excess water would be available for additional storage at Island Park and Ashton Reservoirs, but that assumption would require confirmation during a future phase.

2.2.2 Crosscut Canal Conveyance

The current capacity of the existing Crosscut Canal is approximately 600 cfs at the upstream end of the canal and approximately 400 cfs at the downstream end (FMID, personal communication, 2011). To better enable Henrys Fork Basin alternatives to help meet demands in the Lower Teton Basin, an evaluation was conducted to expand the hydraulic capacity of the Crosscut Canal by 400 to 600 cfs, depending on the reach, to achieve a uniform conveyance capacity of 1,000 cfs.

Dimensions for an expanded Crosscut 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"). Canal parameters for capacity iterations were generally in accordance with Reclamation's Canal Design Flowchart (Reclamation, 2010) for the five canal sections reported in the profile and section design drawings (Reclamation, 1936).

Exhibit 2-2 summarizes the key physical characteristics of the canal, and the differences between existing and proposed flow areas were used to determine excavation quantities and other costs defined in Section 2.3.4.2 – *Crosscut Canal*.

EXHIBIT 2-2
Crosscut Canal Characteristics

Section	Length (mi)	Manning's Roughness (n)	Longitudinal Slope	Side Slope	Existing Condition		Proposed Expansion	
					Capacity (cfs)	Flow Area (sq. ft)	Capacity (cfs)	Flow Area (sq. ft)
1	2.0	0.0225	0.0003	1.5H:1V	589	197	1,000	286
2	0.6	0.0225	0.0003	1.5H:1V	754	241	1,000	293
3	0.6	0.0225	0.0009	1.5H:1V	562	143	1,000	246
4	1.1	0.0225	0.0005	1.5H:1V	407	132	1,000	262
5	2.3	0.0225	0.0004	1.5H:1V	399	140	1,000	282

2.2.3 Hydropower Potential

Hydropower generation benefits were not considered in this study, but hydropower potential was estimated. Penstocks were laid out from the outlet works below the dam to a tentative powerhouse location. Hydropower potential was calculated based on an estimated design flow (assuming 80 percent of the reservoir capacity was released uniformly over a 270 day period), head between the full reservoir water surface elevation and the ground elevation at the powerhouse, 90 percent generator efficiency, 90 percent turbine efficiency, and an efficiency loss of 3 percent per mile of penstock.

2.3 Cost Estimation

2.3.1 Purpose

Relative construction costs were developed for the dam raise 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:

- Supplemental pumping and conveyance infrastructure for water distribution from the reservoir
- Provision for fish passage (upstream or downstream)
- Land acquisition and easements
- Lifecycle costs for operation, maintenance, and replacement.
- Impacts to wildlife and migration corridors
- Extraordinary permitting costs
- Costs to amend an existing FERC hydropower license
- Impacts to existing infrastructure, including utilities and roads
- Litigation
- Delay due to approval challenges
- Acquisition or negotiation of water rights or exchange rights

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

- Hydropower
- Water supply
- Emergency water supply or firm yield
- Recreation
- Supplemental fish flows
- Flood control

It should also be noted that only a limited number of alternatives and sub-alternatives have been evaluated. In some cases, potential variations or improvements to alternatives have been identified. Relative costs for revised alternatives should be considered separately if carried forward.

2.3.3 Approach

A cost spreadsheet was developed to calculate relative, representative system costs for each dam-delivery system, broken out by the following major system components: Crosscut Canal, dam embankment, emergency spillway, outlet works and service spillway, penstock, and hydropower facilities. 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 Crosscut Canal

Canal costs were based on four components, as summarized in Exhibit 2-3. Unit costs were selected as representative values for similar earthwork projects.

EXHIBIT 2-3
Crosscut Canal Cost Components

Cost Component	Assumptions	Unit Costs
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 (Reclamation, 1936). Depth and width were iterated to achieve the velocity target and minimize flow area. 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.	$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)

2.3.4.2 Dam – Embankment

Embankment costs for the dam raises and new saddle dikes were based on total embankment volume, a "Remoteness Factor" and a "Foundation Factor." The representative unit cost ($10/CY) represents a weighted average of all embankment materials, including relatively low-cost local cut and fill and higher-cost imported materials such as low-permeability core material, filter/seepage material, riprap, and foundation treatment. Site-specific adjustment to this unit cost was facilitated by providing two subjective factors to account for perceived site challenges. Future refinements will be possible once site-specific borrow locations, material properties, embankment dimensions, and volumes are developed.

2.3.4.3 Dam – Emergency Spillway

Costs for sub-alternatives that included new emergency spillways were based on abutment cut volume at an excavation price of $20/CY, a subjective "Site Factor," and a lump sum allowance of $1 million to provide a concrete weir and lining, a spillway chute, and a stilling basin. Future refinements will be possible once inflow design floods and specific spillway concepts are developed.

2.3.4.4 Dam – Outlet Works and Service Spillway

For the alternatives that included a dam crest raise, a lump sum base allowance of $1 million dollars was assigned to a standard 150-ft high tower outlet configuration. This base cost was then scaled up and down based on the ratio of the dam height to the 150-ft standard. An additional "Site Factor" was included to allow for subjective site conditions.

2.3.4.5 Penstock

Because all sub-alternatives assumed that the powerhouse would be located at the toe of the dam, the penstock was assumed to be integral with the outlet works and was not priced separately.

2.3.4.6 Hydropower

Hydropower costs were based on a cost curve used for pump stations, but using output power in place of input power. A 2002 CH2M HILL cost curve was factored up by 1.39 based on the ENR index ratio between the 3rd quarter of 2002 and the 4th quarter of 2011, and the input to the cost curve was the powerhouse generating potential. The full reservoir head above the stream was used for powerhouse costs. The design flow rate was based on discharging 80 percent of the total reservoir storage capacity uniformly over 270 days. Detailed operational scenarios, including variable reservoir head, were not evaluated. KW output was based on 90 percent generator efficiency, 90 percent turbine efficiency, and an efficiency loss of 3 percent per mile of penstock.

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 percent to account for unlisted construction items, and by 5 percent to account for mobilization. Together, the Base Field Cost, unlisted items, and mobilization sum to the Field Cost without Contingency. Adding a 30 percent contingency for uncertainty produces the Total Field Cost. Non-field costs (such as engineering, permitting, legal and administrative costs) are calculated as 30 percent of the Total Field Cost and were added to produce a relative Total Relative Construction Cost for comparing alternatives.

2.4 Basin Water 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 sections 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 surface water storage 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 surface water storage 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

State regulatory processes should be considered in the evaluation of new storage projects, and some of the relevant laws and policies include the following:

- Water rights:
  - The necessary water rights must be obtained and administered in accordance with state law including Chapter 2, Title 42, Idaho Code.
  - For new water right permit applications, Section 42-203A requires that the following criteria be considered:
    - whether the proposed use will reduce the quantity of water under existing water rights, or
    - whether the water supply itself is insufficient for the purpose for which it is sought to be appropriated, or
    - whether it appears to the satisfaction of the director that such application is made in good faith, is not made for delay or speculative purposes, or
    - whether the applicant has sufficient financial resources with which to complete the work involved therein, or
    - whether it will conflict with the local public interest as defined in section 42-202B, Idaho Code, or
    - whether it is contrary to conservation of water resources within the state of Idaho, or
    - whether it will adversely affect the local economy of the watershed or local area within which the source of water for the proposed use originates, in the case where the place of use is outside of the watershed or local area where the source of water originates.

- A new project should be consistent with policies set forth in the State Water Plan implemented by the Idaho Water Resource Board (IWRB). Pertinent policies include:
  - State protected river designations: When designated as a natural river in accordance with Section 42-1734A, Idaho Code, the following activities are prohibited:
    - Construction or expansion of dams or impoundments
    - Construction of hydropower projects
    - Construction of water diversion works
    - Dredge or placer mining
    - Alterations of the stream bed
    - Mineral or sand and gravel extraction within the stream bed
  - 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.
  - State minimum stream flow water rights: Management of the Snake River consistent with minimum stream flow water rights established at the Milner, Murphy, Weiser, Johnson Bar and Lime Point gaging stations is fundamental to State policy. In addition, a number of minimum stream flow water rights have been developed in the Henrys Fork Basin. Each minimum stream flow was established to address specific management objectives, and together, the minimum stream flows form an integrated plan for management of the Basin and Snake River as a whole. The basis and intention of the minimum stream flows as well as the current management of the system should be included in the evaluation of a new project tributary to the Snake River to ensure consistency with the State Water Plan and State regulatory obligations.
  - Eastern Snake Plain Aquifer Comprehensive Aquifer Management Plan (ESPA CAMP 2009): The long-term goal of the ESPA CAMP is to incrementally achieve an annual net addition of 600,000 af to the aquifer water budget, with a short-term target of between 200,000 af and 300,000 af. A new project in the Henrys Fork Basin should support the ESPA CAMP objectives.
- Pursuant to Section 42-1737, Idaho Code, approval by the IWRB is required for all project proposals involving the impoundment of water in a reservoir with an active storage capacity in excess of 10,000 af.
- Water Quality Certification from the Idaho Department of Health and Welfare in connection with the Federal Clean Water Act.
- Obtain approval of engineering designs, operation, and maintenance through the Idaho Safety of Dams program.
- Stream Channel Alteration Permit for improvements made to the channel to accommodate flood flows and routine releases.
- Coordinate with the IDWR floodplain manager to confirm compliance with the National Flood Insurance Program (NFIP) requirements in Idaho.

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. Physical water availability has been approximated based on regression equations, but actual runoff has not been measured, and firm yield has not been evaluated. Complete water balance and refined operations have not been evaluated.
- Storage potential is preliminary: A limited number of site and alignment alternatives have been explored, and judgment has been used to balance maximum storage potential with efficient embankment configurations.
- System water balance was not evaluated: At this stage, no accounting was done for direct precipitation on the reservoir, seepage losses in the reservoir, or evaporation losses from the reservoir. Water balance considerations were not evaluated at this stage and will depend on the elevation-capacity relationship for each reservoir, how the reservoir is operated, and whether drought conditions are considered.
- Embankment configurations are generalized: Site-specific materials and material properties have not been evaluated, and optimized dam approaches have not been proposed. A detailed evaluation of dam-raise design considerations should be performed in future phases to assess feasibility.
- 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.
- Detailed geotechnical evaluation is deferred: Geologic and geotechnical site analysis is based on available geologic literature, soil mapping, and review of geotechnical literature and reports. No field reconnaissance or geologic mapping was conducted as part of this investigation and analysis.
- No quantitative hazards analysis was performed.

2.9 Data Sources

2.9.1 Storage and Needs Studies

- Bureau of Reclamation (Reclamation). 2012. Draft Henrys Fork Watershed Basin Study Water Needs Assessment, March.
- Idaho Water and Energy Resources Research Institute (IWRRI). 1981. A Preliminary Appraisal of Offstream Reservoir Sites for Meeting Water Storage Requirements in the Upper Snake River Basin, for the U.S. Army Corps of Engineers, Walla Walla District, February.
- Idaho Water Resource Board (IWRB). 1992. Comprehensive State Water Plan – Henrys Fork Basin.
- Van Kirk, R., Rupp, S., and J. De Rito. 2011. Ecological Streamflow Needs in the Henrys Fork Watershed, September.

2.9.2 Hydrology

- United States Geological Survey (USGS), 2011, StreamStats Idaho: http://water.usgs.gov/osw/streamstats/idaho.html

  Six reports document the regression equations available in StreamStats for Idaho, the errors associated with the estimates, and the methods used to develop the equations and to measure the basin characteristics used in the equations.

  - Hortness, J. E., and Berenbrock, Charles, 2001, Estimating Monthly and Annual Streamflow Statistics at Ungaged Sites in Idaho: U.S. Geological Survey Water Resources-Investigations Report 01-4093, 36 p.
  - Berenbrock, Charles, 2002, Estimating the Magnitude of Peak Flows at Selected Recurrence Intervals for Streams in Idaho: U.S. Geological Survey Water Resources-Investigations Report 02-4170, 59 p.
  - Hortness, J. E., and Berenbrock, Charles, 2001, 2003, Estimating the Magnitude of Bankfull Flows for Streams in Idaho: U.S. Geological Survey Water Resources-Investigations Report 03-4261, 36 p.
  - Hortness, J.E., 2006, Estimating low-flow frequency statistics for unregulated streams in Idaho: U.S. Geological Survey Scientific Investigations Report 2006-5035, 31 p.
  - Wood, M.S., Rea, Alan, Skinner, K.D., and Hortness, J.E., 2009, Estimating locations of perennial streams in Idaho using a generalized least-squares regression model of 7-day, 2-year low flows: U.S. Geological Survey Scientific Investigations Report 2009-5015, 26 p.
  - Rea, Alan, and Skinner, K.D., 2009, Estimated perennial streams of Idaho and related geospatial datasets: U.S. Geological Survey Data Series 412, 32 p.

2.9.3 Geotechnical Review

- Aerial photographs: National Agriculture Imagery Program (NAIP). 2009. 1-meter color imagery (GIS-based web service).
- Soil maps: NRCS 1:24,000 soil map units (1988).
- Topographic maps: USGS 1:24,000 Quadrangle (GIS-based web service).
- Available water well logs in the vicinity of the project.
- Gilbert, J.D., Ostenaa, D., and C. Wood. 1983. Seismotectonic Study, Island Park Dam and Reservoir, Minidoka Project, Idaho-Wyoming. Bureau of Reclamation, Seismotectonic Report 83-1.
- Gilbert, J.D., Ostenaa, D., and C. Wood. 1983. Seismotectonic Study, Jackson Lake Dam and Reservoir, Minidoka Project, Idaho-Wyoming. Bureau of Reclamation, Seismotectonic Report 83-8.
- Patrick, D.M., and C.B. Whitten. 1981. Geological and Seismological Investigations at Ririe Dam, Idaho, Miscellaneous Paper GL-81-7, for the U.S. Army Corps of Engineers, Walla Walla District, September.
- Reclamation. 2010. Island Park Dam, Comprehensive Facility Review, Minidoka Project, Pacific Northwest Region, December.
- URS Greiner Woodward Clyde. 2000. Preliminary Probabilistic Seismic Hazard Analyses: Island Park, Grassy Lake, and Jackson Lake Dams – Minidoka Project; Palisades Dam – Palisades Project; Ririe Dam – Ririe Project; Eastern Idaho and Western Wyoming, for the Bureau of Reclamation, June.

2.9.4 Cost Development

- Cost indices: Engineering News-Record. 2012. http://enr.construction.com/economics/historical_indices/
- Proprietary projects with similar design components

2.9.5 Crosscut Canal

- 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.
- Reclamation. 1936. Crosscut Canal Profile and Sections, Upper Snake River Project-Idaho.

SECTION 3

Island Park Dam Raise

3.1 Alternative Description

3.1.1 Overview

The Island Park Dam Raise Alternative consists of raising Island Park Reservoir normal pool by one to eight feet to increase reservoir storage by 8,000 to 74,000 acre-feet (af). The one foot raise would be accomplished by replacing the rubber bladder on the spillway, and the eight foot raise would be accomplished by building up the entire embankment and raising the spillway. Island Park Reservoir is located directly on the Henrys Fork River at the Town of Island Park and would require no secondary water sources. When full, the proposed one foot reservoir raise could provide a roughly 44-foot drop to the existing hydropower facility on the Henrys Fork River at the base of the dam, and the eight foot dam raise would provide a roughly 51-foot drop to a proposed new hydropower facility. A variation of this alternative includes expansion of the Crosscut Canal, which would allow water released from the reservoir to be transferred to the Lower Teton Basin.

3.1.2 Alternative Variations

The following sub-alternatives were identified by varying the dam raise concept.

- IP-1: Raise Island Park Reservoir operating pool 1-foot by replacing an existing 1-foot-high rubber bladder on the spillway with a new, operable 2-foot-high rubber bladder to produce an additional 8,000 af of storage.
- IP-1_CC: Same as IP-1 but also includes expansion of the Crosscut Canal to provide water to the Lower Teton Basin.
- IP-8: Raise entire Island Park Dam embankment approximately 8 feet to produce an additional 74,000 af of storage.
- IP-8_CC: Same as IP-8 but also includes expansion of the Crosscut Canal to provide water to the Lower Teton Basin.

3.1.3 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 evaluate potential water availability and design flow to identify sub-alternatives and develop relative costs.

3.2 Key Findings

The Island Park Dam Raise would provide additional water storage for the Henrys Fork Basin, and potentially for the Teton Basin via cross-basin transfer using the Crosscut Canal, effectively enhancing water supply by capturing excess peak flows and redistributing that water during periods of higher demand. The available storage would enhance the in-basin water budget by retaining an additional 8,000 to 74,000 af during the annual high flow period and storing that water until more critical, higher demand periods. This storage water could help satisfy unmet irrigation demands in the North Fremont, Lower Watershed (via the Crosscut Canal), and Egin Bench irrigated regions. Reservoir releases during low flow periods would improve connectivity in other downstream river segments, including the Middle Henrys Fork River, Lower Henrys Fork River, North Fork Teton River, and South Fork Teton River, which have all been identified as having additional ecological streamflow needs. Additional impoundment would typically occur during periods when connectivity is not an issue, and flow decreases would not be expected to impact any populations of Yellowstone cutthroat trout, but a priority rainbow trout fishery in the Henrys Fork River could be impacted. The out-of-basin water budget would be temporarily reduced by up to 8,000 or 74,000 af during the annual high flow period when water is retained in the reservoir, but some or all of that quantity may be available at a later time for numerous out-of-basin uses, including needs resulting from climate change; agricultural needs; domestic, municipal, and industrial needs; ecological needs; and for recharge of the ESPA. Exhibit 3-1 provides a tabular summary of the key findings.

