Final Report for

Bridger Valley Reservoir Project, Level II Study

Wyoming Water Development Commission
Bridger Valley Joint Powers Board
Mountain View, Wyoming

SEH No. WWDC0703.00

September 19, 2008
Final Report - Bridger Valley Reservoir Project, Level II Study

Wyoming Water Development Commission and Bridger Valley Joint Powers Board

Mountain View, Wyoming

SEH No. AWWDCO070100

September 19, 2008
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RE: Wyoming Water Development
    Commission and Bridger Valley Joint
    Powers Board
    Final Report - Bridger Valley Reservoir
    Project, Level II Study
    Mountain View, Wyoming
    SEH No. AWWDC0070100

Mr. Steve Muth
Project Manager
Wyoming Water Development Office
6920 Yellowtail Road
Cheyenne, Wyoming 82002

Dear Mr. Muth:

Transmitted herewith are ten (10) copies each of the above referenced Final Report and Executive Summary for your distribution. Also transmitted are ten (10) CD copies each in PDF format, two (2) CD copies each in native format, and one (1) unbound reproducible copy each.

All comments received on the Draft Report have been appropriately addressed in the Final Report.

We appreciate your support and guidance on this most interesting and challenging project.

Short Elliott Hendrickson Inc. (SEH®)

Sincerely,

Douglas M. Yadon, PE
Principal/Project Manager

Douglas M. Yadon, PE
Principal/Project Manager
I hereby certify that all portions of this report except as noted below were prepared by me or under my direct supervision, and that I am a duly Licensed Professional Engineer under the laws of the State of Wyoming.

Douglas M. Yadon

Date: 9-15-08  Lic. No.: PE-4650

I hereby certify that Section 4.2-1 and Appendix B of this report were prepared by me or under my direct supervision, and that I am a duly Licensed Professional Geologist under the laws of the State of Wyoming.

Patrick S. Plumley

Date: 9/15/08  Lic. No.: PG-3387
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1.0 Introduction

1.1 Purpose and Scope

The primary purpose of the Bridger Valley Reservoir Project, Level II Study was to further evaluate the feasibility of developing a new dam and reservoir (including inlet and outlet facilities) at one of two previously identified sites. The reservoir would store 750 acre-feet of water for release when needed to the existing water treatment plant (WTP) near Mountain View, Wyoming owned and operated by the project sponsor Bridger Valley Joint Powers Board (BVJPB).

This purpose was accomplished by completing the following key tasks during the course of the study:

- Characterize and compare the two previously identified alternative Basin A and Basin B storage sites, and recommend one of the sites as the preferred location for a new dam and reservoir to store 750 acre-feet.
- Survey and conduct preliminary geologic/geotechnical investigations of the preferred alternative storage site.
- Review existing direct flow and storage water rights relevant to supplying and operating the proposed new reservoir.
- Develop a recommended system to supply water to the new reservoir and release stored water to the existing water treatment plant.
- Prepare conceptual designs for the proposed new reservoir, embankment dam (including any necessary foundation improvements), inlet facilities (pumping station and inlet pipeline), outlet works (outlet structure and piping), and spillway.
- Estimate capital and operations, maintenance and replacement (OM&R) costs for the proposed project; capital costs to include construction costs and all other costs to implement the project (land acquisition, permitting...
and environmental mitigation, engineering design and construction engineering, legal costs, etc.).

- Determine BVJPB’s share of the total project cost under a range of appropriate funding scenarios and the annual cost (debt service) on that amount; estimate the increased monthly cost to the end users (i.e., BVJPB customers) assuming service fees are the means by which debt will be retired and new OM&R costs will be paid.

- Identify all necessary land purchases, easements and rights-of-way required to construct and operate the proposed project.

- Characterize and evaluate known or potential environmental issues and mitigation and all relevant permits and clearances necessary for the proposed project.

The above summarized scope of this study is fully responsive to the Scope of Services in Exhibit “A” of the Consultant Contract for Services.

During the course of the study a total of five (5) meetings were held with the BVJPB in Mountain View. These included the scoping meeting on June 13, 2007, project meetings on August 8 and December 12, 2007 and February 13, 2008, and a results presentation meeting on August 13, 2008. Information presented at these meetings and any associated follow-on memoranda are provided in Appendix A.

1.2 Overview and Background

Overview. The Bridger Valley Reservoir Project site area is located approximately two (2) miles south of the Town of Mountain View as shown on Figure 1.2-1. The two alternative new reservoir storage sites that are the subject of this study, Basin A and Basin B, are shown on Figure 1.2-1. The Basin A site lies approximately 0.9 miles north-northeast of the existing BVJPB diversion on the East Fork of Smiths Fork River and approximately 0.7 miles south-southeast of the WTP. The Basin B site is about 1.7 miles northeast of the diversion and 0.4 miles east-southeast of the WTP. Table 1.2-1 shows the location of these sites by latitude/longitude and township, range and section. Access to the site area is via Wyoming State Highway 410, a paved, two-lane, all-weather road.

The topography in the site area is characterized by a broad, gently north sloping, locally dissected old alluvial terrace surface known as Tipperary Bench. Tipperary Bench is on the order of 100 feet above the floodplain of the Smiths Fork and Blacks Fork Rivers to the west. No perennial streams are present in the site area.

Land use in the site area is predominantly irrigated agriculture. Other locally significant land uses that affect the proposed new reservoir storage to one degree or another include: active aggregate mining and processing, dormant aggregate mining, an active construction trucking terminal, an auto salvage yard, and low density rural residential properties, some of which are developed and occupied.

Background. The Bridger Valley Joint Powers Board (BVJPB) diverts, treats and supplies potable water to approximately 5,500 residents in the
Towns of Lyman and Mountain View and in surrounding rural areas in the Bridger Valley. The existing WTP has a design maximum capacity of four (4) million gallons per day (MGD). The WTP is currently supplied by water generated largely in the Uinta Mountains to the south in Utah, which is the source area for the Smiths Fork and Blacks Fork Rivers. Flows are diverted from the East Fork of the Smiths Fork River approximately 1.6 miles upstream and conveyed by gravity pipeline to the plant. A diversion on the Blacks Fork River allows water to be transferred to the East Fork of Smiths Fork River above the diversion on the East Fork. The legal sources of the diverted water include direct flow rights on the Smiths Fork and Blacks Fork Rivers and a 1,500 acre-foot storage account in the U.S. Bureau of Reclamation’s Stateline Dam in Utah. Stateline Dam is operated by the Bridger Valley Water Conservancy District.

The existing sources of supply to the WTP are generally adequate for the current service area population during most of the year. During the late summer and fall, especially during the past several years of regional drought, supplies have been marginal at best when irrigation demands are high and streamflows are low. The quality of the existing sources of supply to the WTP is generally excellent. However, it is not uncommon for turbidity during the spring runoff to be high enough to require expensive treatment and occasionally so high (as in spring 2008) that a boil order is required for delivered water. Although less common, there are also periods of intense rainfall during the summer or fall when streamflows are low and turbidity levels are temporarily high and problematic.

1.3 Previous Studies

ECI Level II, Phase I Study. This Level II study follows two previous WWDC Level II studies of storage potential for BVJPB. The first of the previous studies was conducted by ECI (2004). The ECI Level II, Phase I study evaluated a variety of alternatives for conserving and managing BVJPB’s water supplies available from existing direct flow and storage rights. These alternatives included groundwater pumping, enhanced conservation, and capture of required non-irrigation season releases from BVJPB’s storage account in Stateline Reservoir that were not usable due to lack of storage below Stateline Reservoir but above the existing BVJPB diversion on the East Fork of Smiths Fork River. This Phase I study recommended the Jack Hollow site near the existing WTP as the favored location for a new reservoir with a storage capacity of 1,500 acre-feet. A number of alternatives were examined for supplying the new reservoir and use of an existing irrigation ditch (either the Milich or Davis and Company Ditch) was recommended.

Gannett Fleming Level II, Phase II Study. A Level II, Phase II study by Gannett Fleming, Inc. (2006) followed the ECI (2004) study. This Phase II study was originally scoped to evaluate the technical feasibility and estimated cost of the previously recommended Jack Hollow dam and reservoir in greater detail. A number of significant geotechnical and water quality concerns were identified at the Jack Hollow site during the Phase II study, including compressibility and strength of the dam foundation materials, presence of dispersive clay in both alluvial and residual soil deposits in the foundation, and poor water quality (including elevated
sulfates, total dissolved solids and arsenic) from surface runoff and groundwater inflow that could require additional and/or advanced treatment at the existing WTP. Given these concerns, the scope of the Phase II study was amended to perform pre-conceptual level evaluations of two new alternative storage sites designated as Basin A and Basin B.

1.4 Authorization and Responsibility

This project was authorized by Consultant Contract for Services No. 05SC0293240 effective June 7, 2007 between the Wyoming Water Development Commission (WWDC) and Short Elliott Hendrickson Inc. (SEH). The official contractual representative for the WWDC was Michael Purcell, Director of the Wyoming Water Development Office (WWDO). Steve Muth served as the WWDO Project Manager and primary point of contact for SEH on both technical and administrative matters.

SEH’s Project Manager for this study was Douglas M. Yadon, Wyoming PE No. 4650, and all engineering work on the project was performed under his responsible charge. Patrick S. Plumley, PG, CEG, Wyoming PG No. 3387 of Plumley and Associates, Inc. (PAI) was in responsible charge of all geologic work on the project. Except for Mr. Plumley, the work for this project was performed by Mr. Yadon and other selected SEH staff including William R. Kelly, PE, Alan C. Jewell, PE, Aaron S. Ritter, EIT, Michael A. Flaim, LS, and Christopher J. Wichmann.

1.5 Acknowledgments

WWDO Project Manager Steve Muth, supported by Deputy Director Phil Ogle, provided timely and helpful guidance and direction to SEH on both administrative matters and technical issues throughout the course of the study. The members of the Bridger Valley Joint Powers Board contributed significantly to the project with important information, helpful insights, and crucial input on several key issues requiring decisions to be made. LaDonna Bugas and Rocky Irick of the BVJPB staff and Dave Dasher of the Town of Mountain View were especially helpful in answering questions and offering suggestions as to other sources of information as the project progressed. Ken Walker, PE of Uinta Engineering and Surveying, Inc. as BVJPB’s engineer provided helpful information on the existing raw water pipelines and WTP facilities as well as thoughts on the design concepts for use of the pipelines. Kevin Kondus, lessee and operator of the sand and gravel mining operation at the preferred Basin A site provided first-hand knowledge of the site and materials, and performed test pit excavations during the field investigations.

2.0 Access

A land ownership map of property within the immediate vicinity of the project was prepared in order to identify potentially affected parties. The map of the area is shown as Figure 2.1-1. Relevant parties were contacted prior to accessing their property. Early in the project a decision was made to pursue Basin A in detail as discussed further in Section 3.0. As a result, the focus of property access was directed at properties in the Basin A vicinity.

Table 2.1-1 lists contacts made and phone numbers where various parties were reached. Also identified are those that could not be reached.
3.0 Obtain Geotechnical Data for Basins A and B

Basins A and B were identified in the prior Level II, Phase II study (Gannett Fleming, 2006) as potential alternative sites for a reservoir of approximately 750 acre-feet capacity. This task involved obtaining preliminary information relative to each of the two sites to enable selection of the most promising site for more detailed evaluation. Geotechnical investigations were addressed as part of the work described under Section 4.0. To assist the WWDO and the Project Sponsor, the Bridger Valley Joint Powers Board (BVJPB), in making a decision regarding alternative sites, a summary comparison of the two alternatives was prepared and is provided as Tables 3.0-1 and 3.0-2. Following presentation of this comparison at a project meeting on August 8, 2007, a decision was made to pursue Basin A in detail.

4.0 Site Survey and Investigations

4.1 Site Survey and Mapping

Summary. A topographic survey of the site was conducted with a survey-grade GPS unit on September 12 through 19, 2007. The survey included locating the physical features and grade breaks sufficiently to prepare topographic mapping of the Basin A site at a scale of 1 in = 200 ft with two-foot contours. Survey data were downloaded and converted to a three-dimensional AutoCAD file. Portions of the site could not be accessed due to property ownership constraints. In particular, the owner of the Swearengin Trust properties (Donna Gourley) could not be reached and so access along the west side of the bluff adjacent to the Smiths Fork River was limited to the existing BVJPB pipeline easement which enabled establishing a survey line along the toe of the slope. Contours along the slope were then interpolated between that line and a similar line at the top of the slope accessed from the Rees gravel pit property.