EXHIBIT 3-1
Key Findings from the Reconnaissance Evaluation

Estimated Cost per af	Impact on In-Basin Water Budget	Impact on Out-of-Basin Water Budget	Change in Connectivity of Impacted River Segment
\$100 - \$2,900	8,000 to 74,000 af, to be retained during the annual high flow period and released during high demand periods.	8,000 to 74,000 af reduction during the annual high flow period, in accordance with priority rights. Part or all of this quantity would be available later for out-of-basin needs.	Improvement in connectivity of downstream river segments, including Middle Henrys Fork River, Lower Henrys Fork River, North Fork Teton River, and South Fork Teton River. Potential impacts to supply sources, none of which contain conservation populations of Yellowstone cutthroat trout.

3.3 Engineering Results

3.3.1 Hydrology

The Henrys Fork River is impounded by Island Park Dam and was the only water supply source evaluated (Exhibit 3-2, on the following page). Exhibit 3-3 presents a summary of total water from the single source based on analyses using StreamStats (USGS, 2011; see Section 2.2.1 – *Hydrology*).

EXHIBIT 3-3
Water Potentially Available for Storage at Island Park Reservoir

Source	Watershed Area (sq. mi)	Quantity (af/year)
Henrys Fork River [a]	500	426,838

[a] Quantity reported for regulated systems is total estimated water in system. Excess spring runoff calculation was considered invalid for these systems because of upstream dam regulation.

3.3.2 Existing Dam Configuration

3.3.2.1 Embankments

Island Park Dam is a zoned earthen embankment structure on the Henrys Fork of the Snake River (see Exhibit 3-4). The existing dam was constructed between 1935 and 1938. The structure impounds about 127,000 af of water at elevation 6302.0. A hydroelectric powerplant was added in 1994.

The existing dam has a crest length of 1,607 feet and a crest width of 35 feet. In 1985 the dam crest was raised from elevation 6309.0 to elevation 6312.0. In 1984, the right end of the dam (about 400 feet long) was reconstructed after removal of potentially liquefiable loose volcanic ash found in the foundation.

The existing dam has a hydraulic height of 75 feet. The upstream face of the dam is protected by 3 feet of riprap placed on a 2 horizontal: 1 vertical (H:V) slope in the upper portion of the structure and 4H:1V to 5H:1V in the lower portions of the structure. The downstream face of the existing dam is constructed at a 2H:1V and is protected by a rockfill zone of variable thickness. The internal zoning within the structure is not currently available for review (Reclamation, 2010).

A 7,950-foot long dike extends from the left end of the dam and has upstream slopes of 3H:1V with 2 feet of riprap, while the downstream slopes are 2H:1V with no slope protection. The crest width of the dike varies from 24 feet to 39 feet. The crest of the dike was also raised in 1985 from elevation 6309.0 to 6312.0.

3.3.2.2 Spillways

A service spillway is located at the right abutment and consists of a concrete bathtub-type crest and inlet (see Exhibit 3-5) connecting to a 17 foot high horseshoe-shaped tunnel that transitions to a nearly horizontal 13-foot diameter circular tunnel section. The spillway crest is 260 feet long, with long sections on either side that are approximately 99 feet long each and connected by a horseshoe shaped section at the end that is 62 feet long.

EXHIBIT 3-2
Island Park Dam Raise Alternative: Hydrology

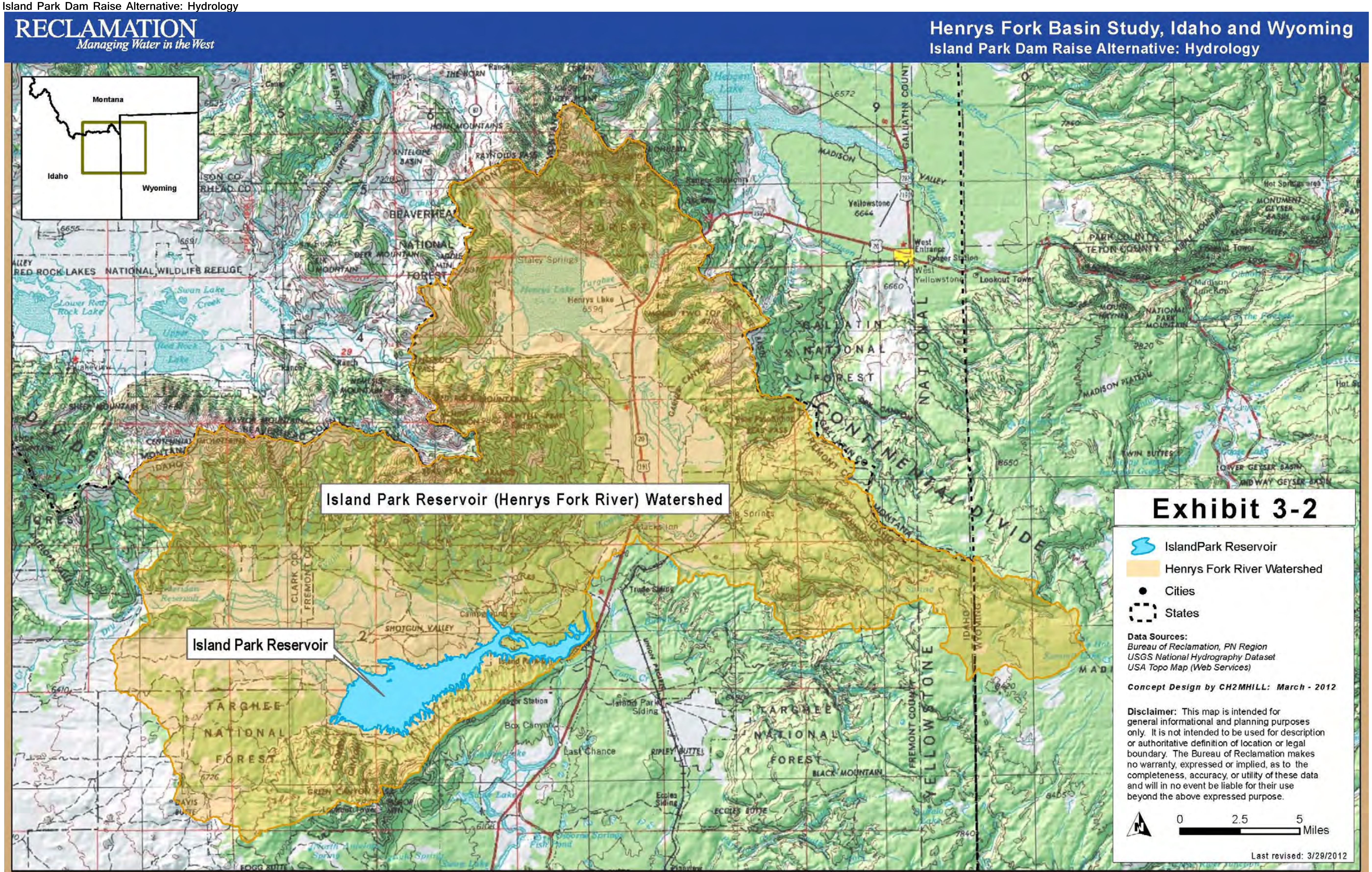


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EXHIBIT 3-4
Island Park Dam Raise Alternative: Plan View of Dam

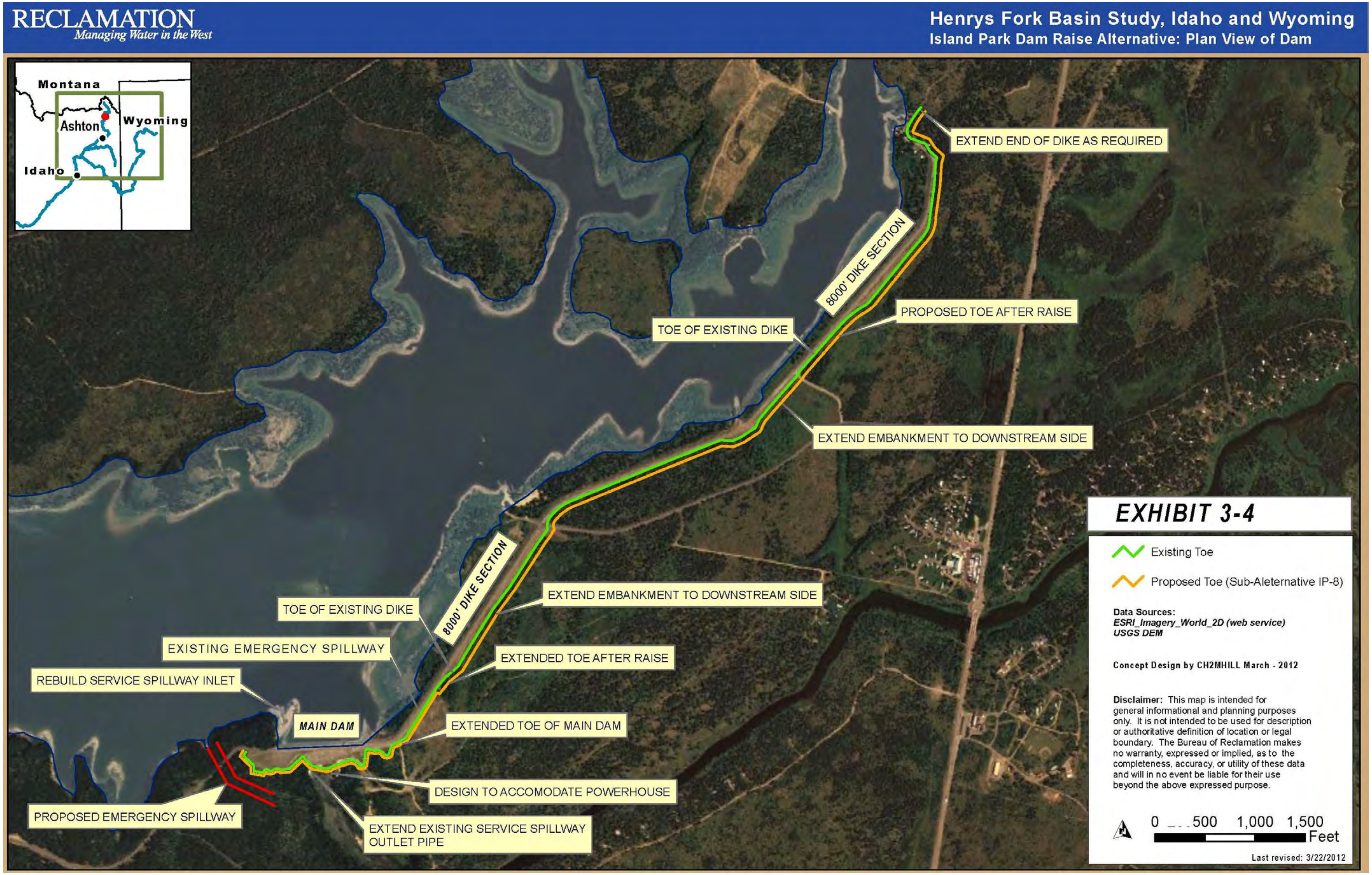

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EXHIBIT 3-5
Island Park Dam Raise Alternative: Service Spillway

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The 62-foot upstream portion has an ogee shape with a top elevation of 6303.0. The remaining 198 feet of the crest is also an ogee concrete weir with a top elevation of 6302.0 feet, but this segment includes an inflatable bladder that, when inflated, provides a final crest elevation of 6303.0. The concrete lining of the spillway inlet and tunnel was extensively repaired in 1979. Crest modifications and the inflatable bladder crest installation at the bathtub inlet were performed in 1996. The design discharge capacity of the service spillway is approximately 5,000 cubic feet per second (cfs) at water surface elevation 6305.0.

An emergency spillway was excavated within the dike and lined with riprap. It is trapezoidal-shaped and has an invert crest that is 500 feet wide at elevation 6309.0. The spillway sides are sloped at 2.5H:1V from the spillway crest to the dike crest.

3.3.2.3 Foundation

The dam foundation is thought to consist of alluvium and/or colluvium overlying bedrock. Bedrock under the dam is thought to consist of rhyolite tuff (Mesa Falls Tuff) and/or basalt (Gerrit Basalt). The depth of overburden is unknown; however, steep slopes and rock outcrops in some areas along the sides of the valley suggest that rock could be encountered at relatively shallow depths. The abutments of the dam are thought to encounter colluvium, talus, and possible landslide deposits overlying rhyolite tuff (Mesa Falls Tuff) including pumice and volcanic ash (Gilbert et al., 1983). Exhibit 3-6 presents a profile along the dam axis and highlights geologic features that could affect the foundation.

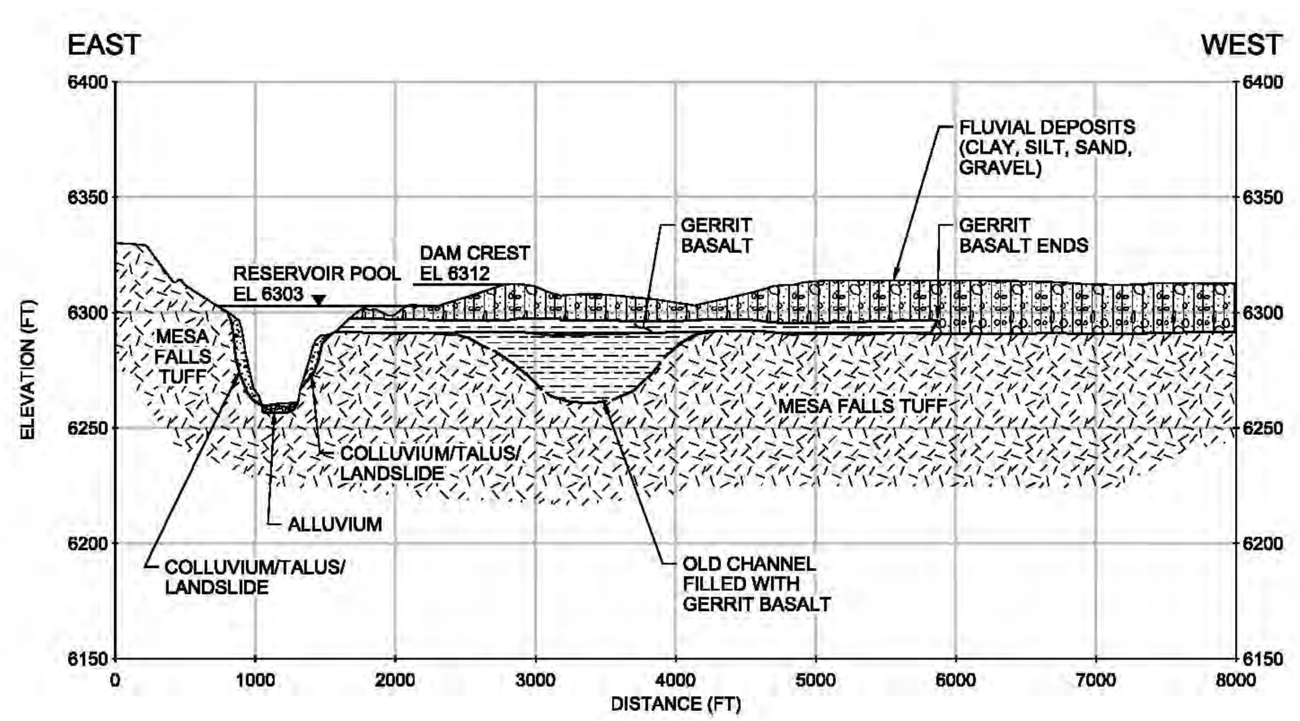


EXHIBIT 3-6
Island Park Dam Geologic Profile

3.3.3 Proposed Dam Configuration

3.3.3.1 One-Foot Bladder Raise Sub-Alternative

This sub-alternative would require replacing the existing 1-foot inflatable bladder on the two sides of the service spillway with a 2-foot bladder, and adding a 1-foot ogee-shaped concrete cap to the 62-foot horseshoe-shaped end section, to raise the reservoir water surface one foot to elevation 6304. It is currently unknown whether the existing concrete base to which the new rubber dams attach would require modification, but the base width could be widened by adding concrete if required. Inflatable bladders in other locations have been used to retain water heights exceeding 11 feet, so one foot of additional height should be readily achievable. The combined capacity of the service spillway and emergency spillway will need to be evaluated in future phases to ensure their ability to safely pass the inflow design flood.

3.3.3.2 Eight-Foot Dam Embankment Raise Sub-Alternative

This sub-alternative would require raising the existing dam by approximately 8 feet to elevation 6320, with a corresponding raise in normal operating pool from 6303 to 6311.

Although the internal zoning of the dam is not currently available for review, it is likely that a design could be developed that would accommodate such a raise and allow extending impervious and drainage zones within the dam as needed. Assuming slopes similar to existing slopes (2H:1V upstream and downstream for the main dam and 3H:1V upstream and 2H:1V downstream for the 8,000-foot long dike), and assuming the dam would be raised by extending the embankment to the downstream side of the existing embankments, the base of the downstream side of the dam would be widened by approximately 32 to 62 feet, depending on the cross-section location.

Exhibit 3-4 illustrates the approximate increased downstream footprint of the dam and dike raise. Extending embankments in the downstream direction would impact existing structures including the existing powerhouse and tailrace, service spillway inlet and discharge pipe, and emergency spillway. These structures would all require extensions, protective retaining walls, or other modifications that would preserve the integrity and function of the facilities while accommodating the increased fill and pool height. Raising the dam may also impact the powerhouse, and the structure may require modifications to accommodate the increased head and capacity.

Exhibit 3-7 illustrates the concept of raising the dam by showing an approximate section of the raised embankment at the main dam and at the dike. Saddle dams may also be required at some locations around the perimeter of the lake.

Embankment for the dam raise may require internal drainage zones and the construction of an internal cutoff or tie to the existing core of the dam. The internal drainage zones may be required to control seepage and internal piping. The cutoff may be required if the additional head results in increased seepage and could be constructed of foundation grouting, sheet piles, or other materials. The construction of the embankments may include a variety of naturally available materials including silt, sand, gravel and rockfill. Suitable borrow sources would need to identified during a later phase of study, but the geology of the area suggests that suitable materials are locally available.

It is assumed that the existing service spillway and discharge tunnels and pipes could be modified to accommodate the increased head. However, because the increased dam height poses greater potential for erosion from concentrated flows, the existing riprap-lined emergency spillway may need to be replaced. An alternative emergency spillway alignment around the right abutment has been identified to accommodate a more erosion-resistant structure with a higher weir elevation.

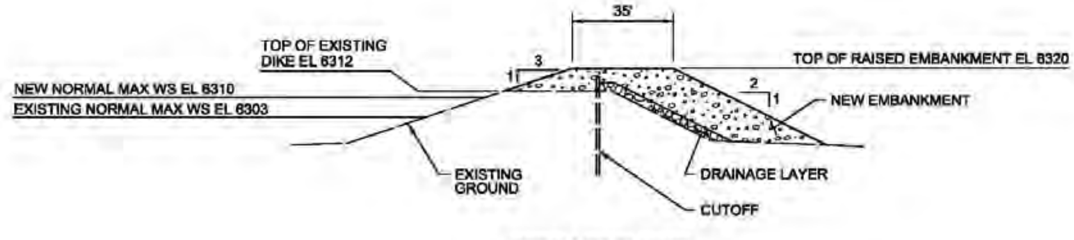
3.3.4 Crosscut Canal

The Crosscut Canal, which runs from the Henrys Fork River to the lower Teton River, allows inter-basin transfer of water. The current capacity of the existing Crosscut Canal is approximately 600 cfs at the upstream end of the canal and approximately 400 cfs at the downstream end (FMID, personal communication, 2011). To better enable this alternative to help meet demands in the Lower Teton basin, hydraulic capacity of the Crosscut Canal would be expanded to 1,000 cfs for two of the sub-alternatives (IP-1_CC and IP-8_CC), as described in Section 2.2.2 – *Crosscut Canal Conveyance*.

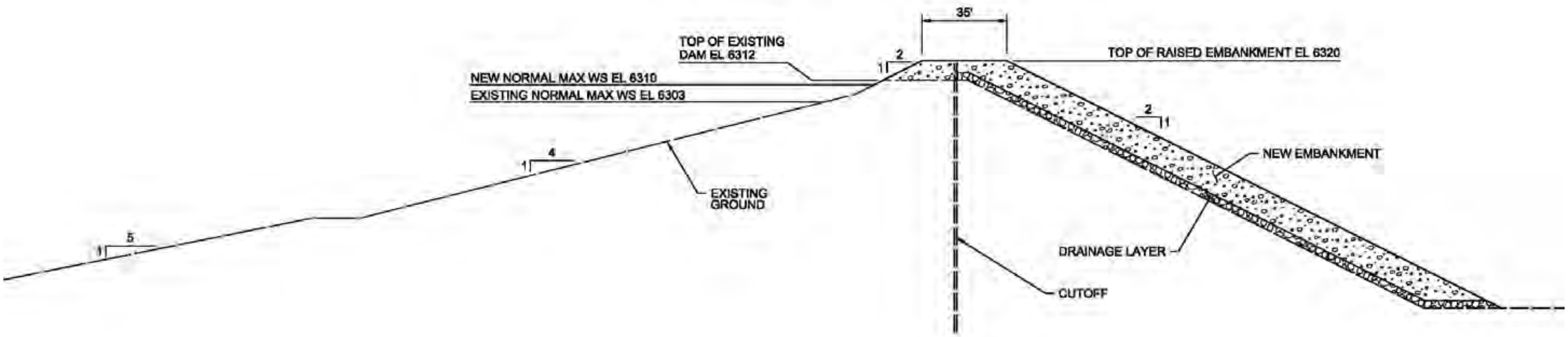
3.3.5 Hydropower Potential

When full, the proposed one foot reservoir raise (IP-1) could provide a roughly 44-foot drop to the existing hydropower facility on the Henrys Fork River at the base of the dam, and the eight foot dam raise (IP-8) would provide a roughly 51-foot drop to a proposed new hydropower facility. As presented in Exhibit 3-8, hydropower potential associated with Island Park Reservoir would vary from approximately 640 to 1,087 kW.

EXHIBIT 3-7
Island Park Dam Existing and Proposed Cross-Sections



8000'-LONG DIKE



MAIN DAM

EXHIBIT 3-8
Island Park Hydropower Potential

Sub-Alternative	Design Flow (cfs)	Penstock Length (mi)	Head (ft)	Power Potential (kW)
IP-1, IP-1_CC	212	0[a]	44	640
IP-8, IP-8_CC	311	0[a]	51	1,087

[a] It is assumed that turbines are located at the bottom of the outlet works. Therefore, no penstocks are needed.

3.4 Cost Estimate

A summary of the cost per af of incremental (beyond existing) water stored for each sub-alternative is presented in Exhibit 3-9. These costs include hydropower facilities and expansion of the Crosscut Canal. A more detailed breakdown of each cost element is provided in Exhibit 3-10.

EXHIBIT 3-9
Island Park Dam Raise Cost Estimate Summary

Sub-Alternative	Total Storage Volume (af)	Incremental Storage Volume (af)	Total Construction Cost[a]	Cost Per Incremental Unit Yield ($/acre-foot)
IP-1	142,000	8,000	$850,000	100
IP-1_CC	142,000	8,000	$22,980,000	2,900
IP-8	208,000	74,000	$29,330,000	400
IP-8_CC	208,000	74,000	$51,470,000	700

[a] Total estimated construction costs were rounded to the nearest $10,000 and unit costs were rounded to the nearest $100.

EXHIBIT 3-10
Detailed Relative Construction Cost for Island Park Dam Raise Sub-Alternatives

Component	Quantity[a]	Unit	Cost Basis	Estimated Costs by Sub-Alternative			
				IP-1	IP-1_CC	IP-8	IP-8_CC
Dam - Embankment	0 670,000	CY	embankment, remoteness factor, foundation factor	$0	$0	$8,040,000	$8,040,000
Dam – Emergency Spillway	0 62,963	CY	spillway excavation, lump sum (weir, chute, stilling, bladder)	$0	$0	$2,259,259	$2,259,259
Dam –Outlet Works and Service Spillway	1	LS	outlet tower, site factor, scaling factor	$400,000	$400,000	$966,667	$966,667
Penstock	0	Miles	design flow, length and diameter	$0	$0	$0	$0
Hydropower	644 909	KW	KW (head and design flow), penstock length and diameter	$0	$0	$2,617,811	$2,617,811
Crosscut Canal Enlargement	6.6	Miles	excavation, local fill, parallel gravel access roads, migration crossings	$0	$10,480,060	$0	$10,480,060

EXHIBIT 3-10
Detailed Relative Construction Cost for Island Park Dam Raise Sub-Alternatives

Component	Quantity[a]	Unit	Cost Basis	Estimated Costs by Sub-Alternative			
				IP-1	IP-1_CC	IP-8	IP-8_CC
Base Field Cost				$400,000	$10,880,060	$13,883,737	$24,363,797
Unlisted Items (20%)				$80,000	$2,176,012	$2,776,747	$4,872,759
Mobilization (5%)				$20,000	$544,003	$694,187	$1,218,190
Field Cost w/out Contingency				$500,000	$13,600,075	$17,354,671	$30,454,746
Contingency (30%)				$150,000	$4,080,023	$5,206,401	$9,136,424
Total Field Cost				$650,000	$17,680,098	$22,561,073	$39,591,170
Non-Field Cost (30%)				$195,000	$5,304,029	$6,768,322	$11,877,351
Total Relative Construction Cost				$845,000	$22,984,127	$29,329,394	$51,468,521

[a] When two quantities are listed, first quantity is for sub-alternative IP-1 (and IP-1_CC) and second quantity is for sub-alternative IP-8 (and IP-8_CC).

3.5 Basin Water Needs

The storage provided by the Island Park Dam Raise would enhance the in-basin water budget by retaining an additional 8,000 to 74,000 af during the annual high flow period and storing that water until more critical, higher demand periods during the summer and early fall. Water stored in the reservoir would help satisfy unmet irrigation demands in the North Fremont, Lower Watershed (via the Crosscut Canal), and Egin Bench irrigated regions (Reclamation, 2012). Reservoir releases would also be used to enhance ecological in-stream flows (see Section 3.7.2 – *Change in Connectivity*).

The out-of-basin water budget would be temporarily reduced by up to 8,000 to 74,000 af during the annual high flow period when water is retained in the reservoir, but some or all of that quantity may be available at a later time for numerous out-of-basin uses, including needs resulting from climate change; agricultural needs; domestic, municipal, and industrial needs; ecological needs; and for recharge of the ESPA (Reclamation, 2012).

3.6 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*.

3.7 Environmental Benefits and Impacts

3.7.1 Impacted River Segments

River segments potentially impacted by various sub-alternatives include the Henrys Fork, Teton, and South Fork Teton Rivers, as identified in Exhibit 3-11.

3.7.2 Change in Connectivity

Potential impacts to river connectivity consist of decreased flow (impoundment in the reservoir) for river segments providing reservoir supply and increased flow for river segments receiving reservoir releases. As described in Section 2.2.1.3 – *Potentially Available Water*, additional impoundment would likely occur during the excess spring runoff period and reservoir releases would likely occur during more critical low flow periods in the summer and fall. Potential impacts to connectivity of each impacted river segment are identified in Exhibit 3-11. In addition to the segments listed in Exhibit 3-11, enhanced connectivity would be experienced in other downstream river segments, including the Lower Henrys Fork River, North Fork Teton River, and South Fork Teton River, which have all been identified as having additional ecological streamflow needs (Van Kirk et al., 2011).

EXHIBIT 3-11

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

			Connectivity		State Aquatic Species of Special Concern			Special Designation[a]				
Surface Storage Site	Sub-Alternative	Impacted River Segments	Flow Decrease (Supply Source)	Flow Increase (Receives Reservoir Releases)	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
Island Park	IP-1, IP-8	Henrys Fork	•	•		•	RBT Priority					None
Island Park	IP-1_CC, IP-8_CC	Henrys Fork	•	•		•	RBT Priority					None
		Teton[e]		•	•		YCT Conservation					None
		South Fork Teton[e]		•	•		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.

[e]River segments may receive cross-basin water transfer via the Crosscut Canal.

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

3.7.3 State Aquatic Species of Special Concern

The Henrys Fork River is home to a priority rainbow trout fishery, but the reservoir inundation area is not in crucial habitat for Yellowstone cutthroat trout, and no substantial Yellowstone cutthroat trout population has been identified. State Aquatic Species of Special Concern in potentially impacted river segments are indicated in Exhibit 3-11.

3.7.4 Other Environmental Factors

The proposed enlargement of the Island Park Reservoir inundation area serves as a migration corridor for big game. Species tracked by the United States Fish and Wildlife Service (USFWS) known to occur in the area include two federally listed threatened species, the grizzly bear and the Canadian lynx, and two candidate species, the wolverine and the greater sage grouse. The Island Park area is home to several species considered at-risk by the Bureau of Land Management (BLM), the U.S. Forest Service (USFS), and the Idaho Department of Fish and Game (IDFG), including American avocet (Recurvirostra americana), American white pelican (Pelecanus erythrorhynchos), bald eagle, black-crowned night-heron (Nycticorax nycticorax), California gull (Larus californicus), Caspian tern (Hydroprogne caspia), common loon (Gavia immer), Forster's tern (Sterna forsteri), Franklin's gull (Leucophaeus pipixcan), sandhill crane, sharp-tailed grouse, trumpeter swan, western grebe (Aechmophorus occidentalis), white-faced ibis (Plegadis chihi), and Wyoming ground squirrel (Spermophilus elegans nevadensis). The expanded reservoir would impact wetlands in the lower reaches of Sheridan Creek, Icehouse Creek, Hotel Creek, and others, likely affecting an area between 1 and 200 acres. This reach of the Henrys Fork River has no special designations.

Potential wildlife habitat impacts, federally listed species, and wetlands habitat impacts within the reservoir inundation area are also summarized in Exhibit 3-12, while State of Idaho aquatic species of special concern (Yellowstone cutthroat trout and rainbow trout) and special river designations for all potentially impacted river segments are summarized in Exhibit 3-11.

3.8 Land Management, Recreation and Infrastructure impacts and benefits

Island Park Reservoir is located on private, state, and federal land; has a low recreation and economic rating for the 1-foot raise and a moderate rating for the 8-foot raise; and is rated as having a moderate number of potential infrastructure impacts for the 1-foot raise (primarily roads) and high number of potential infrastructure impacts for the 8-foot raise (roads, docks, and approximately 100 structures), as summarized in Exhibit 3-13.

3.9 Assumptions and Limitations

General assumptions and limitations applicable to all of the surface-storage alternatives are described in Section 2.8 – *Key Assumptions and Limitations*. Additional assumptions and limitations specific to this alternative are listed below:

- Excavation for the open spillway under Sub-Alternative IP-8 would likely be in colluvial soils and/or rock. It is possible that the spillway may be in soft erodible materials and if an open channel spillway is used, it may require concrete or rock linings that are suitable to match the intended spillway flows. A lined concrete spillway was assumed for costing purposes. Alternative spillway approaches should also be investigated once the inflow design flow has been established and local site conditions are better understood.
- Existing freeboard (approximately 9 feet) would be maintained for Sub-Alternative IP-8.
- For Sub-Alternative IP-1, a lump sum allowance was included for raising the service spillway by 1-foot through installation of new inflatable bladders. See Exhibit 3-10.

EXHIBIT 3-12

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

Surface Storage Site	Wildlife Habitat[a] Big Game Winter Range	Big Game Migration Corridors	Rating	Federally Listed Species At-Risk (USFS & BLM sensitive species, and Idaho Species of Greatest Conservation Need)[b]	Threatened, Endangered, Candidate and Experimental Nonessential Species[c]	Rating	Wetland/Habitat Value NWI Wetlands	Rating
Island Park			None	american avocet, american white pelican, bald eagle, black-crowned night-heron, galifornia gull, caspian tern, common loon, foster's tern, franklin's gull, sandhill crane, sharp-tailed grouse, trumpeter swan, western grebe, white-faced ibis, wyoming ground squirrel	grizzly bear, Canada lynx, sage grouse, wolverine	Federal Terrestrial / Sensitive	•	Moderate

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	<1 Acre

EXHIBIT 3-13

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

		Land Management Data[a]					Recreation/Economic Value								Infrastructure[e]				
Surface Storage Site	Sub-Alternative	Private	Federal	State	Conservation Easements[b]	Rating	Boating	Fishing	Yellowstone National Park	Guiding/ Outfitting	Scenic/ Natural Features[c]	Cultural/ Historic Resources[c]	Land Recreation	Rating	Roads	Structures	Habitation	Additional Infrastructure Notes	Rating
Island Park	IP-1, IP-1_CC	•	•	•		Federal	•[d]	•[b]						Low	•				Moderate
Island Park	IP-8, IP-8_CC	•	•	•		Federal	•[d]	•[b]				•[d]	•[d]	Moderate	•	•	•	Approximately 100 structures affected	High

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]Per personal communications with the Henrys Fork Foundation.

[e]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

- It is possible that the existing service spillway and its discharge tunnel could be modified to accommodate the increased head under Sub-Alternative IP-8, but for the sake of being conservative the cost estimate assumed full replacement. Minor changes to the outlet works and full replacement of the service spillway would comparable in cost to full installation of a tower outlet works for the new surface storage alternatives.
- A new hydropower facility would be required for Sub-Alternative IP-8 because of increased design flows and because extension of the downstream face of the embankment may impact the existing facility.