Survey Documentation. The survey was completed as Wyoming State Plane West Zone at Ground. More specifically the survey was completed with:

- **Equipment:** Survey Grade - Trimble 5700 & 5800 GPS
- **Methods:** OPUS derived control points & RTK topographic survey
- **Units:** US Survey Foot
- **Coordinates:** Wyoming State Plane (NAD1983-West Zone 4904) At Ground Grid to Ground Datum Adjustment Factor (DAF) = 1.0003898031
- **Scaled about project origin of 41°14'18.30308"N Lat, 110°22'04.92844"W Long; Project GRS80 ellipsoidal Height = 7005.388USft; Geoid Model: GEOID03(ConUS)**

Gravel Mining Operations. At the time the survey was being completed, gravel mining and processing operations were active at the south end of the site. Since gravel mining is ongoing, some modifications to the map would be necessary to bring it up to date at any given time. Key changes are expected at the south end of the site. The gravel pit operator (Kevin Kondus) has indicated his intent to leave minor pockets and surface layers (as at the middle to north end of the site) in place. The large pile of gravel east of the
current south end operations is reportedly of a quality which results in more difficulty meeting specifications and will be left in place until more favorable reserves are exhausted. Mr. Kondus has also indicated that he is permitting an additional site at the southwest corner of the current operations (Lupher property) which will be mined in the more immediate future.

4.2 Geologic/Geotechnical Investigations

A geologic and geotechnical investigation program was undertaken under the responsible direction of Patrick Plumley, PG, CEG of Plumley & Associates, Inc. (PAI) with field work completed during the period of September 25 through 28, 2007. A complete copy of the Technical Memorandum by PAI is included in Appendix B. A brief summary of key information from the Technical Memorandum and SEH’s interpretations of that information are provided in the following paragraphs, together with additional information from studies by SEH on potential off-site borrow material sources and regional seismotectonic conditions (i.e., earthquakes and active faulting).

4.2.1 Site Geologic/Geotechnical Conditions

Plumley first completed a thorough reconnaissance of the available site surface exposures including the high wall at the south end of the site, the exposed surface of the gravel pit, and the bluff along the west edge of the site (as could be seen from the toe below since access permission had not been granted for the Swarengin Trust property). Geological field mapping was then completed with the aid of the recently prepared site topographic map and a handheld GPS unit. A total of 15 test pits and four (4) drill holes were completed, with two of the test pits supervised and logged by Doug Yadon/SEH during a site visit on August 8 and 9, 2007. Based on the site reconnaissance, field mapping and subsurface exploration, a geologic map of the site was prepared and is provided as Figure 4.2-1. Accompanying geologic cross-sections are included in Appendix B.

Site exploration and interpretation indicate that the reservoir site is underlain by an erosional bedrock surface sloping toward the north approximately parallel to the overall ground slope on Tipperary Bench. Sandstone bedrock is present in the shallow subsurface over the majority of the site, except in the southwest corner of the site where finer-grained bedrock (predominantly mudstone or siltstone) is present at or near the surface locally overlying (likely interfingering with) the sandstone. The bedrock units are nearly flat-lying with dips in the vicinity less than about 5 degrees from the horizontal.

Below a depth of typically about 5-10 feet it appears that both the sandstone and finer-grained bedrock units are relatively less weathered and fractured, and are inferred to be of low to moderately low permeability. The upper 5-10 feet of bedrock across the site is generally more weathered and characterized by typically intense open fracturing and parting along bedding planes, leading to inferred relatively high bulk (i.e., fracture, joint and parting dominated) permeability. Although generally classified as relatively weak rock, the strength and compressibility of both the shallower weathered and deeper relatively fresh bedrock are judged more than adequate for the anticipated embankment loads at the site.
An unusual behavior was found with some of both the relatively fresh and weathered mudstone/siltstone during informal crumb testing to check for dispersivity (i.e., breakdown of certain susceptible clays in the presence of water). These finer-grained bedrock materials were found to disaggregate rapidly without any mechanical disturbance to non-plastic silt by a single cycle of air drying sufficient to reduce the moisture content below in situ levels, followed by rewetting. Prior to the drying and rewetting these bedrock materials were relatively dense, hard and moderately strong (at least in soils terms). After cycling, the resulting non-plastic silt was judged unmanageable as a potential source of fill material. The undisturbed material (material at natural in situ moisture) was also judged unsuitable in the foundation or as embankment fill if there was any realistic potential that it could be subject to cycles of deep drying and subsequent rewetting.

The weathered bedrock at the site is overlain by a zero to five- or six-foot thickness of residual sand or silt soil depending on the nature of the underlying bedrock. These soils are inferred as having developed in place by deep, long-term weathering of the bedrock. The silt is very fine-grained and completely non-plastic, thus easily eroded. This material is also judged unsuitable for use as fill for any purpose on the project as it would not be practical to control its moisture content and achieve reliable and consistent density during compaction. The sand is fine to medium grained, dense in place, but relatively friable (and thus easy to excavate and potentially erodible especially after having been borrowed and placed as fill). This material, as contrasted with the silt, would serve as suitable borrow for appropriate uses on the project.

Terrace deposits overlie the sand or silt, the thickness of which depends on the degree of mining completed to date. These deposits are characterized as a heterogeneous mixture of boulders (observed up to 2-foot diameter), gravel, sand and silt. Where exposed, in-place deposits of these terrace deposits appear to be skip-graded with relatively less percentages of gravel as compared to the other size fractions. Additional exploration and testing are necessary to determine if this condition is representative of the bulk of the terrace material still present in the site area. The permeability of these deposits in place is likely quite variable, with better-sorted (more uniform) materials with relatively less fines (sand and silt) expected to have high to very high permeability. However, less sorted (less uniform gradation) materials with significant percentages of matrix-filling sands and silts may exhibit relatively low permeability. Experience with similar materials (based on available gradations from ECI, 2004) suggests that these materials may have quite low permeability when excavated, handled, hauled, placed and compacted.

Groundwater was locally encountered in bedrock in some of the exploratory borings and test pits typically at the south end of the site but not at any regular depth and/or plan locations. This indicates that the occurrences found are probably perched pockets of groundwater. The presence, and if present, the depth of a groundwater table or confined aquifer(s) underlying the site are unknown. Depth to groundwater in four wells completed in the Bridger Formation and located within three miles east and southeast of the Basin A site reportedly ranged from 15 to 50 feet (Robinove and Cummings,
1963). Given the local groundwater drainage effect of the hillslope at the western border of the Basin A site, it is not surprising that the groundwater table was not encountered at the site to the depths explored in this study (maximum of 21.5 feet).