3.10 Evaluation Criteria

3.10.1 Stakeholder Group Measurable Criteria

There are four Stakeholder Group Measurable Criteria, with results summarized in Exhibit 3-14:

- Water Supply: The net change for in basin and out of basin water budgets in af 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 3.6.
- Environmental Considerations: Environmental benefits and impacts are summarized above in Section 3.7.
- Economics: The estimated reconnaissance-level field cost to construct the project is summarized in Section 3.4.

EXHIBIT 3-14
Stakeholder Group Measurable Criteria Summary

Stakeholder Group Measurable Criteria	Criteria Characterization
Water Supply (in-basin water transfer)	8,000 - 74,000 af/yr
Water Supply (out-of-basin water transfer)	8,000 - 74,000 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)	$850,000 - $51,470,000

[1] – Net environmental impact would depend on reservoir operations; further analysis required in future phase of study.

3.10.2 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

Ashton Dam Raise

4.1 Alternative Description

4.1.1 Overview

The Ashton Dam Raise Alternative consists of raising Ashton Dam by approximately 43 feet to a total height of 100 feet to increase reservoir storage by 20,400 af to a total of 30,200 af. Ashton Reservoir is located directly on the Henrys Fork River at the City of Ashton, and would require no secondary water sources. When full, Ashton Reservoir could provide a roughly 80-foot drop to a proposed new hydropower facility at the base of the dam. A variation of this alternative includes expansion of the Crosscut Canal, which would allow water released from the reservoir to be transferred to the Lower Teton Basin.

4.1.2 Alternative Variations

Several alternative alignments for the raised dam were considered, as documented in Section 4.3.3 – *Proposed Dam Configuration*. However, only a single preferred dam concept was carried through cost development, with a possible conveyance variation as noted below:

- A-43: Reconstruct Ashton Dam just downstream of the existing structure, raising the crest by approximately 43 feet to produce an additional 20,400 af of storage.
- A-43_CC: Same as A-43 but also includes expansion of the Crosscut Canal to provide water to the Lower Teton Basin.

4.1.3 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 evaluate potential water availability and design flow to identify sub-alternatives and develop relative costs.

4.2 Key Findings

The Ashton Dam Raise would provide additional water storage for the Henrys Fork Basin, and potentially for the Teton Basin via cross-basin transfer using the Crosscut Canal, effectively enhancing water supply by capturing excess peak flows and redistributing that water during periods of higher demand. The available storage would enhance the in-basin water budget by retaining an additional 20,400 af during the annual high flow period and storing that water until more critical, higher demand periods. This storage water could help satisfy unmet irrigation demands in the North Fremont, Lower Watershed (via the Crosscut Canal), and Egin Bench irrigated regions. Reservoir releases during low flow periods would improve connectivity in other downstream river segments, including the Middle Henrys Fork River, Lower Henrys Fork River, North ForkTeton River, and South Fork Teton River, which have all been identified as having additional ecological streamflow needs. Additional impoundment would typically occur during periods when connectivity is not an issue, and flow decreases would not be expected to impact any populations of Yellowstone cutthroat trout, but a priority rainbow trout fishery in the Henrys Fork River could be impacted. The out-of-basin water budget would be temporarily reduced by up to 20,400 af during the annual high flow period when water is retained in the reservoir, but some or all of that quantity may be available at a later time for numerous out-of-basin uses, including needs resulting from climate change; agricultural needs; domestic, municipal, and industrial needs; ecological needs; and for recharge of the ESPA. Exhibit 4-1 provides a tabular summary of the key findings.

EXHIBIT 4-1
Key Findings from the Reconnaissance Evaluation

Estimated Cost per af	Impact on In-Basin Water Budget	Impact on Out-of-Basin Water Budget	Change in Connectivity of Impacted River Segment
$800 - $1,900	20,400 af, to be retained during the annual high flow period and released during high demand periods.	20,400 af reduction during the annual high flow period, in accordance with priority rights. Part or all of this quantity would be available later for out-of-basin needs.	Improvement in connectivity of downstream river segments, including Middle Henrys Fork River, Lower Henrys Fork River, North Fork Teton River, and South Fork Teton River. Potential impacts to supply sources, none of which contain conservation populations of Yellowstone cutthroat trout.

4.3 Engineering Results

4.3.1 Hydrology

The Henrys Fork River is impounded by Ashton Dam and was the only water supply source evaluated (Exhibit 4-2). Exhibit 4-3 presents a summary of total water from the single source based on analyses using StreamStats (USGS, 2011; see Section 2.2.1 – *Hydrology*).

EXHIBIT 4-3
Water Potentially Available for Storage at Ashton Reservoir

Source	Watershed Area (sq. mi)	Quantity (af/year)
Henrys Fork River[1]	1,096	760,748

[1] – Quantity reported for regulated systems is total estimated water in system. Excess spring runoff calculation was considered invalid for these systems because of upstream dam regulation.

4.3.2 Existing Dam Configuration

4.3.2.1 Embankment

Ashton Dam is an embankment structure on the Henrys Fork of the Snake River (see Exhibits 4-4 and 4-5). The structure impounds approximately 9,800 af of water at elevation 5156.6 feet and is currently operated as a run-of-the-river facility. A hydroelectric powerplant contains two generating units rated at 2,500 kilowatts (kW) and one generating unit rated at 2,850 kW (7,850 kW total capacity).

The existing dam is approximately 450 feet long and 57 feet tall (approximate height from base to spillway crest). The crest elevation of the dam is generally 5156.6 but rises to elevation 5161.6 beside the spillway. The dam is earth and rock-filled and has a downstream slope covered with roller compacted concrete and an upstream slope stabilized by additional rock fill. The existing dam cross-section is presented in Exhibit 4-6.

In consultation with the Federal Energy Regulatory Commission (FERC), PacifiCorp began rehabilitation of Ashton Dam in 2010-2011 to mitigate seepage and piping (internal erosion) risks posed by a deteriorating upstream silt core within the dam. The rehabilitation involves excavating and reconstructing a significant portion of the core and upstream embankment. Other improvements by PacifiCorp include constructing a new bypass tunnel, replacing the headrace retaining wall, replacing the concrete crest structure, and adding a concrete overlay to an unprotected portion of rockfill between the spillway and the powerhouse.

EXHIBIT 4-2
Ashton Dam Raise Alternative: Hydrology

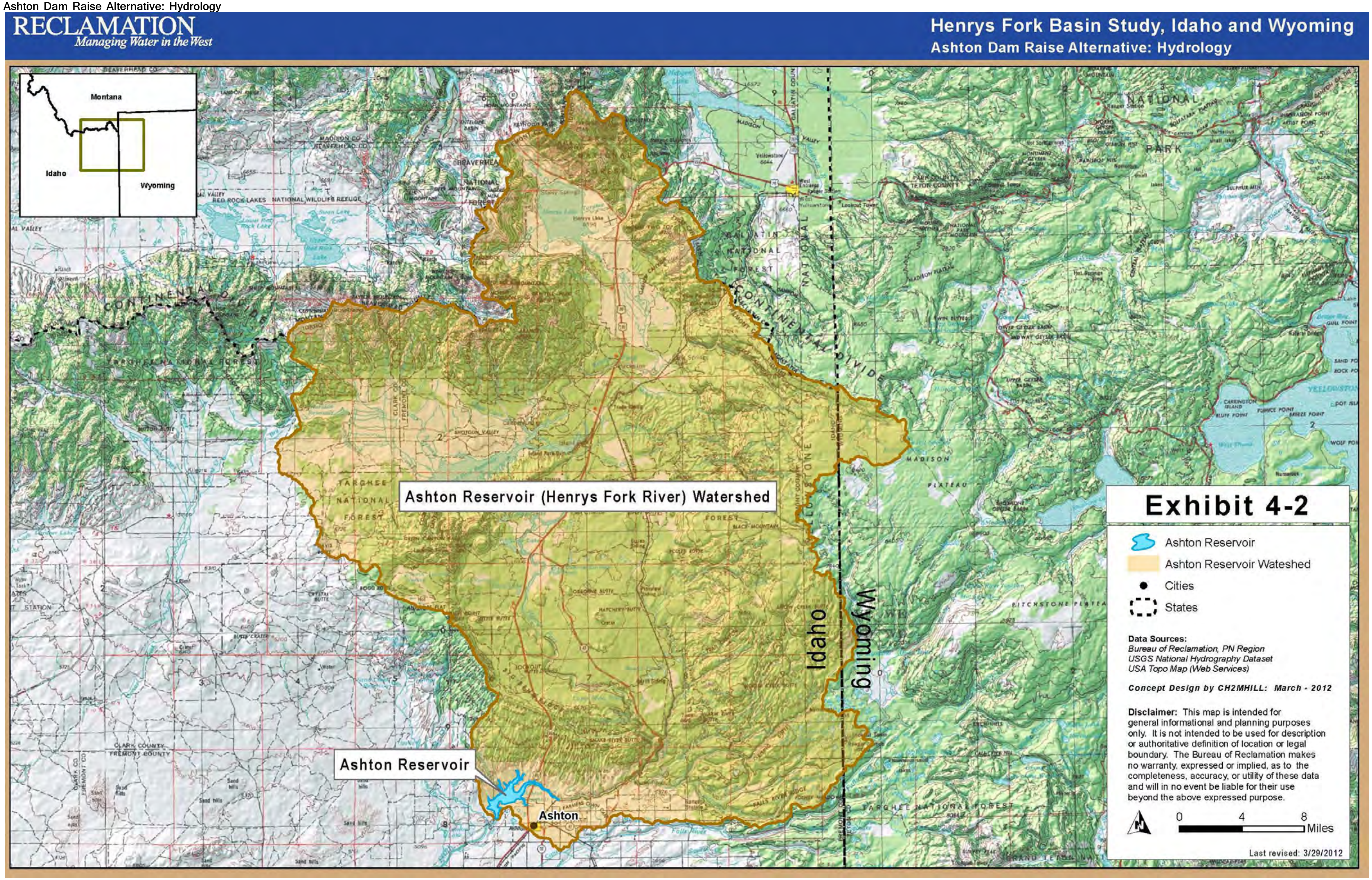


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EXHIBIT 4-4
Ashton Dam Raise Alternative: Existing and Proposed Reservoir Footprints

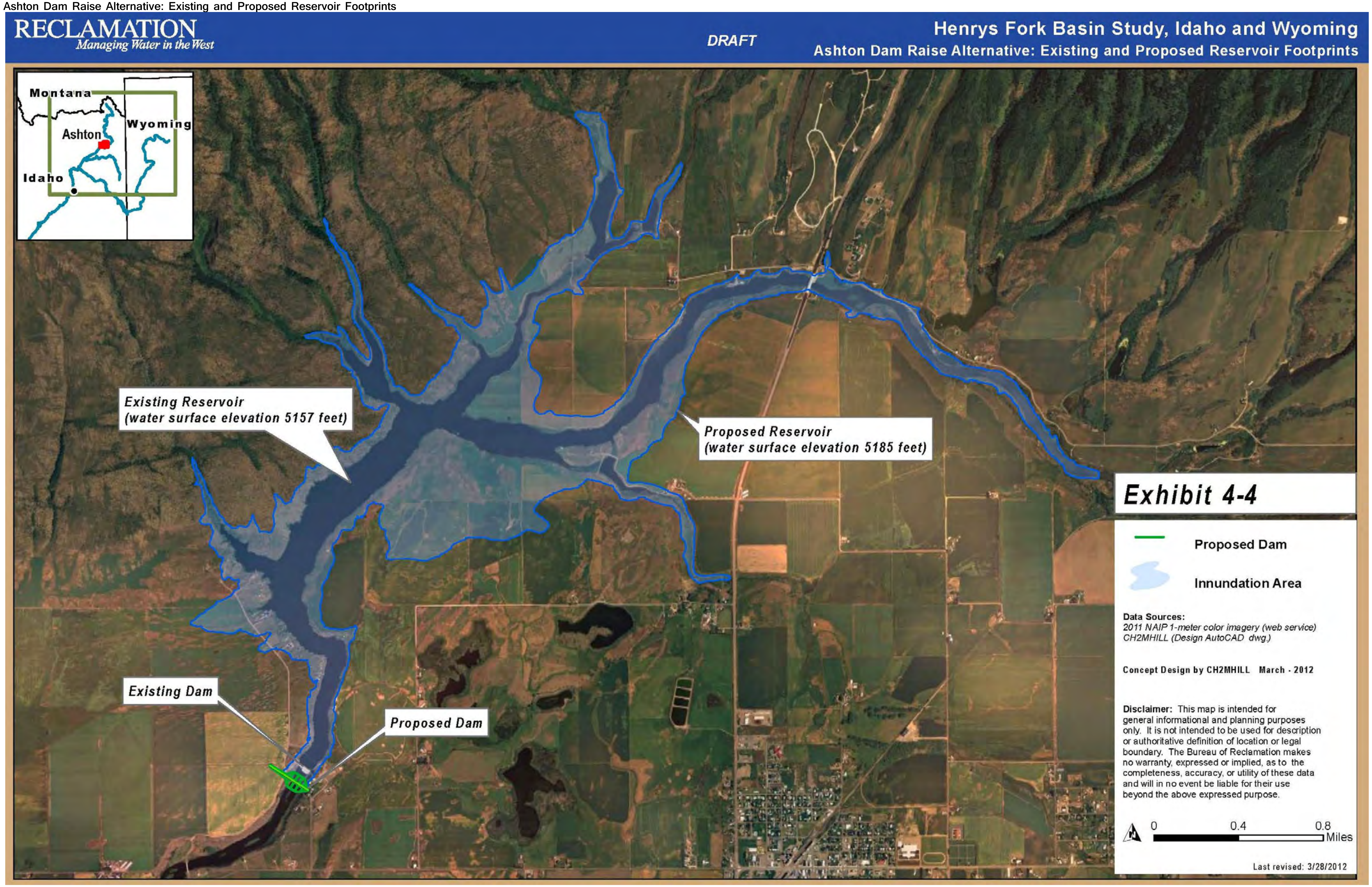

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EXHIBIT 4-5
Ashton Dam Raise Alternative: Proposed Dam and Appurtenant Structures