In-hole falling head tests completed in some of the bore holes as part of the screening level geotechnical investigation proved to be unsuccessful in reliably determining the permeability of the bedrock units. This situation is believed to have occurred due to the probable disturbance of the borehole wall using the auger drilling technique (resulting in finer-grained material filling open fractures and partings). Additional conventional drill holes completed using rotary wash techniques and in-situ water loss testing (e.g., packer testing, open hole constant or falling head testing, etc.) and large-scale trench exploration and infiltration testing could be used to estimate the in situ permeability as a basis to better assess the degree of seepage anticipated in the bedrock fractures/partings at the site. However, extensive exploration drilling, trenching, and testing would be required at the site to develop a more reliable order-of-magnitude estimate of the permeability of the bedrock beneath the reservoir and perimeter embankment. Even with extensive exploration and in-situ permeability testing, there would be unavoidable uncertainty associated with the final permeability estimate associated with the inferred or uncertain geologic conditions (particularly density, orientation and aperture of fractures) between the exploration points. Therefore, considering these inherent uncertainties, and the requirement to minimize seepage losses, it is assumed at this level of study that the reservoir would be constructed using a liner. See related discussion in Section 7.0 and Appendix B.

4.2.2 Off-Site Borrow Sources

An evaluation was made by SEH of potential off-site sources of clay borrow for use in a conventional low permeability core for the embankment dam at the site as an alternative to using a synthetic liner as the embankment water-stop. This evaluation included contacting Nathan Roth of the Lyman office of the Natural Resources Conservation Service (NRCS) (Personal communication, January 17, 2008), and reviewing relevant geologic reports/maps including: Robinove and Cummings (1963); Bradley (1964); Welder (1968); and Roehler (1992). Based on this information, the most likely target unit for potentially suitable clayey core material is the Laney Shale Member of the Green River Formation. A measured section of the Laney Shale located “east of Piedmont” (estimated as on the order of 15 road miles west of the Basin A site) is described in Bradley (1964). At this location relatively soft mudstone and shale are the predominant units, comprising about 86 percent of the 283 feet of section measured.

The area between the Town of Milburne and Bridger Butte to the northwest of the Basin A site is mapped by Robinove and Cummings (1963) as the undifferentiated Laney Shale and Wilkins Peak Members of the Green River Formation. These undifferentiated units are described as “Thin-bedded, drab sandstone, siltstone, and mudstone, paper shale, and some thin limestone beds”. Based on this description, these units would not be targeted as a clay core source. If in fact, however, this area is underlain by the Laney Shale Member and is characterized by the relatively soft shales and mudstones
described in the measured section further to the southwest, then this might be a suitable source area for clay borrow. The closest mapped boundary of this unit to the Basin A site is approximately 5.5 road miles away. Depending on site geology, land ownership, and access conditions (including the crossings of the Smiths Fork and Blacks Fork Rivers), the actual haul distance to reach this mapped unit may be significantly greater. If instead, this area is more characterized by less plastic units (sandstone, siltstone and silty mudstone) it may not be a suitable clay source. In that case, a one-way haul on existing roads of at least 15 miles is likely.

It is assumed for purposes of this study, based on available information, that a suitable borrow source for a conventional clay core is not available at an economic round-trip haul distance (estimated as about 10-15 miles). However, further evaluation of the area just northwest of Milburne is recommended during final design to determine if suitable clay borrow is present within an economic haul distance.

### 4.2.3 Seismotectonic Setting

The Bridger Valley Reservoir Project site lies near the eastern edge of the Intermountain Seismic Belt (ISB). The ISB is a regionally extensive zone of active faulting and seismicity (i.e., earthquake occurrence) that extends approximately north-south from northwestern Montana to southern Nevada/northern Arizona. A seismological characterization of Uinta County prepared by the Wyoming State Geological Survey (Case, et al., 2002) provides a thorough summary of the historic seismicity in Uinta County and the surrounding region, a deterministic analysis of regional active faults and floating or random earthquake sources, and probabilistic seismic hazard analyses applicable to critical facilities in the County. The Case, et al. (2002) characterization provides the basis for the following summary discussion unless noted otherwise, and is included as Appendix C to this report.

**Historic Seismicity.** A total of 23 earthquakes of magnitude greater than 1.5 have been recorded in Uinta County. The largest of these was a 3.4 magnitude event about 9 miles north-northwest of Carter near the Uinta-Lincoln County border. The majority of these events occurred in the central and western portions of the County. Historic events in the vicinity of the Basin A site include the following:

- Magnitude 2.1 on June 26, 1976 about 6-7 miles south-southeast of Piedmont
- Magnitude 2.5 on August 13, 1985 about 7 miles southeast of Robertson
- Magnitude 2.4 on December 24, 1989 just northeast of Milburne
- Magnitude 1.7 on March 22, 1990 about 3 miles northeast of Milburne
- Magnitude 2.1 on June 25, 1990 about 5 miles south of Robertson
- Magnitude 2.25 on October 15, 1990 about 6 miles south-southeast of Piedmont
- Magnitude 2.5 on December 4, 1990 about 3 miles southeast of Robertson
- Magnitude 2.28 on December 18, 1993 about 5 miles southwest of Robertson
- Magnitude 2.77 on December 27, 1993 about 5 miles west-northwest of Mountain View
- Magnitude 2.0 on January 21, 1995 near Fort Bridger
- Magnitude 2.8 on July 5, 2002 about 3 miles west of Lyman

Although these historic events were all small magnitude earthquakes that did no discernible damage they are direct evidence that the region is seismically active.

Active Faults. There are three active faults or fault zones currently mapped in Uinta County (http://gldims.cr.usgs.gov/qfault/viewer.htm). Of these, only the Bear River fault zone is judged capable of generating earthquakes of significance to the Basin A site (see Figure 4.2-2). Estimates of the peak horizontal ground accelerations (PHGA) at Mountain View near the Basin A site from a maximum credible earthquake (MCE) on this fault zone is 0.13g (Case et al., 2002). More recent work (USGS, 2008) would likely result in a higher estimate of PHGA from this source as discussed in the following subsection. The Hogsback fault zone, although located closer to the Basin A site than any of the other active or potentially active faults (see Figure 4.2-2), is an older fault (estimated as >750,000 years since last offset) and judged much less likely to produce damaging earthquakes than the Bear River fault zone.

There are no known active or potentially active faults in the immediate Basin A site area that would pose any risk of surface offset.

Random/Floating Earthquake. Sometimes earthquakes of moderately high magnitude that produce potentially damaging ground motions cannot be clearly associated with a causative active fault. These events are termed floating or random earthquakes. The floating or random event applicable to the Basin A site is assumed to have a magnitude in the range of 6.0-6.5 with an average value of 6.25. In assessing the potential effects of such an event, it is fairly common to assume that the event occurs at a distance of 15 kilometers from the given site (a typical assumption to represent the relatively high probability of such an event occurring near a site, but the very low probability of it occurring directly under any given site). A magnitude 6.25 event 15 kilometers from the Basin A site would be expected to produce a PHGA of about 0.15g at the site (Case, et al., 2002).

Probabilistic Ground Motions. The U.S. Geological Survey (USGS) has developed a model that predicts potential future ground motions at any point in the United States based on historic seismicity, known and inferred seismogenic sources (active faults, folds and other geologic structures), and characterization of the propagation of seismic waves from an earthquake source to a site of interest. Among the results available from this model that are most relevant to this study are peak horizontal ground accelerations (PHGA) at a given probability that those accelerations will not be exceeded over a specified exposure period. The exceedance probability and exposure period applicable to a high hazard dam as proposed at the Basin A site are 2
percent and 50 years, respectively, resulting in a return period (or recurrence interval) of 2,500 years. The estimated PHGA from this methodology based on Case, et al. (2002) is on the order of 0.2g.

Based on the very recent update of the 2002 USGS model (USGS, 2008), the PHGA at the proposed Bridger Valley Reservoir Project site with a 2,500-year return period is on the order of 0.38g or nearly twice the earlier estimate (see Figure 4.2-2). This very recently updated result of 0.38g is the result of both underlying updates in the model methodology and revisions to the characteristics inferred for the Bear River fault zone which largely controls predicted ground motions in the site area.

4.3 Existing Groundwater Quality
Perched groundwater was encountered in several of the exploratory borings and test pits at the south end of the Basin A site. Water from one of the test pits (TP-A2) was sampled on August 9, 2008, and submitted to the Colorado State University laboratory for Domestic Water Analysis. The results of that analysis are provided in Appendix D. All parameters included in the analysis except sodium and TDS were found to be within the EPA suggested limits for domestic use. TDS was measured at 796 mg/l compared to a recommended limit of 500 mg/l while sodium was measured at 178 mg/l compared to a recommended limit of 20 mg/l. Neither of those parameters are expected to cause water quality issues within the proposed reservoir due to the combination of the extremely small expected influence of groundwater on the total water balance (minimal to no groundwater contribution to the storage reservoir is anticipated considering low groundwater flow, reservoir lining and higher hydraulic head in the reservoir; see also discussion in Section 7.0), and the relative concentration of the parameter compared to the recommended limit.

5.0 Review of Water Rights
The following discussion addresses existing direct flow rights and storage contracts relevant to supply and operation of the proposed Bridger Valley Reservoir Project. See related discussion regarding acquisition of new and enlarged rights in Section 11.4.2.

5.1 Direct Flow Rights
The Bridger Valley Joint Powers Board (BVJPB) has direct flow water rights on both the Smiths Fork and Blacks Fork Rivers as summarized in Table 5.1-1. Copies of the Certificates of Appropriation for these rights are included in Appendix E. These rights provide much of the annual supply to the water treatment plant (WTP) to meet current demands. These existing direct flow rights range in priority from 1914 transferred irrigation use rights to relatively junior 1978 municipal use rights.

Some of the existing direct flow rights are conditioned to allow diversion only during the 105 day period after May 15 each year. However, the aggregated permitted flow for these rights is only 0.14 cfs resulting in 29.14 acre-feet during the allowed period of diversion.

In typical years BVJPB’s existing direct flow rights are often not sufficient to supply the municipal raw water needs during the late summer when the rivers
are under regulation. These supply limitations are aggravated during dry years and periods of extended drought (ECI, 2004).

Although not directly relevant to BVJPB’s current surface water supplies, Table 5.1-1 also includes other minor municipal use surface water rights held by BVJPB participants the Town of Lyman and Town of Mountain View.

5.2 Storage Rights/Contracts

5.2.1 Stateline Reservoir

In addition to direct flow rights, BVJPB also has a contract for a firm annual yield from storage of 1,500 acre-feet in the Bureau of Reclamation’s Stateline Reservoir in Utah (ECI, 2004). Releases from storage made in accordance with the storage contract (as amended) are used to supplement direct flow diversions when necessary to meet BVJPB’s raw water supply needs. These releases are assessed a shrinkage (carriage loss) of 10 percent below the Utah-Wyoming state line according to Jade Henderson/Wyoming State Engineer’s Office (WSEO) (Personal communication, June 10, 2008).

Storage and release of BVJPB’s 1,500 acre-feet share of the total storage in Stateline Reservoir are governed by the specified schedule shown in Table 5.2-1 which was reportedly adopted by a letter of agreement executed in 1995 which revised the schedule originally adopted by an agreement among the parties on May 30, 1978 (BVJPB, 2003). In accordance with the schedule in Table 5.2-1, water not requested by BVJPB for release from storage in a given month (or between October 1 and June 1 where the schedule is by season rather than by month) may be lost (i.e., no longer available for release to BVJPB in a later month). Although not explicit in the documents reviewed for this study, it is our understanding that these storage reservation provisions have been interpreted by the parties as requiring that 700 acre-feet of BVJPB’s storage allotment be released between October 1 and June 1 and that the remaining 800 acre-feet of storage be released in accordance with Table 5.2-1 (assuming that amount was available in storage from that year’s inflows to Stateline Reservoir). Releases made to avoid losses of BVJPB’s storage allotment are reportedly often not needed to meet current system demands, and are thus lost (i.e., released without benefit to BVJPB).

Furthermore, the original contract (assuming that the terms of the final executed contract are the same as in the “R. O. Draft, 10/1/76” provided for review in this study) provided that:

“Any water to which the Contractor [BVJPB] is entitled and which is not taken by the Contractor in any calendar year shall become part of the total project water supply for the following year and the Contractor will have no separate holdover storage right from 1 year to the next in the Stateline Reservoir.” (Article 5(c), page 6; clarification added)

The above provisions of the existing water storage contract and associated agreements and the agreed storage/release practices among the parties thereto are a significant part of the decision by BVJPB to seek additional storage at a new reservoir near the existing WTP.
5.2.2 Jack Hollow Reservoir/Pipeline
In addition to their Stateline Reservoir storage contract, BVJPB applied for municipal/industrial use storage rights for the previously proposed Jack Hollow Pipeline and Reservoir (see Table 5.1-1). However, the applications for what would have been 2003 priority rights were rejected by the WSEO. As a result, these applications are not believed to have any direct relevance to the Basin A site.