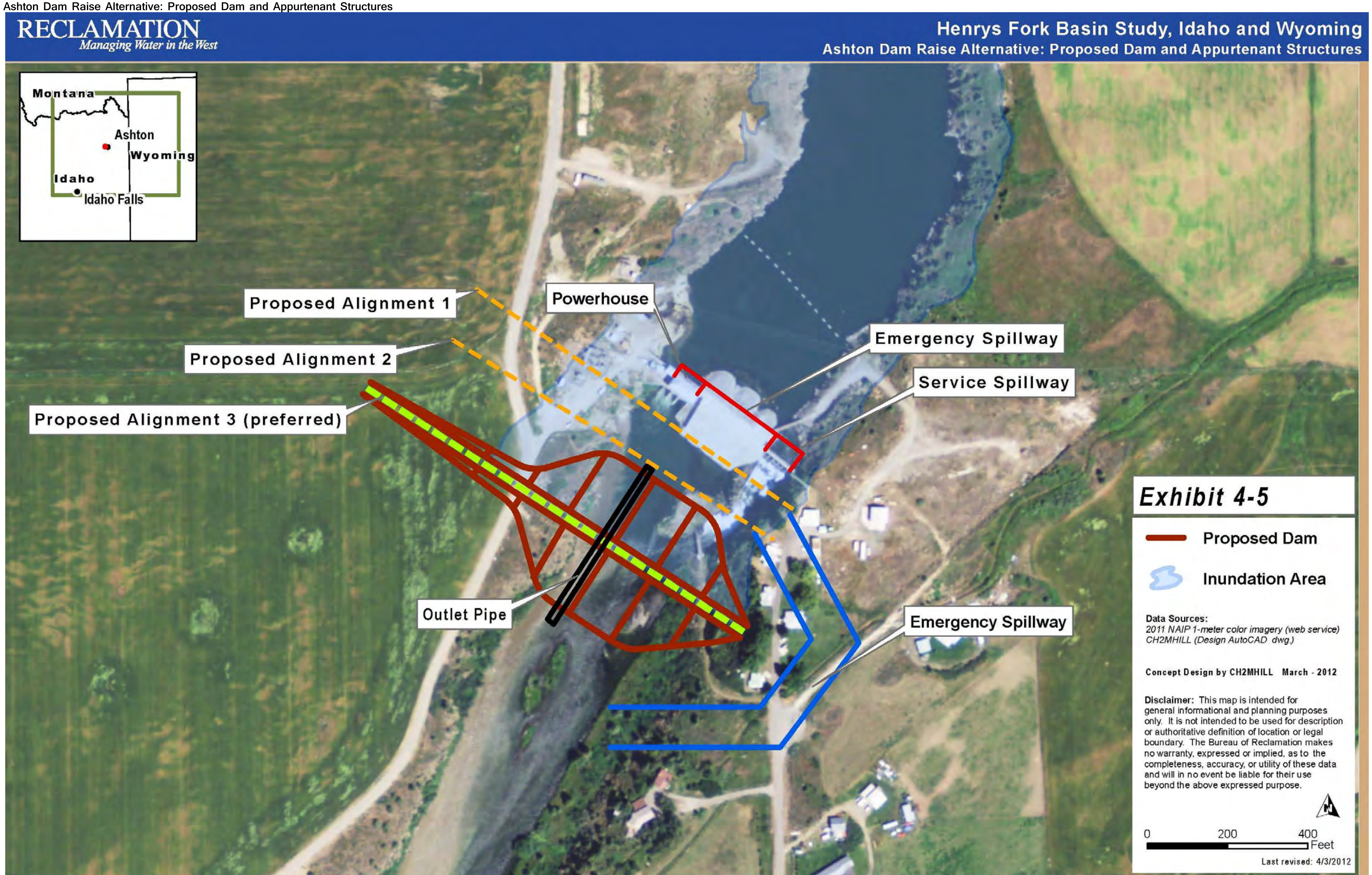

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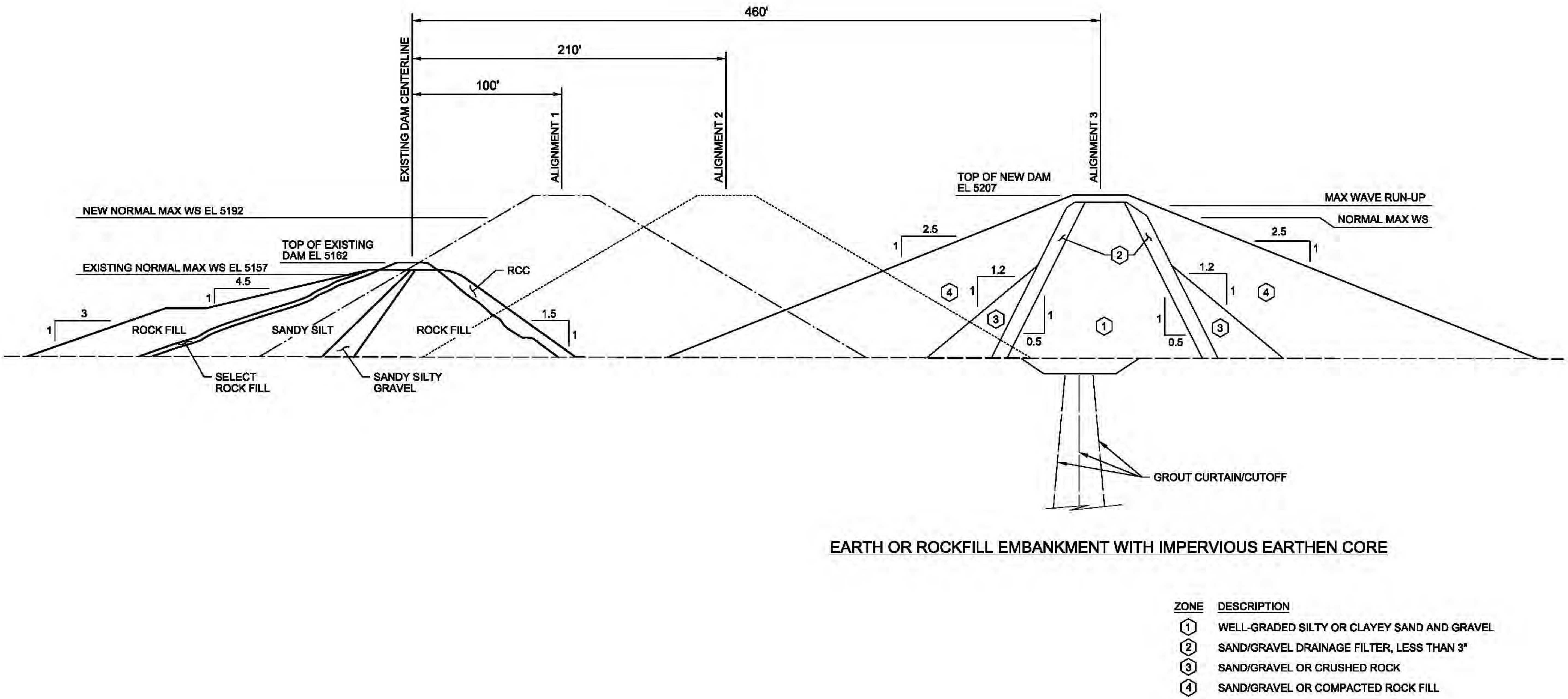
EXHIBIT 4-6
Ashton Dam Existing and Proposed Cross-Sections



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4.3.2.2 Spillway and Powerhouse

Water surface elevation of Ashton Reservoir is controlled by a 70-foot wide powerhouse structure with intakes near the right side of the dam and an 82-foot wide reinforced concrete service spillway with six 10-foot high radial gates on the left side of the dam. The central portion of the dam is composed of an approximately 200-foot wide emergency overflow spillway composed of a reinforced concrete crest section and a roller compacted concrete (RCC) cap extending over the downstream portion of the embankment. The emergency spillway contains training walls on either side of the RCC section. There are two-foot high flashboards on the crest of the dam to prevent spillage from reservoir wave action.

4.3.2.3 Foundation

Rock is exposed at or near the surface along the sidewalls of the river valley and within the reservoir area, and it is expected that rock may be encountered at relatively shallow depths throughout the area. The rock near the dam site is mapped primarily as Huckleberry Ridge Tuff and Falls River Basalt. Huckleberry Ridge Tuff is flat-lying at the site and no faults are mapped in the vicinity of the dam. However, tuffaceous rock that underlies the dam abutments could be fractured, interbedded, transmissive, and weakly-cemented in places. It is likely that alluvial sediments exist in the river bottom, but the depth of these sediments is unknown. Exhibit 4-7 presents a profile along the dam axis and highlights geologic features that could affect the foundation.

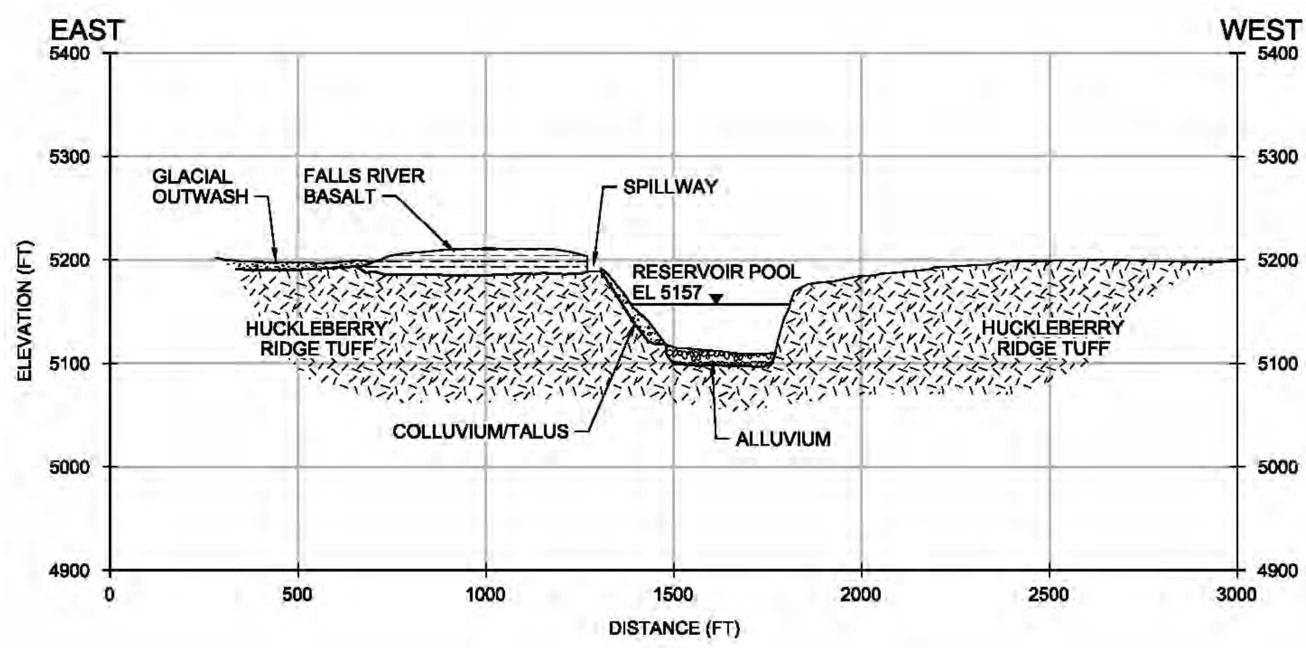

EXHIBIT 4-7
Ashton Dam Geologic Profile

4.3.3 Proposed Dam Configuration

The Ashton Dam Raise Alternative consists of raising Ashton Dam by 43 feet to elevation 5,200 to maximize storage potential within local topographic constraints.

4.3.3.1 Alignment

Three dam alignments were considered, as presented in Exhibits 4-5 and 4-6. Alignment 1 entails a downstream raise of the existing embankment, which would present substantial design issues and construction challenges. Since the dam would be raised to almost twice its current height, substantial changes to the existing embankment would likely be required to provide a safe and reliable seepage cutoff. Modification of the existing powerhouse, pipelines, spillway, and other dam appurtenances would also have a major influence on the design and construction of the enlarged structure. Furthermore, if conditions within the existing embankment were found during construction to be different than assumed in the design, it could lead to costly delays and design modifications.

Alignment 2 entails leaving the existing embankment as a berm at the toe of the upstream slope to reduce a small portion of the required fill material. This approach may avoid some of the design and constructability issues associated with Alignment 1, since the existing embankment is not integral to most of the new embankment, but suitability of the existing rock fill for inclusion at the toe of the new embankment is unknown.

Alignment 3 is located far enough downstream to allow construction of an entirely new dam without incorporating the existing structure within the new embankment. Alignment 3 appears to offer the following advantages and was selected as the preferred alignment for this evaluation:

- Rock is exposed in the canyon walls, but depth to rock under the dam is unknown. It is more likely that predictable foundation and abutment conditions could be confirmed by selecting a location downstream of the existing dam.
- During construction, the existing dam could provide impoundment for diversion as well as continue current functions, including hydroelectric generation, flood control, and recreation. To maintain stream diversion for a dry construction site and hydropower functions, the existing powerhouse draft tube/outlet works pipe could likely be tied directly to a diversion pipe or tunnel. Groundwater dewatering for construction of cutoff and drainage elements in the foundation of the new dam could potentially be tied into this system, or more likely would be provided through separate pumping.
- A new dam could be constructed at this location without being influenced by the unfavorable foundation conditions at the existing dam.
- It may be possible to phase construction and temporary reservoir drawdown to use some of the existing embankment as a borrow source for shell material.

4.3.3.2 Embankment

Exhibit 4-5 shows the general locations for the proposed dam, appurtenant structures, and emergency spillway. A rockfill or granular earthfill dam would be constructed along Alignment 3 to impound the Henrys Fork River and create an enlarged Ashton Reservoir. The cross-section presented in Exhibit 4-6 shows a typical configuration for the proposed dam at this location, which features a central core with filter blanket drains and earthfill/rockfill shells. A concrete grout curtain/cutoff would also be required to limit seepage through the dam foundation. The bottom of the valley at the proposed dam location is at an approximate elevation of 5,100 feet and the top of the dam would be at an approximate elevation of 5,200 feet for a maximum height of about 100 feet. The length of the dam at this elevation would be about 1,120 feet, which includes a dike approximately 450 feet long on the right abutment. The resulting reservoir would have about 30,200 af of storage, representing an additional 20,400 af beyond the existing 9,800 af of storage. When full, the reservoir’s surface area would be approximately 1,250 acres, compared to an existing normal pool of 400 acres.

4.3.3.3 Emergency Spillway and Outlet Works

A potential spillway alignment has been identified on the left abutment, and the dam would require a low-level outlet that provides a safe way to drain the reservoir and integrate with ultimate water distribution and hydropower schemes. The lowest part of the existing valley is located near the right abutment, which would serve as a likely location for the outlet.

4.3.3.4 Foundation

Foundation conditions along Alignment 3 would be anticipated to be similar to the existing dam site (discussed in Section 4.3.2.3 – *Foundation*). The depth to rock along this alignment is unknown but steep slopes and rock mapping along the sides of the valley suggest that rock could be encountered at relatively shallow depths on the slopes.

4.3.4 Crosscut Canal

The Crosscut Canal, which runs from the Henrys Fork River to the lower Teton River, allows inter-basin transfer of water. The current capacity of the existing Crosscut Canal is approximately 600 cfs at the upstream end of the canal and approximately 400 cfs at the downstream end (FMID, personal communication, 2011). To better enable this alternative to help meet demands in the Lower Teton basin, hydraulic capacity of the Crosscut Canal would be expanded to 1,000 cfs, as described in Section 2.2.2 – *Crosscut Canal Conveyance*.

4.3.5 Hydropower Potential

When full, the enlarged Ashton Reservoir could provide a roughly 80-foot drop to a proposed new hydropower facility. As presented in Exhibit 4-8, hydropower potential associated with Ashton Reservoir would be approximately 250 kW. Note that the existing Ashton Dam hydropower facility contains generating units (Section 4.3.2 – *Existing Dam Configuration*) far exceeding the potential estimated here. The method used to estimate hydropower potential is documented in Section 2.2.3 – *Hydropower Potential* and is primarily intended to provide a common basis for comparison against other surface storage alternatives.

EXHIBIT 4-8
Ashton Hydropower Potential

Sub-Alternative	Design Flow (cfs)	Penstock Length (mi)	Head (ft)	Power Potential (kW)
All	45	0[1]	80	250

[1] – It is assumed that turbines are located at the bottom of the outlet works. Therefore, no penstocks are needed.

4.4 Cost Estimate

A summary of the cost per af of incremental (beyond existing) water stored is presented in Exhibit 4-9. These costs include hydropower facilities and expansion of the Crosscut Canal. A more detailed breakdown of each cost element is provided in Exhibit 4-10.

EXHIBIT 4-9
Ashton Dam Raise Cost Estimate Summary

Sub-Alternative	Total Storage Volume (af)	Incremental Storage Volume (af)	Total Construction Cost[1]	Cost Per Incremental Unit Yield ($/acre-foot)
A-43	30,200	20,400	$17,140,000	$800
A-43_CC	30,200	20,400	$39,280,000	1,900

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

EXHIBIT 4-10
Detailed Relative Construction Cost for Ashton Dam Raise

				Estimated Costs by Sub-Alternative	
Component	**Quantity**	**Unit**	**Cost Basis**	**A-43**	**A-43_CC**
Dam - Embankment	370,000	CY	embankment, remoteness factor, foundation factor	$4,440,000	$4,440,000
Dam – Emergency Spillway	37,037	CY	spillway excavation, lump sum (weir, chute, stilling, bladder)	$1,740,741	$1,740,741
Dam – Outlet Works and Service Spillway	1	LS	outlet tower, site factor, scaling factor	$1,166,667	$1,166,667
Penstock	0	Miles	design flow, length and diameter	$0	$0
Hydropower	250	KW	KW (head and design flow), penstock length and diameter	$766,713	$766,713
Crosscut Canal Enlargement	6.6	Miles	excavation, local fill, parallel gravel access roads, migration crossings	$0	$10,480,060

EXHIBIT 4-10
Detailed Relative Construction Cost for Ashton Dam Raise

				Estimated Costs by Sub-Alternative	
Component	**Quantity**	**Unit**	**Cost Basis**	**A-43**	**A-43_CC**
Base Field Cost				$8,114,121	$18,594,181
Unlisted Items (20%)				$1,622,824	$3,718,836
Mobilization (5%)				$405,706	$929,709
Field Cost w/out Contingency				$10,142,651	$23,242,726
Contingency (30%)				$3,042,795	$6,972,818
Total Field Cost				$13,185,446	$30,215,543
Non-Field Cost (30%)				$3,955,634	$9,064,663
Total Relative Construction Cost				$17,141,080	$39,280,207

4.5 Basin Water Needs

The storage provided by the Ashton Dam Raise would enhance the in-basin water budget by retaining an additional 20,400 af during the annual high flow period and storing that water until more critical, higher demand periods during the summer and early fall. Water stored in the reservoir would help satisfy unmet irrigation demands in the North Fremont, Lower Watershed (via the Crosscut Canal), and Egin Bench irrigated regions (Reclamation, 2012). Reservoir releases would also be used to enhance ecological in-stream flows (see Section 4.7.2 – *Change in Connectivity*).

The out-of-basin water budget would be temporarily reduced by up to 20,400 af during the annual high flow period when water is retained in the reservoir, but some or all of that quantity may be available at a later time for numerous out-of-basin uses, including needs resulting from climate change; agricultural needs; domestic, municipal, and industrial needs; ecological needs; and for recharge of the ESPA (Reclamation, 2012).

4.6 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*.

4.7 Environmental Benefits and Impacts

4.7.1 Impacted River Segments

River segments potentially impacted by various sub-alternatives include the Henrys Fork, Teton, and South Fork Teton Rivers, as identified in Exhibit 4-11.