6.0 Develop Water Delivery System
6.1 Existing Facilities
As noted previously the BVJPB has a water right and contract to store and release 1500 acre-feet from Stateline Reservoir every year. Of this total, only 800 acre-feet can be released during the normal irrigation season. The remaining 700 acre-feet is to be released between October 1 and June 1. It is this water that must be delivered during the non-irrigation season (i.e., released during the fall through spring months) that is to be stored in the proposed reservoir.

Two raw water pipelines connect the intake structure on the Smiths Fork River (upstream of Site A) to the water treatment plant (WTP) located downstream of Site A. The two lines are nearly parallel to each other and are located near the toe of the slope below Site A between the bluff and the adjacent river. An access road suitable for maintenance/inspection of the pipelines is located alongside the pipelines in an easement near the toe of the slope. The larger pipe is a 20-inch HDPE pipeline constructed in 2002 to feed the new water treatment plant. The other pipe is a 14-inch asbestos cement (AC) pipe constructed around 1977. The 14-inch pipe is currently off-line but is reportedly in functional condition. Both pipelines operate under gravity flow conditions from the intake structure, with a residual head at the entrance to the WTP where flow is regulated.

6.2 Delivery Options
Options for delivery of water to the Basin A site were considered and a decision to pump from the existing 14-inch raw water pipeline was made based on the proximity of the pipeline to the site (see Section 6.1 for location of existing pipeline). No other options were found to be competitive in this or previous studies (ECI, 2004; Gannett Fleming, 2006).

Options were considered relative to where to pump into the basin and where to withdraw from the basin. The prior Level II study (Gannett Fleming, 2006) suggested a common inlet/outlet near the north-south center of the site. Although slightly more expensive, a separate inlet and outlet were evaluated and presented to the BVJPB who selected the separate inlet/outlet configuration. A copy of the table presented to the BVJPB comparing the two options is included as Table 6.2-1.

One key advantage of the separate inlet and outlet arrangement is the ability to use the basin as a settling pond during periods of high turbidity as opposed to drawing the reservoir down during such conditions. In the prior Level II study, for a dry-year scenario and a population of 9000 the total annual estimated storage need was 766 acre-feet. For those conditions, the study
allocated 332 acre-feet (or 43 percent of the total storage) to discharge during the spring under high turbidity conditions and 434 acre-feet to satisfying demands for water shortage during dry conditions in the fall (Gannett Fleming, 2006). By routing the flow through the basin during periods of high turbidity (and thereby avoiding the planned spring drawdown) the capacity of the system that can be allocated to serve a greater population is significantly increased.

An additional consideration evaluated is the need to allocate part of the water stored annually to evaporative losses, and if the basin is not lined, to seepage losses. Expected annual losses due to evaporation equate to 100 acre-feet, based on a net evaporation rate of 30 inches per year and a surface area of 40 acres. This volume would need to be subtracted from the effective storage available for municipal usage. This situation further favored the need to avoid spring drawdown for turbidity mitigation in the future.

Another key consideration in placing the inlet at the opposite end of the basin to the outlet was the ability to circulate water through the basin should stagnation become a water quality issue within the storage basin.

The proposed inlet to the reservoir would be located near the southwest corner of the site with a pumping station located near the existing pipeline at the bottom of the slope. A 14-inch pipeline would extend from the pumping station perpendicular to and up the slope, across the top of the embankment to where the inflow discharges to a manhole from which it would flow into an energy dissipation structure at the southwest corner of the basin. An erosion-protected channel would be constructed from the point of release to the opposite end of the basin to prevent erosion of the sand cover protecting the basin liner when the basin is filling from a drawn-down condition. The outlet facilities would be located at the north end of the site, at the opposite end of the basin from the inlet. Figure 6.2-1 presents a profile of the existing pipeline system as it relates to the proposed reservoir.

Estimates of sediment accumulation indicate that loss of storage to sediment deposition should not be a factor. Data relative to TSS of the raw water is relatively sparse. However, preliminary estimates using available turbidity data suggest that even with all flow routed through the reservoir over a fifty-year period sediment accumulation would be expected to be less than 10 acre-ft.

6.3 Design Flow Rate

On an annual basis a total of up to 700 acre-feet (less carriage or conveyance losses of 10 percent as assigned by WSEO and less any concurrent direct flow diversions of the 700 acre-feet to the WTP for municipal usage) would be diverted from the Smiths Fork River through the 14-inch pipeline to the pumping station at the southwest corner of the new storage reservoir. The schedule for pumping is only defined as being between October 1 and June 1, a 243-day period. Pumping the entire 700 acre-feet over the full 243 days would result in an average pumping rate of 1.45 cfs (652 gpm). During spring and early summer when high turbidity conditions could potentially exist, it may be desirable to pump the entire flow to the WTP through the storage basin. Projected flows for a population of 12,000 during the runoff
period are 3.68 cfs during April, 4.30 cfs during May and 4.95 cfs during June. A maximum pumping rate of 3.0 mgd (4.64 cfs) was selected as providing sufficient capacity for most potential future needs. This increased capacity would enable delivering the entire 700 acre-feet of storage water within a 76 day period. A total of three variable-speed pumps with a combined capacity of up to 3.0 mgd would be provided to meet a potentially wide range of both current and future water delivery needs with substantial operational flexibility and appropriate redundancy. Current needs can be met with only one pump running, and no more than two pumps are required to supply the 700 acre-feet of storage at the reduced flows necessary if most or all of the full 243 day period from October 1 to June 1 is used.

7.0 Conceptual Designs and Cost Estimates

The proposed design includes a reservoir with a nominal storage capacity of 750 acre-feet, a pumping station with a maximum capacity of 3.0 mgd (4.64 cfs) to deliver water to the reservoir, and an outlet works with a normal capacity of 4.0 mgd (6.2 cfs) to release water from the reservoir to the BVJPB water treatment plant (WTP). The reservoir would be constructed in the location of an existing gravel pit (the Basin A site) which is nearing the end of its economic life. The reservoir would be provided with slope protection from riprap derived locally by processing terrace deposits, with a geocomposite liner covering both the interior embankment slope and the basin floor, and with a toe drain to collect potential seepage. The basin would be provided with an outlet works having capacity to meet emergency evacuation requirements consistent with the dam safety hazard rating anticipated for the dam. It is believed that the dam would be rated as a high hazard dam (i.e., Class I – loss of human life expected in the event of dam failure). An overflow spillway would also be provided to prevent inadvertent overtopping of the embankment. Sheets 7.1 through 7.4 provide drawings illustrating the design concepts.

Material from within the limits of the existing gravel pit is proposed for use in constructing embankments, filters, drains and erosion protection. To the extent that the existing material (as inventoried based on the conditions at the time of the field survey for this study) has been used in future gravel mining operations, it will be necessary to replace that material by hauling from an offsite source. For purposes of budgeting, cost estimates were prepared for both alternatives of utilizing “onsite borrow” and for using “offsite borrow”. Offsite borrow materials are assumed to come from the location of the Basin B site as identified in Section 1.0 and Appendix A (see presentation materials for project meeting on August 8, 2007).

7.1 Conceptual Designs

7.1.1 Reservoir

The proposed reservoir is illustrated on Sheet 7.1. It provides a storage capacity of 744 acre-feet at a maximum pool elevation of 7066.0 feet. The top of embankment is set at elevation 7071 feet to provide a normal freeboard of five feet. Surface drainage is to be routed away from the reservoir so the only flow entering the reservoir is that pumped into the basin from the East Fork of Smiths Fork River and direct precipitation. The reservoir floor slopes from the south at approximately elevation 7056 feet to
the outlet at the north end of the basin at elevation 7029 feet. At maximum pool, water depths would vary from 10 feet at the south end of the reservoir to 37 feet at the north end. An elevation-capacity curve is provided in Figure 7.1-1. During a normal to dry year (assuming no drawdown during high turbidity spring runoff but with releases for increased future municipal demands) it is anticipated that the pool level would be lowered by only about 10 to 15 feet leaving all but a small portion of the southern end of the reservoir covered with water. This anticipated normal range of operating pool level will minimize the exposure of the liner/cover system on the reservoir floor.

Criteria considered in the layout of the reservoir included, but were not necessarily limited to the following:

- Provide approximately 750 acre-feet at maximum pool
- Provide five feet of freeboard at maximum pool
- Limit the reservoir encroachment to the property presently owned by Rees, Blaine J. or Rees, Blaine J. dba Rees Enterprises which constitutes the gravel pit operations at the time of the survey – avoid other properties with existing usages (at the time of this report preparation, consideration was being given by owners Rinker, Stanley B. and Wendy J. to relocate their existing trucking company operations from property at the east-central portion of the site area – if this relocation is finalized it may be advisable and beneficial to the project to incorporate much of that property within the reservoir basin)
- Provide an approximate balance of cut and fill for materials onsite at the time of the survey
- Leave the overburden silt materials in-place in the southeast corner of the reservoir (unsuitable as fill material in embankment)
- Limit excavation of otherwise suitable overburden and underlying weathered bedrock beneath most of the embankment footprint to minimize foundation grading cost
- Limit excavation of weathered bedrock within the area of the reservoir floor to two feet maximum (deeper excavation may result in rock more difficult and costly to excavate and process for placement in the embankment)
- Provide a space (approximately 30 ft wide) around the outside perimeter of the reservoir for access to the toe of slope for maintenance, drainage, etc.

7.1.2 Hydraulic Structures

Pumping Station/Inlet Pipeline. The basis of design of the pumping station and inlet pipeline is described in Section 6.0. The pumping station is illustrated on Sheet 7.2. The system capacity would range from a low of approximately 300 gpm up to a peak pumping capacity of 2085 gpm. It would include three variable speed pumps each rated at 694 gpm at 75 feet TDH, with 20 hp, variable speed drives, flow measurement and a SCADA system to provide feedback to the WTP enabling flow monitoring and setting pumping rates/operations. An above grade package pumping station has
been assumed at this level of planning (see manufacturer’s literature in Appendix F).

The pumps would deliver water from the pumping station located near the existing 14-inch pipeline alongside the Smiths Fork River to an outlet structure located at the southwest corner of the reservoir.

This alternative would also include improvements to the existing access road where practicable within the constraints of existing easements and/or additional ROW acquisition, and the adjacent river corridor/wetlands.

**Outlet Works/Delivery Pipeline.** The outlet works would be located at the north end of the reservoir and would be capable of draining all but the lowest foot or two of the reservoir (leaving a small dead pool to prevent sediment from burying the low-level outlet gate). As shown on Sheet 7.3, one outlet gate would be set at an invert elevation of 7030 feet and the other at an elevation of 7038.5 feet.

The upper gate would enable drawing the best water quality (largely sediment free) from the reservoir for treatment at the WTP. Accordingly, the upper gate would normally be used to regulate flow discharge from the reservoir. A pressure transducer would be installed within the reservoir to enable monitoring reservoir level remotely. A magnetic flow meter installed in a meter vault downstream from the outlet gate would provide feedback to the WTP for use in regulation of the sluice gate. Normally, drawdown for municipal usage would leave a minimum of 10 to 15 feet of water depth over the upper gate. Note that the reservoir would contain only approximately 150 acre-feet of water at a pool level 10 feet above the upper gate, and 20 acre-feet at the top of the upper gate. Adequate head exists to deliver water to the WTP from within the full range of reservoir operating levels. The new basin outlet pipeline would be installed from the reservoir to the north and then west where it would connect to the existing 14-inch diameter asbestos cement (AC) pipe that connects to the WTP.

Sluice gates would be provided with hydraulic operators with a hydraulic power unit located at the top of the embankment. A trash rack would be provided upstream of the gates as part of the outlet structure to enable removal of debris ahead of the entrances to the outlet piping system.

The lower sluice gate would be provided to enable draining the reservoir, including during emergency evacuation conditions. To facilitate draining the reservoir in emergency conditions and/or periodic flushing of the area around the vicinity of the low-level gate a valved pipeline would be extended from the connection to the existing 14-inch diameter AC pipe to discharge to the Smiths Fork River.

**Spillway.** A spillway would be provided at the southeast corner of the reservoir at a location where the top of embankment (elevation 7071 feet) approximately matches the existing ground to the south of the site. The spillway would function as an emergency spillway for the very unlikely event that either:
The pumps stuck in the “on” position (assuming control failure and an extended period of unattended operation) for a long enough duration to cause the reservoir to raise sufficiently to endanger the embankment, or Direct precipitation from a major/extreme event (i.e., Probable Maximum Precipitation (PMP)) coupled with higher than normal operating pool level causing the reservoir level to rise excessively.