EXHIBIT 4-11

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

			Connectivity		State Aquatic Species of Special Concern			Special Designation[a]				
Surface Storage Site	Sub-Alternative	Impacted River Segments	Flow Decrease (Supply Source)	Flow Increase (Receives Reservoir Releases)	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
Ashton	A-43	Henrys Fork	•	•		•	RBT Priority		•			None
Ashton	A-43_CC	Henrys Fork	•	•		•	RBT Priority		•			None
		Teton[e]		•	•		YCT Conservation					None
		South Fork Teton[e]		•	•		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.

[e]River segments may receive cross-basin water transfer via the Crosscut Canal.

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

4.7.2 Change in Connectivity

Potential impacts to river connectivity consist of decreased flow (impoundment in the reservoir) for river segments providing reservoir supply and increased flow for river segments receiving reservoir releases. As described in Section 2.2.1.3 – *Potentially Available Water*, additional impoundment would likely occur during the excess spring runoff period and reservoir releases would likely occur during more critical low flow periods in the summer and fall. Potential impacts to connectivity of each impacted river segment are identified in Exhibit 4-11. In addition to the segments listed in Exhibit 4-11, enhanced connectivity would be experienced in other downstream river segments, including the Lower Henrys Fork River, North Fork Teton River, and South Fork Teton River, which have all been identified as having additional ecological streamflow needs (Van Kirk et al., 2011).

4.7.3 State Aquatic Species of Special Concern

The Henrys Fork River is home to a priority rainbow trout fishery, but the reservoir inundation area is not in crucial habitat for Yellowstone cutthroat trout, and no substantial Yellowstone cutthroat trout population has been identified. State Aquatic Species of Special Concern in potentially impacted river segments are indicated in Exhibit 4-11.

4.7.4 Other Environmental Factors

The proposed enlargement of the Ashton Reservoir inundation area serves as a migration corridor and as winter range for big game. Species tracked by the USFWS that are known to occur in the area include two federally listed threatened species, the grizzly bear (Ursus arctos horribilis) and the Canadian lynx (Lynx canadensis), and two candidate species, the wolverine (Gulo gulo luscus) and the greater sage-grouse (Centrocercus urophasianus). The bald eagle (Haliaeetus leucocephalus), black-crowned night-heron (Nycticorax nycticorax), California gull (Larus californicus), Caspian tern (Hydroprogne caspia), common loon (Gavia immer), Forster's tern (Sterna forsteri), Franklin's gull (Leucophaeus pipixcan), sandhill crane (Grus canadensis tabida), sharp-tailed grouse, trumpeter swan (Cygnus buccinator), western grebe (Aechmophorus occidentalis), and white-faced ibis (Plegadis chihi), considered at-risk by the BLM, USFS, and IDFG, are also found in the area. The expanded reservoir would impact wetlands in the lower reaches of Baker Springs, Rattlesnake Creek, and other tributaries, likely affecting an area between 1 and 200 acres. The reach of the Henrys Fork River upstream that would be inundated is designated as a State Natural River.

Potential wildlife habitat impacts, federally listed species, and wetlands habitat impacts within the reservoir inundation area are also summarized in Exhibit 4-12, while State of Idaho aquatic species of special concern (Yellowstone cutthroat trout and rainbow trout) and special river designations for all potentially impacted river segments are summarized in Exhibit 4-11.

4.8 Land Management, Recreation and Infrastructure impacts and benefits

Ashton Reservoir is located on private, federal, and conservation easement land; has a high recreation and economic rating; and is rated as having a large number of potential infrastructure impacts, as summarized in Exhibit 4-13.

4.9 Assumptions and Limitations

General assumptions and limitations applicable to all of the surface-storage alternatives are described in Section 2.8 – *Key Assumptions and Limitations*. Additional assumptions and limitations specific to this alternative are listed below:

- Although a rockfill or granular earthfill dam was considered for costing purposes in this evaluation, a range of potential dam types (including roller compacted concrete) should be considered until more site-specific details become available.

EXHIBIT 4-12

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

Surface Storage Site	Wildlife Habitat[a]			Federally Listed Species			Wetland/Habitat Value	
	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
Ashton	•[4]	•[1]	Migration	american avocet, american white pelican, bald eagle, black-crowned night-heron, galifornia gull, caspian tern, common loon, foster's tern, franklin's gull, sandhill crane, sharp-tailed grouse, trumpeter swan, western grebe, white-faced ibis	grizzly bear, Canada lynx, wolverine, sage grouse	Federal Terrestrial / Sensitive	•	Moderate

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 the Henrys Fork Foundation.

[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, American Rivers, the IDFG February 2011 dataset, and personal communications with the Henrys Fork Foundation.

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	<1 Acre

EXHIBIT 4-13

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

	Land Management Data[a]					Recreation/Economic Value								Infrastructure[d]				
Surface Storage 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
Ashton	•	•		•	Federal/ Conservation	•[b]	•[b,c]		•[b]				High	•		•		High

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

- A new hydropower facility, emergency spillway, and outlet works would be required for the new dam as proposed. However, if a concept that raised the dam while utilizing a portion of the existing embankment was selected during final design, some of the existing appurtenant structures may be modified instead of replaced.
- Excavation for the open spillway would likely be in colluvial soils and/or rock. It is possible that the spillway may be in soft erodible materials and if an open channel spillway is used, it may require concrete or rock linings that are suitable to match the intended spillway flows. A lined concrete spillway was assumed for costing purposes. Alternative spillway approaches should also be investigated once the inflow design flow has been established and local site conditions are better understood.
- Costs for the new embankment assumed utilization of new sources of material. Salvage of select elements from the existing facilities may be feasible but would require more detailed evaluation.
- The proposed dam's crest height would be 43 feet higher than existing, but the pool would only be raised 28 feet because the proposed dam concept includes 15 feet of freeboard (existing dam has virtually none), consistent with the other new surface storage alternatives. Note that a new RCC dam with very little freeboard could be considered in a future phase of study to increase potential storage.

4.10 Evaluation Criteria

4.10.1 Stakeholder Group Measurable Criteria

There are four Stakeholder Group Measurable Criteria, with results summarized in Exhibit 4-14:

- Water Supply: The net change for in basin and out of basin water budgets in af 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 4.6.
- Environmental Considerations: Environmental benefits and impacts are summarized above in Section 4.7.
- Economics: The estimated reconnaissance-level field cost to construct the project is summarized in Section 4.4.

EXHIBIT 4-14
Stakeholder Group Measurable Criteria Summary

Stakeholder Group Measurable Criteria	Criteria Characterization
Water Supply (in-basin water transfer)	20,400 af/yr
Water Supply (out-of-basin water transfer)	20,400 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)	$17,140,000 - $39,280,000

[1] – Net environmental impact would depend on reservoir operations; further analysis required in future phase of study.

4.10.2 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.

#	Page	Line	Comment	Comment Category[a]	Response (if necessary)
1	9	20	City of Ashton, not Town	1	Comment addressed in final TM.
2	39	7	The additional areas that would be inundated around IP Reservoir are big game migration corridors.	1	Comment addressed in final TM.
3	39	11	Add sharp-tailed grouse	1	Comment addressed in final TM.
4	40		Add sharp-tailed grouse. The expanded area of IP Reservoir would impact wetlands in the lower reaches of Sheridan Creek, Icehouse Creek, Hotel Creek, and others.	1	Comment addressed in final TM.
5	41		IP Reservoir is a popular boating area. For the 8-foot dam raise, would impact the historic Trude Ranch, perhaps other historic sites, Nez Perce Trail? The 8-foot alternative would also impact considerable land-based recreation – hunting, hiking, camping, ATV riding, etc.	1	Comment addressed in final TM.
6	43	7	City of Ashton, not Town	1	Comment addressed in final TM.
7	44	9	Clarify that Ashton Reservoir is currently operated as a run-of the river facility, no water impounded for irrigation storage. There are 3 generating units, one if 2.85 MW, the other two are both 2.5MW, so total 7.85MW.	1	Comment addressed in final TM.
8	44	11	Existing Ashton Dam is 226 ft. long and 60 feet tall.	1/2	The existing spillway is approximately 226 feet long, but the length of the entire structure is approximately 450 feet. The final TM clarifies that the 57 foot dam height is the approximate height to the top of spillway.
9	44	18	Building a new dam bypass tunnel north of the dam was a major component of the Ashton Dam remediation project.	1	Comment addressed in final TM.
10	57		The additional area that would be inundated by Ashton Reservoir would back up into a State Designated Recreational River.	1	Comment addressed in final TM.
11	58	12	NO YCT??	2	YCT populations not documented in available literature in this reach of the Henrys Fork River.
12	58	15	The expanded Ashton Reservoir would inundate big game winter range in addition to migratory corridor.	1	Comment addressed in final TM.
13	58	19	Add sharp-tailed grouse, and probably all of the wading birds and waterfowl also listed for Island Park Reservoir.	1	Comment addressed in final TM.
14	58	21	The expanded Ashton Reservoir would inundate wetlands in the lower reaches of Baker Springs, Rattlesnake Creek, others…	1	Comment addressed in final TM.
15	59		Add big game winter range, add sharp-tailed grouse and other wading birds and waterfowl, add wetland impacts.	1	Comment addressed in final TM.

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RECLAMATION
Managing Water in the West

Henrys Fork Basin Study
Teton Dam Storage Alternative

Technical Series No. PN-HFS-004

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

October 2012

MISSION OF THE U.S. DEPARTMENT OF THE INTERIOR

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian tribes and our commitments to island communities.

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The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Photograph on front cover: Aerial view of the Teton Dam site on the Teton River, Idaho.

RECLAMATION

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October 2012

Table of Contents

List of Exhibits

1. INTRODUCTION

The Teton Dam Surface Storage Alternative (Alternative) for the Henrys Fork Watershed Basin Study evaluates the reconstruction of a dam at the location of the original Teton Dam on the Teton River. This technical series report provides a brief summary of this alternative which being considered along with the other storage alternatives presented in *Technical Series Report No. PN-HFS-002, Henrys Fork Basin Study - Surface Storage Alternatives*.

A new dam would be constructed on the site of the original Teton Dam to impound water in the Teton River canyon for irrigation, flood control, hydropower generation, recreation, and fish and wildlife purposes as originally authorized by Congress. This alternative analysis is focused on those authorized functions without consideration of water agreements, water rights, or required instream flows for wildlife purposes that have come into play since the original dam's failure. Because of the local trauma associated with the failure of Teton Dam and remaining local concerns about the safe operation of a second dam at the site, any reconstruction plan must focus on functions that meet basin needs as documented in the *Henrys Fork Watershed Basin Study Water Needs Assessment* (Reclamation 2012).

In 1964, Congress authorized the construction of the Lower Teton Division, with Teton Dam and Reservoir as its key features. Phase I of the project included the construction of the dam and reservoir; Phase II of the project included the development of groundwater for new agricultural developments on the Rexburg Bench. In 1976, the Bureau of Reclamation (Reclamation) had almost completed construction of the dam and reservoir at a cost of $70 million and the reservoir had almost filled when Teton Dam failed. The failure of Teton Dam resulted in the loss of 11 lives and approximately $2 billion in property damage.

About 10 years later, upper Snake River water users, local irrigation interests, and the State of Idaho requested that Reclamation consider rebuilding the dam. In 1991, Reclamation released a Reappraisal Report of the project; much of that research and analysis is presented here. The reappraised project included Phase I under which the dam, reservoir, hydroelectric facilities, pumping plant, and new conveyance system would be constructed. Under Phase II in the Reappraisal Report, groundwater would be developed for irrigation water to new agricultural lands on the Rexburg Bench.

For the Henrys Fork Watershed Basin Study, Phase II was not considered. Development of new agricultural lands was not considered and new conveyance systems to those lands would not be necessary. This alternative considers only rebuilding a dam and reservoir, as presented in the 1991 Reclamation Reappraisal Report, and using the existing irrigation water conveyance system to the existing agricultural lands.

HDR Engineering, Inc. conducted a reconnaissance study of rebuilding Teton Dam on a smaller scale to generate hydroelectric power. The report was submitted to the Fremont-Madison Irrigation District (FMID) in their evaluation of potential water storage sites. FMID initiated the study in search for additional water storage to fill their projected needs in their area of operation. HDR Engineering provided preliminary designs and cost estimates for a storage reservoir and hydropower plant on the Teton River at the site of the original dam. Their findings make up two of the alternatives considered in this Technical Series Report.

2. TETON DAM

2.1. Overview

This Alternative includes building Teton Dam and its facilities to the same scale as was proposed in the 1991 Reappraisal Report which included:

- Dam, spillway, and reservoir
- Power generation, switchyard, power substations, and transmission line facilities
- Fish and wildlife mitigation facilities, lands, and improvements
- Recreation lands and facilities
- General property, Government-reserved works

An average annual supplemental water supply of 55,000 acre-feet is expected to be provided by the project; 44,000 acre-feet would be available for irrigation to 111,210 acres and 11,000 acre-feet would be released for wildlife mitigation needs. During the driest years, there would be a supplemental need for 514,000 acre-feet of water, an amount in excess of the project's capacity. The supplemental supply would reduce the critical year shortages to an average of about 10 percent.

1.1. Alternative Variations

In 1995, a Reconnaissance Study was submitted to FMID covering the reconstruction of Teton Dam on a smaller scale (HDR 1995). A proposed roller-compacted concrete gravity dam with a lower dam crest elevation than the original dam was proposed, with the potential for raising the dam crest at a later date.

1.1.1. *Operational Assumptions*

Detailed operations have not been evaluated for any of the alternatives; however, operation of any surface storage alternative would be coordinated with existing storage projects in consideration of downstream water users, senior water rights, and existing water agreements. During below average water years, storage capability would be limited. Water exchanges may be possible when and where needed to meet the demands; however, this water source cannot be guaranteed.

In the Teton Dam Rebuild Alternative, the entire active storage capacity of Teton Reservoir (200,000 acre-feet) would be available on a joint-use basis to store flows excess to the downstream channel capacities. The evacuation and use of space in the reservoir would be based on forecasts of seasonal flood runoff volumes and parameter curves that take into consideration the date, allowable downstream channel capacities, and forecasted seasonal runoff volumes. Part of the reservoir capacity would be reserved for flood control through the winter and for storage of rain floods during early spring months.

Assumptions made for Small Dam A and B alternatives include:

- The minimum instream flow would be 150 cfs
- The stored water was not used to supplement the natural flows during low flow periods, but was set equal to the natural inflow if the natural inflow was less than 150 cfs
- Irrigation releases would occur July through September, with 40 percent of the flow released during July and August and 20 percent during September

Based on reservoir operation studies, the Teton Dam Rebuild Alternative would afford full control of floods up to a 200-year frequency flood. Flood control would be accomplished by jointly using the 200,000 acre-feet of active storage space with irrigation. Of the active storage space, 30,000 acre-feet would be reserved for floods under established flood control rule curves that were developed for the original project.

The maximum probable flood of 79,000 cfs was assumed for both Teton Small Dam A and B. The flood volume would be approximately 285,000 cfs over 15 days. Since this volume is almost six times more than the total storage volume of Small Dam A and almost three times the volume of Small Dam B, the majority of the flood flows would be passed on downstream.

The floodplain below Teton Dam was significantly changed with the failure of the original dam; consequently, an estimate of potential flood control benefits would require a detailed inventory of existing development.

2. KEY FINDINGS AND LIMITATIONS

In the Teton Dam Rebuild Alternative, the Teton Reservoir would provide an active capacity of approximately 200,000 acre-feet per year for release or diversions; however, the active capacity volume is much larger than the yield (Exhibit 1). On average, much of the annual runoff entering the reservoir would be released to meet senior water rights downstream and would not be available for storage or new uses in the Henrys Fork basin. In the 1991 Reappraisal Report, the ratio of active storage capacity to project water supply was stated to be about 2.4 to 1. Existing water rights and the widely varying amount of annual precipitation and runoff constrain the project accomplishment and may be similar in future analyses since those conditions still exist. The ratio between stored water and water supply may also become larger with projected climate changes.

The minimum storage for the Small Dam A would be 10,000 acre-feet and the minimum storage for Small Dam B would be 25,000 acre-feet and would likely be at or near minimum storage on October 1 of each year.

Exhibit 1. Impacts of the alternatives on water budgets and river segments.

	Impact on In-Basin Water Budget	Impact on Out-of-Basin Water Budget	Change in Connectivity of Impacted River Segment
Rockfill embankment dam and rolled concrete dam alternatives	55,000 acre-feet during average or above average water years	Seasonal during high flow periods – Water will first meet senior downstream water rights and obligations; remainder would be used in-basin	Improvement in connectivity of downstream river segments, including the lower Teton River, South Fork Teton River, and the Lower Henrys Fork River through water storage or groundwater recharge from irrigation; large disconnect in river segments above and below dam; very difficult or no fish passage
50,000 acre-foot and 100,000 acre-foot reservoir alternatives	40,000 or 75,000 acre-feet during average or above average years	Seasonal during high flow periods – Water will first meet senior downstream water rights and obligations; remainder would be used in-basin	Improvement in connectivity of downstream river segments, including the lower Teton River, South Fork Teton River, and the Lower Henrys Fork River through water storage or groundwater recharge from irrigation; large disconnect in river segments above and below dam; very difficult or no fish passage

2.1. Engineering Results

2.1.1. *Hydrology*

The Teton River and its tributaries contribute approximately 600,000 acre-feet per year to the Henrys Fork River (Reclamation 2012). These flows are fed largely by snowmelt and generally have regular patterns of low flows during late summer, fall, winter, and early spring months and high flows during the late spring and early summer (Exhibit 2). Runoff volumes caused by snowmelt can be forecast with reasonable accuracy based on seasonal precipitation, water content of the snow on the ground, earlier runoff, and other factors that can be evaluated prior to the spring runoff (Reclamation 1991).

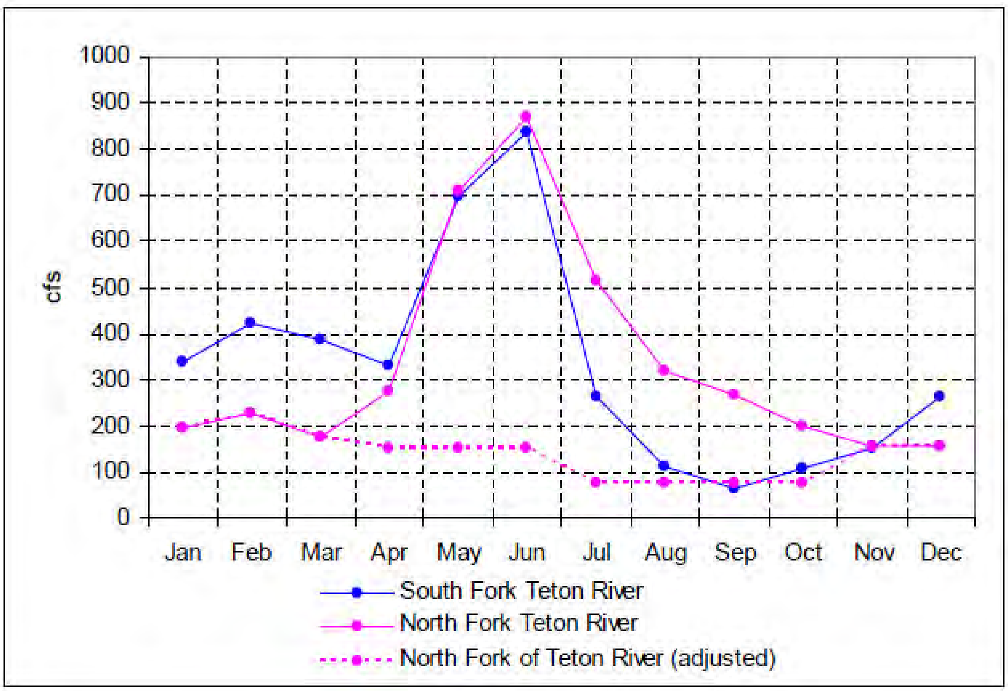

Exhibit 2. Average monthly flow in the Teton River (from gaging stations at Rexburg and Teton, respectively) from 1977 to 2002 (Reclamation 2012).

Water must be stored every year in Teton Reservoir to meet the water needs. The Snake River is fully appropriated during dry years; therefore, Teton Reservoir storage would belong to downstream users during dry years. During wet or average water years, Teton Reservoir would provide additional storage water for the Teton Basin, effectively enhancing water supply by capturing excess peak flows and redistributing that water during periods of higher demand. However, during dry years, the natural stream flows do not meet the existing natural flow and storage water rights and storage capability would be limited.

2.1.2. *Conveyance*

With all of the alternatives, water would be delivered to the existing canal system via the Teton River so there would be no need for additional conveyance system construction.

2.1.3. *Dam Configuration*

Two design options were considered for this alternative: a rockfill embankment dam and a roller-compacted concrete dam. Both designs would accommodate the probable maximum flood having a peak inflow of 79,000 cubic feet per second (cfs) and a 15-day volume of 287,000 acre-feet. The total reservoir capacity would be 288,000 acre-feet, of which 200,000 acre-feet would be active capacity for both options (Exhibit 3).

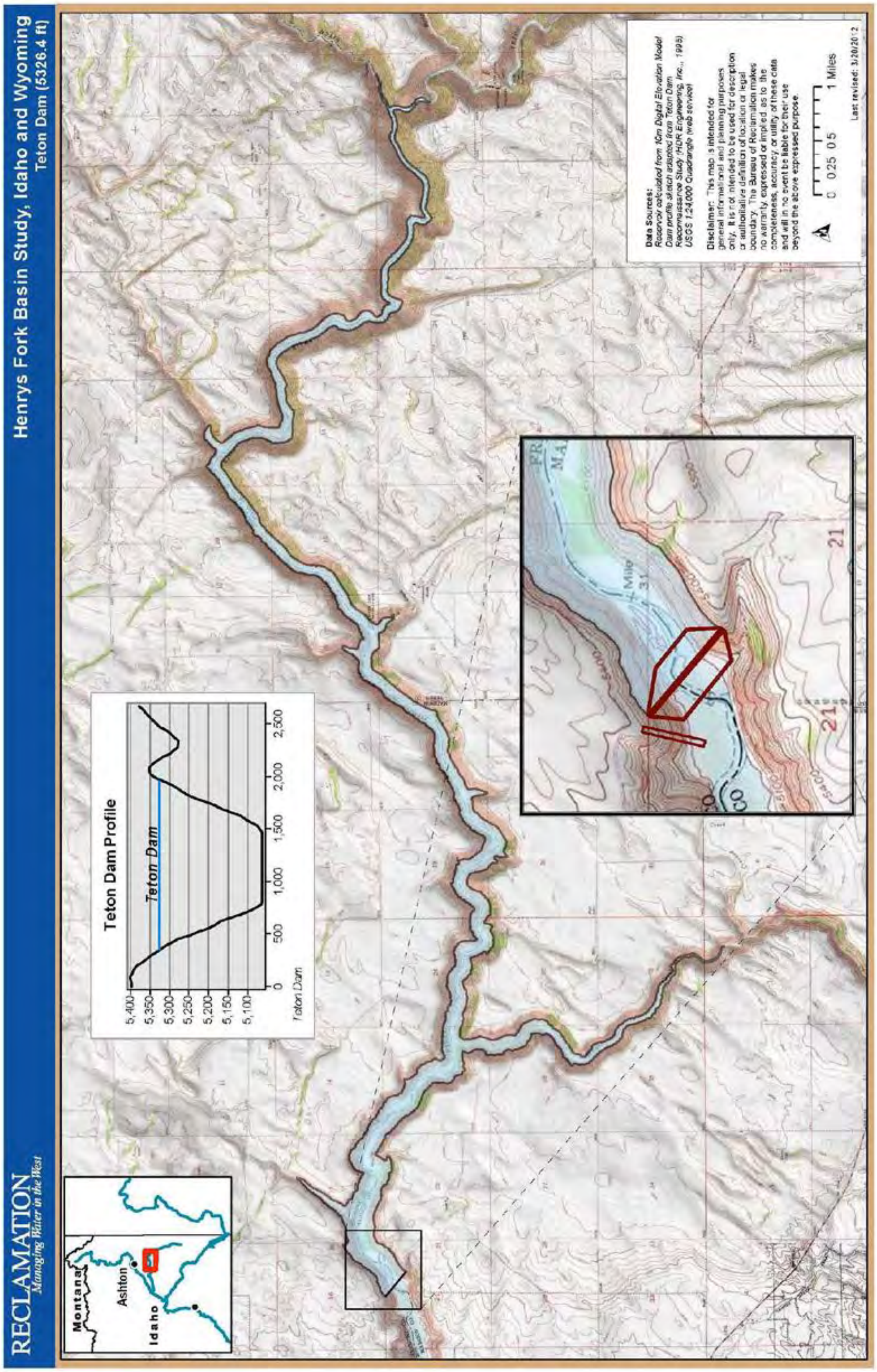

Exhibit 3. Topographic map showing the location of the dam and reservoir of the Teton Dam Rebuild Alternative, both construction options.

The existing gated spillway with a crest length of 72 feet and a crest elevation of 5305.0 feet would be incorporated in both options, and both options would require an auxiliary spillway. Portions of the original embankment on the right and left abutments would also be incorporated into both alternatives and would require removal of the existing dam structure.

The embankment dam would have a crest width of 35 feet, crest length of 1,700 feet, crest elevation of 5332.0 feet above sea level, and structural height of 302 feet. The auxiliary spillway would be constructed in a low area in the reservoir rim approximately 8,500 feet northeast of the existing spillway and discharge into an existing stream that empties into the Teton River approximately 4 miles downstream from the dam. The auxiliary spillway would be a 500-foot-wide excavated trapezoidal channel, containing a reinforced concrete crest structure. The spillway crest elevation would be at elevation 5321 feet, with the unlined excavated channel at elevation 5317.5 feet. The crest elevation was established at 1 foot above the normal reservoir surface elevation to reduce the potential of overtopping by wave action during normal reservoir releases.

Electrical generation would be incidental to the reservoir operations and would not specifically draw on the storage in the reservoir. The Teton Dam Rebuild Alternative would include a powerplant consisting of two 10,000 kilowatt generators, with space for a third 10,000 kilowatt unit, a switchyard, and a substation with the associated lines. Based on the 1962 Teton Project report and the 1969 preconstruction report, the average annual energy generation powerplant would be about 80 gigawatt Hours (GWh). The dependable generating capacity would be about 11 megawatts. These facilities would be constructed at the same location as the original plans and meet the same criteria as the original structures.

Recreational facilities recommended for development include 400 campsites, 200 picnic units, and 6 boat ramps over approximately 122 acres of land for the Teton Dam Rebuild Alternative. A detailed analysis based on current recreation information should be included if the project investigation is initiated. Storage space in the reservoir will not be dedicated to the recreation function.

Facilities are needed to house tools, shop, and garage equipment, communication equipment, and laboratory equipment for government contract inspectors. After the completion of the project, the structures would be used for housing equipment needed by operation and maintenance personnel.

The concrete dam would have a crest width of 30 feet, crest length of 2,250 feet, crest elevation of 5326.4 feet, and structural height of 405 feet. The additional height of the concrete dam in relation to the embankment dam (405 feet compared to 302) includes the below-surface level due to the necessity of excavating down to bedrock for the foundation. The auxiliary spillway would be part of the dam structure and would have a crest elevation

5320.4 feet. The spillway could have a stepped chute which converges to 800 feet of width at the toe of the dam. A spillway crest length of 1,000 feet would establish a maximum reservoir water surface at elevation 5326.4 feet.

1.1.1. *Teton Small Dam A Alternative*

Teton Small Dam A would be a roller-compacted concrete dam about 250 feet high from bedrock and 140 feet above the streambed (Exhibit 4). This proposed dam design would use the existing main outlet works and the original powerplant site and be located to take advantage of the previous foundation grouting and excavation to bedrock. The reservoir would impound 50,000 acre-feet of storage. A 400-foot-wide stepped spillway to help dissipate energy as water passed over would terminate in a stilling basin. The spillway crest would be capable of passing the probable maximum flood without overtopping the dam. The foundation would entail removing the existing structures to the bedrock surface about 110 feet below the existing stream channel.

In the Small Dam A alternative, a new powerplant would be constructed on top of the original powerplant's foundation. The existing intake structure would need to be modified to fit the smaller dam configurations. The average annual energy output of two horizontal turbines would vary between 28.0 and 65.1 GWh, depending on the reservoir capacity and the configuration and size of the generating units. The number of days that the unit(s) would be able to generate energy would decrease during the period of minimal stream flow releases which would be below the turbine design flows. Additional studies would be needed to find the optimal design and configuration of the turbines to maximize the net benefits.

Some facilities may be needed to equipment for government contract inspectors. After the completion of the project, the structures would be used for housing equipment needed by operation and maintenance personnel.

A detailed analysis based on current recreation information should be included if this alternative is initiated. Storage space in the reservoir will not be dedicated to the recreation function.

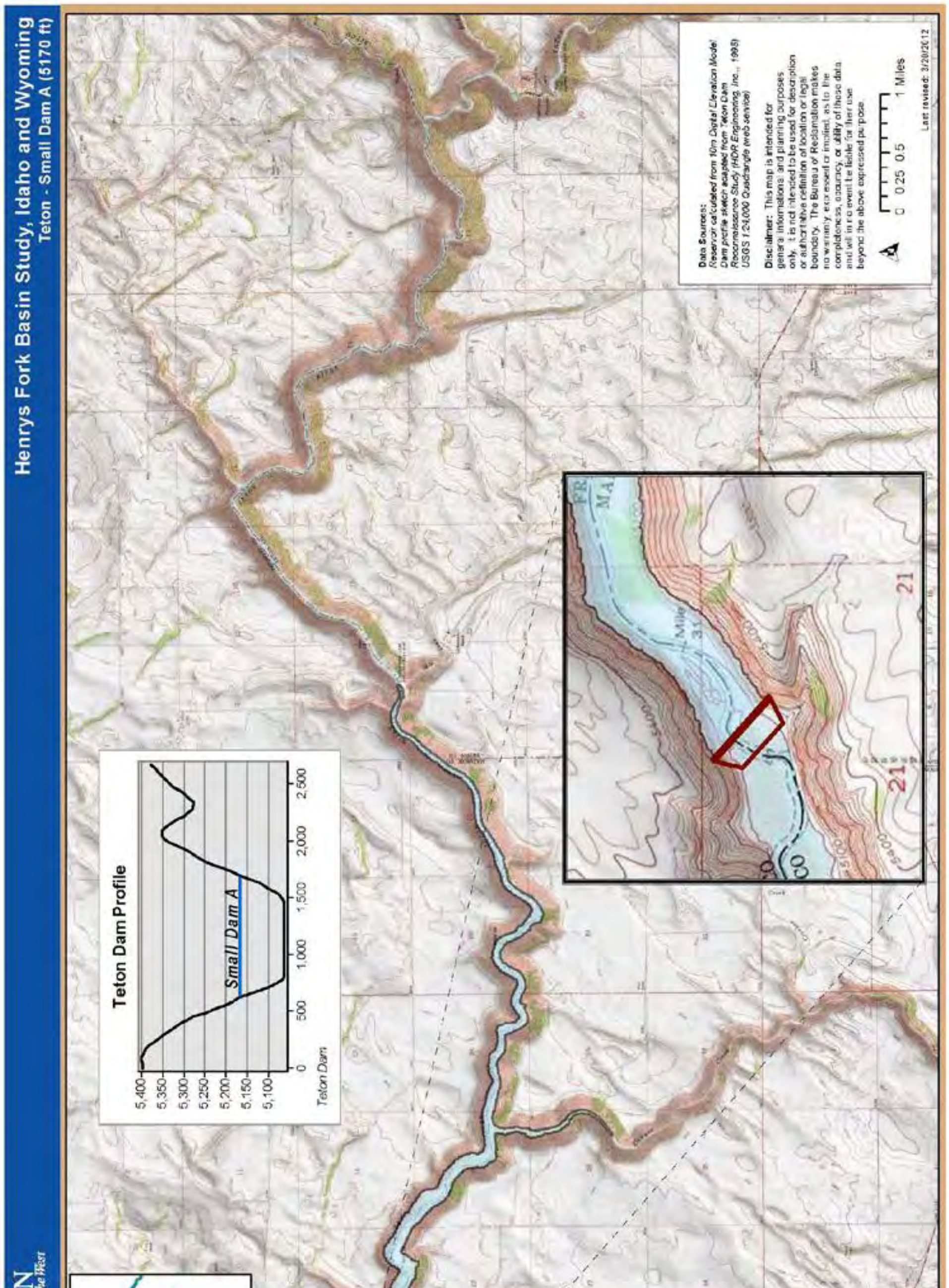

Exhibit 4. Topographic map showing the location of the dam and reservoir of the Teton Small Dam A Alternative.

1.1.2. *Teton Small Dam B Alternative*

Teton Small Dam B would be a roller-compacted concrete dam about 300 feet high from bedrock and 190 feet above the streambed and the reservoir would impound 100,000 acre-feet of storage (Exhibit 5). The foundation of the dam would be placed on the bedrock surface, as in the Teton Small Dam A Alternative.

In the Small Dam B alternative, a new powerplant would be constructed in the same configuration as the Teton Small Dam A Alternative.

Some facilities may be needed to equipment for government contract inspectors. After the completion of the project, the structures would be used for housing equipment needed by operation and maintenance personnel.

A detailed analysis based on current recreation information should be included if this alternative is initiated. Storage space in the reservoir will not be dedicated to the recreation function.

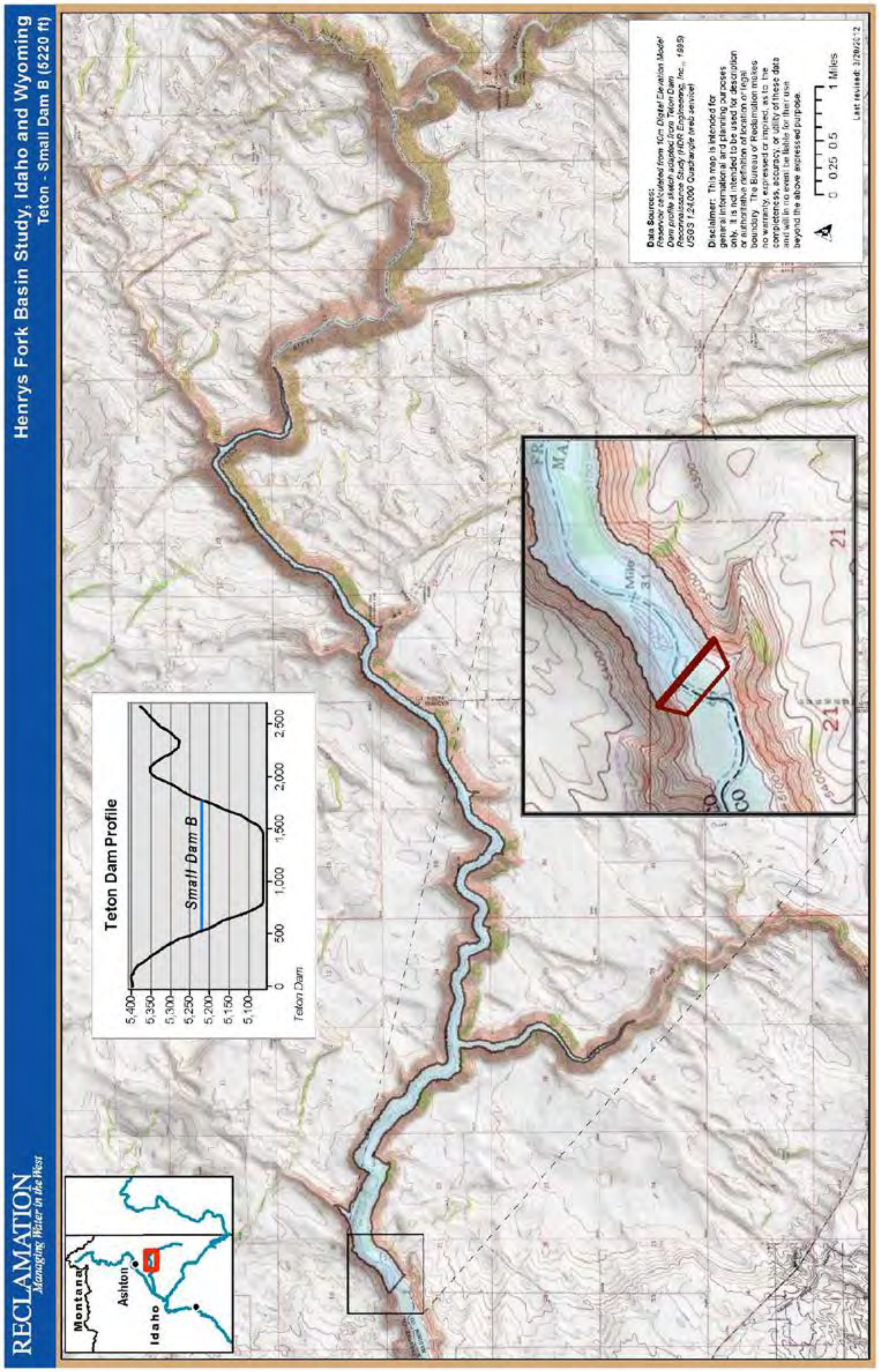

Exhibit 5. Topographic map showing the location of the dam and reservoir of the Teton Small Dam B Alternative.

1.2. Cost Estimation

Relative construction costs were developed for the surface storage alternatives for the sake of comparison (Exhibit 6). Detailed site-specific design information has not been developed; therefore, these costs are based on high-level assumptions that may be significantly modified if the project design progresses beyond this stage.

Exhibit 6. Estimated relative 2012 costs of the Teton Dam Surface Storage Project Alternative as indexed from the 1991 Reappraisal Report and the 1995 Reconnaissance Study. These costs are direct, field costs only and do not reflect indirect costs.

Facilities	Estimated Relative Costs			
	Rockfill Embankment Dam	Roller-Compacted Concrete Dam	Small Dam A	Small Dam B
Teton Dam and Reservoir	$156,789,000	$313,456,000	$63,140,000	$81,334,000
Powerplant, transmission lines, switchyards, and substations	$32,296,000	$32,296,000	$22,125,000	$24,200,000
Fish and wildlife mitigation	$4,175,000	$4,175,000	$4,175,000	$4,175,000
Recreation facilities	$932,000	$932,000	$932,000	$932,000
General property, government reserved works	$2,540,000	$2,540,000	$2,540,000	$2,540,000
Total	**$165,504,000**	**$322,171,000**	**$92,912,000**	**$113,181,000**

A full cost-benefit analysis was not prepared for this study; however, the cost per acre-foot of water found in Exhibit 7 provides a rough estimate of the cost effectiveness of reconstructing Teton Dam. If feasibility level studies are conducted in the future, development of benefits for each function to compare with the costs would be required. Reclamation's criteria for developing irrigation benefits have changed dramatically since the Congressional authorization of the Lower Teton Division and a decision on the criteria to be used for calculating benefits would be needed.

Exhibit 7. Relative alternative cost estimates.

Alternative	Total Storage Volume	Supplemental Water Volume	Total Construction Cost	Cost per Unit Storage (Dollar per acre-foot)	Cost per Unit Supplemental Water (Dollar per acre-foot)
Teton Dam Rebuild – rockfill embankment dam	288,000	55,000	$165,504,000	$575	$3,009
Teton Dam Rebuild – roller-compact concrete dam	288,000	55,000	$322,171,000	$1,119	$5,857
Teton Small Dam A	50,000	50,000	$92,912,000	$1,858	$1,858
Teton Small Dam B	100,000	100,000	$113,181,000	$1,132	$1,132

1.2.1. *Excluded Costs and Benefits*

The total relative construction costs are not intended to represent all costs for the project, which may be misleading if the estimated costs are used as the sole basis for comparing relative costs of this Alternative with the relative costs of the other surface storage alternatives. Some of the known costs that have been excluded include the following:

- Removal of the existing structure
- Preparation of the site for new construction

This cost estimates included in this report do not include potential project benefits of any of the alternatives. Some of the known potential benefits for the alternatives would require further study and may include:

- Hydropower
- Water supply
- Emergency water supply or firm yield
- Recreation
- Supplemental fish flows
- Flood control
- Groundwater recharge

2.2. Basin Needs

In all three alternatives, water would be stored in the reservoirs during high flows and after downstream water rights were met. The release of the stored water would stabilize flows in the Teton River during traditionally low flow periods in late summer and early fall when diversions are greatest. The Teton Dam Rebuild Alternative would supply approximately 55,000 acre-feet to the Lower Watershed region of the Henrys Fork River basin, an area with the greatest water shortages. Teton Small Dams A and B alternatives could also help stabilize the flows in the lower Teton River with the managed release of the 50,000 acre-feet and 100,000 acre-feet, respectively, of water and provide some relief to the irrigation shortages. Reservoir releases from all three alternatives would enhance ecological instream flows.

The out-of-basin water budget would be seasonally decreased when water would be stored during high flow periods, but may be made available later in the year to meet water right demands.

1.3. Environmental Benefits and Impacts

Under the Teton Dam Rebuild Alternative, the average annual amount of project storage available for irrigation could be about 44,000 acre-feet after meeting resident fish mitigation needs. There could be constraints to the release of the water which is needed in April, May, and June. It is unlikely that the entire 44,000 acre-feet could be released in these months without some flooding between Teton Dam and American Falls Reservoir in good water years.

Operating agreements for any of the alternatives would be needed with downstream water users for release of the water from Teton Reservoir for storage and later release from Brownlee Reservoir downstream on the Snake River. Locally, water demands for supplemental irrigation needs and swan and resident fishery flows would nearly fully utilize Teton Reservoir. Any significant increase in demands above those levels would be difficult to meet and could probably be met from the reservoir only in years with above normal water supplies.

With the Teton Dam Rebuild Alternative, the estimated fish and wildlife mitigation construction costs include establishing browse plants in designated areas, land acquisitions for exclusive wildlife habitat, spawning facilities, hatchery ponds, fish screens on major diversions, and a minimum of 300 cfs flow below the dam during average and above average water years. If the reservoir carryover falls below normal, the minimum flow would be reduced to 150 cfs.

The reservoirs of Small Dam A and B inundate smaller areas than the Teton Dam Rebuild Alternative so the area of impact would be proportionally smaller. Minimum fisheries flow would remain at 150 cfs.

1.3.1. *Impacted River Segments*

Hydrologic changes to the water source brought about by the proposed construction would have indirect impacts on a stretch of Teton River that is eligible for Wild and Scenic River status designation. The Teton Small Dams A and B alternatives would impact fewer stream segments than the Teton Dam Rebuild Alternative because of their smaller inundation areas.

1.3.2. *Change in Connectivity*

Potential impacts to river connectivity downstream of the dam would primarily be the reduction stream flows during spring runoff or high flow events and the stability of flows during low flow periods. There would be a large disconnect between the river segments above and below the dam which would make fish passage impossible or difficult. Diversion through the Crosscut Canal would be reduced since water from the reservoir would be used to supplement irrigation in the Lower Watershed region. This would leave more water in Henrys Fork River for the North Fremont and Egin Bench regions. More water in the Lower Watershed and Egin Bench regions would result in additional recharge either back to the rivers or to multiple aquifers.

1.3.3. *Presence of Yellowstone Cutthroat Trout*

The reservoir inundation area for any of the alternatives is not in crucial habitat for Yellowstone cutthroat trout; however, modifications to the hydrology of Teton River downstream of the dam would impact a conservation-and-management designated population of Yellowstone cutthroat trout in an area of concern. The project would need to be operated in a way that benefits the Yellowstone cutthroat trout downstream by providing stability in water flows. The Teton Dam Rebuild Alternative reservoir backs up into the lower reach of Bitch Creek which is home to a core conservation-and-management designated population of the Yellowstone cutthroat trout and is another area of concern. The Teton Small Dam A and B alternatives would not inundate areas of concern for Yellowstone cutthroat trout, but would impact the downstream population about the same as the Teton Dam Rebuild Alternative.

1.3.4. *Other Environmental Factors*

The U.S. Fish and Wildlife Service tracks one ESA-listed threatened species in the Henrys Fork Basin Study area, the grizzly bear, and one candidate species, the wolverine. The trumpeter swan, considered a sensitive species by the Bureau of Land Management and U.S.

Forest Service, also makes its home there. All three alternatives would impact large game winter range and migration corridors proportional to reservoir size.

1.4. 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 River 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 surface water storage in the Henrys Fork River 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 show a partial list of Federal and State regulatory guidelines that may pertain to the implementation of any of the proposed surface water storage alternatives identified through the Henrys Fork Basin Study.

1.4.1. *Federal Laws and Executive Orders*

Following is only a partial listing of Federal laws and Executive Orders (EO) that may pertain to the implementation of any of the proposed alternatives identified by 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
- 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
- EO 11988 - Floodplain Management
- EO 11990 - Protection of Wetlands
- EO 12875 - Enhancing the Intergovernmental Partnership
- EO 12898 - Federal Actions to Address Environmental Justice

1.4.2. *State Laws and Policy*

State regulatory processes should be considered in the evaluation of a new storage project including, but not limited to, the following:

- The necessary water right permits must be obtained. New consumptive use water rights will require evidence that water is available for appropriation and that the new use will not injure other water users. Water rights in the Henrys Fork and on Snake River are administered in accordance with the priority system and Water District 1 reservoir operations requirements.
- A new project must comply with policies set forth in the State Water Plan implemented by the Idaho Water Resource Board (IWRB). Pertinent policies include:
    - State protected river designations: With designating a natural river in accordance with Section 42-1734A, Idaho Code, the IWRB prohibits the following activities:
        - Construction or expansion of dams or impoundments;
        - Construction of hydropower projects;
        - Construction of water diversion works;
        - Dredge or placer mining;
        - Alterations of the stream bed; and
        - Mineral or sand and gravel extraction within the stream bed

- 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*.
- State minimum stream flow water rights: Management of the Snake River to meet or exceed minimum stream flow water rights established at the Milner, Murphy, Weiser, Johnson Bar and Lime Point gaging stations is fundamental to State policy. In addition, a number of minimum stream flow water rights have been developed in the Henrys Fork River basin. Each minimum stream flow was established to address specific management objectives, and together, the minimum stream flows form an integrated plan for management of the basin and Snake River as a whole. The basis and intention of the minimum stream flows as well as the current management of the system should be included in the evaluation of a new project tributary to the Snake River to ensure consistency with the State Water Plan and State regulatory obligations.
- Eastern Snake Plain Aquifer Comprehensive Aquifer Management Plan (ESPA CAMP 2009): The long-term goal of the ESPA CAMP is to incrementally achieve a net water budget change of an additional 600,000 acre-feet annually to the aquifer water budget, with a short-term target of between 200,000 acre-feet and 300,000 acre-feet. A new project in the Henrys Fork River basin should support the ESPA CAMP objectives.

- Pursuant to Section 42-1737, Idaho Code, approval by the IWRB is required for all project proposals involving the impoundment of water in a reservoir with an active storage capacity in excess of ten thousand (10,000) acre-feet.
- Water Quality Certification from the Idaho Department of Health and Welfare in connection with the Federal Clean Water Act.
- Obtain approval of engineering designs, operation, and maintenance through the Idaho Safety of Dams program.
- Stream Channel Alteration Permit for improvements made to the channel to accommodate flood flows and routine releases.
- Coordinate with the IDWR floodplain manager to confirm compliance with the National Flood Insurance Program (NFIP) requirements in Idaho.

County and City Planning and Zoning and environmental regulations are not included in this summary.

1.5. Land Management, Recreation, and Infrastructure Impacts and Benefits

According to the U.S. Census Bureau, the average county population of the Teton River area has increased by about 34 percent since 2000. As the population increases, the need for domestic, municipal, and industrial water will increase as well; however, none of the alternatives address those needs. Hydropower generation will benefit the local area's population growth.

As the population grows, the demand for recreation facilities and opportunities is also expected to grow. High priority development needs were identified to be campgrounds, picnic areas, and swimming areas, along with boating and waterskiing. Rafting, canoeing, and kayaking have become popular activities in the area and the increased flows that would be provided downstream from the dam would enhance these activities. The large reservoir created by Teton Dam would reduce rapid water rafting, canoeing and kayaking upstream of the dam.

1.6. Assumptions and Limitations

This assessment of reconstructing Teton Dam is preliminary in scope and cost estimates are comparative and preliminary. If the Alternative was selected to go forward, detailed investigations in several categories would be required:

- Hydrology is uncertain: Legal water available is not known. Physical water availability has been approximated based on regression equations, but actual runoff has not been measured, and firm yield has not been evaluated. Complete water balance and refined operations have not been evaluated.
- A quantitative hazards analysis
- Analysis of the potential impacts along the proposed canal and pipeline routes
- Additional hydrologic data to test the permeability of the reservoir area
- Further study is needed to adequately define the effects of fissures in the right abutment on seepage and bank storage
- Geologic investigations for the auxiliary spillway in the embankment dam option
- Seismic studies

- Investigations to determine the present conditions of all structures
- Investigate the adequacy of existing structures' capacities
- Investigations of the impacts the project would have on groundwater and recharge
- Preparation of final designs

1.7. Evaluation Criteria

1.7.1. *Stakeholder Group Measureable Criteria*

There are four Stakeholder Group Measurable Criteria, with results summarized in Exhibit 8:

1. Water Supply: The net change for in-basin and out-of-basin water budgets is measured in acre-feet.
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 1.4.
3. Environmental Considerations: Environmental benefits and impacts are summarized above in Section 1.3.
4. Economics: The estimated reconnaissance-level field cost to construct the project is summarized in Section 1.2.

Exhibit 8. Stakeholder Group measureable criteria summary.

Stakeholder Group Measurable Criteria	Criteria Characterization
Water Supply (in-basin water transfer)	55,000 acre-feet per year*
Water Supply (out-of-basin water transfer)	unknown
Legal, Institutional, or Policy Constraints (yes, no)	Yes
Environmental Considerations (net positive, negative or neutral)	Neutral
Economics (reconnaissance-level field costs for implementation)	$224,900,000 - $459,000,000

1.7.2. *Federal Viability Tests*

There are four federal viability tests. The background to evaluate each of these is summarized in the sections above and in the body of the report. Only qualitative, high-level summaries are provided here and in Exhibit 9:

1. Acceptability: To-be-determined (TBD)
2. Effectiveness: TBD
3. Completeness: TBD
4. Efficiency: TBD

Exhibit 9. Federal viability tests summary.

Stakeholder Group Measurable Criteria	Criteria Characterization
Acceptability (qualitatively low, moderate, high)	TBD
Effectiveness (extent to which basin needs are met: low, moderate, high)	TBD
Completeness (extent to which all needs are met: low, moderate, high)	TBD
Efficiency (relative construction/implementation cost per acre-feet: low, mid-range, high)	TBD

2. DATA SOURCES

Bureau of Reclamation. 1967. *Lower Teton Division, Teton Basin Project, Idaho*. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Boise, Idaho. July 1967.

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