The spillway would be a short section of embankment with a lowered driving surface that drained south to a ditch cut to the drainage swale east of the reservoir. To prevent erosion, the driving surface at the spillway would be armored with rock riprap overlain with road base (to form a smooth driving surface) and the ditch would be protected with riprap. PMP is defined as “theoretically, the greatest depth of precipitation for a given duration that is physically possible over a given size storm area at a particular geographical location at a certain time of the year”. The PMP for the Mountain View area is estimated at 20 inches based on HMR 49 (NOAA, 1984) for the month of August. The spillway crest would be set three feet above the normal high water level with the intent of storing the entire PMP prior to discharge over time via the outlet works and/or still providing adequate freeboard against wave run-up during normal operation. Note that it is important that the swale along the east side of the reservoir to which the emergency spillway flows would drain be kept open to prevent runoff from its contributing drainage area from entering the reservoir via the emergency spillway.

### 7.1.3 Embankment and Foundation

The design of the embankment is presented in Sheets 7.1 through 7.4. The embankment section is a homogenous design, with an upstream liner and a seepage filtration/collection trench in the downstream toe. A variety of factors combine to provide challenging conditions to satisfy the design constraints, including limited space, limited borrow availability and characteristics, and unfavorable topography and seepage conditions, as well as the need to minimize cost to the degree consistent with functionality and safety. These design conditions and their solutions are presented in more detail below.

#### Materials Availability and Characteristics.

Several types of local borrow are available for construction of the embankments, albeit in potentially limited quantities relative to what is necessary to construct earthen embankments. Available borrow consists of the following materials:

- **Sand and gravel terrace deposits** located primarily within the reservoir footprint which are currently being mined, processed and sold. These materials may or may not exist in the future at the site, except in the form of reject material. For this reason, two cases, “onsite borrow” and “offsite borrow” (Basin B) have been analyzed in the embankment design as described herein. Sand and gravel materials from either borrow source are presumed to be similar in nature and material properties have been inferred from site exploration data acquired for this study and previous studies at both the Basin A and Basin B sites.

- **Residual soils and weathered bedrock**, consisting of sand, silt, and bedrock fragments derived from sandstone and siltstone bedrock units.
described in Section 4.0 and Appendix B. As described in Section 4.0, the residual silt and its friable parent rock unit are considered unsuitable for use as embankment fill. These deposits are left in place within the reservoir footprint and excluded as potential borrow.

Processing of the sand and gravel deposits is necessary in order to provide key materials for construction of the embankments. Approximately 120,000 cubic yards of the sand and gravel material would be processed to generate the following materials:

- Sufficiently large riprap for erosion protection of the upstream slope
- Riprap filter/small riprap
- Gravel drain
- Coarse liner cover
- Sand filter/medium liner cover

Several alternatives to processing onsite materials were examined, for example: 1) the option of utilizing a soil cement facing in place of riprap, and 2) more extensive foundation preparation and/or use of a fine-grained embankment core to reduce the need for filters, drains and seepage collection systems. Analysis of these options and other variations led to the conclusion that their estimated costs were in excess of the cost of the processing option.

Material gradations and designs have been optimized to make best use of limited amounts of onsite materials as well as to minimize reject (waste) material. A major caveat of these analyses is that the natural gradation of the sand and gravel materials, particularly at the coarse end, utilized to derive riprap and riprap filters is as assumed based on the information available for this study. Final design investigations and analyses should verify the gradations of these materials from the final borrow source(s).

**General Foundation Preparation/Treatment.** Due to the length and size of the necessary embankment, the various embankment reaches have been designed to minimize costs associated with foundation treatment. The basin floor liner described in the next section eliminates most of the potential seepage from the reservoir. Filters and drains effectively control any unavoidable remaining seepage. These two design elements will provide effective seepage/piping (internal erosion) control without the need for a typical zoned earthfill dam clay core/cutoff trench. Foundation materials are stripped of any unsuitable debris/material, the surface compacted and left in place to minimize costs. As discussed later in this section, adequate stability can be achieved without removal of these overburden materials.

**Seepage Control.** Seepage control for the embankment and foundation is designed to achieve multiple goals, including:

- Avoid potential contamination from groundwater sources (terrace deposits to east/south);
- Minimize reservoir losses for economic/operational reasons; and
- Provide for dam safety (minimize pore pressures for enhanced stability, and minimize potential for piping failure).
The individual embankment and reservoir design components selected to achieve the above goals are described below.

Reservoir Floor Liner. The reservoir has been designed to achieve a seepage loss of less than two feet per year, which equates to approximately 80 acre-feet per year or eleven (11) percent of annual stored water. When combined with an estimated 2.5 feet per year of evaporation loss, any seepage loss in excess of two (2) feet would become highly significant in terms of wet water available to supply to the WTP in times of need. This equates to a total estimated seepage rate of 1800 gallons per acre per day or 1.25 gallons per minute per acre (i.e., 57 gpm for the entire basin floor). Assuming that the foundation below the weathered near-surface zone has homogeneous vertical permeability (to significant depths), the vertical seepage gradient will approach one, and the maximum allowable permeability of the foundation would be approximately $2 \times 10^{-6}$ cm/sec. Based on the available surficial and shallow subsurface information collected as part of this study as described in Section 4.0, Appendix B and previous studies, it is unlikely that the foundation will provide this low permeability due to the known presence of at least some degree of fracturing. As a result, a reservoir floor liner is assumed necessary to achieve the target maximum seepage rate.

The selected liner material is a geocomposite liner (GCL - bentonite clay and geomembrane) that provides the necessary seepage reduction as well as additional protection against potential liner damage whereby the swelling bentonite clay tends to seal punctures in the geomembrane. For purposes of design and costing, CETCO Bentomat CL liner has been assumed (see Figure 7.1-2) and manufacturer’s literature has been included in Appendix F. CETCO reports that the estimated flux through an undamaged CL liner, including seams, is as low as 38.5 gallons per acre per day at heads up to 75 feet, which is significantly less than required. However, research indicates that competing geomembrane liners can experience substantial increases in leakage rates under real-world conditions due to pinhole defects, defective seams, damage during installation and other factors. While insufficient research has been conducted on the self-healing capability of GCLs, the design has conservatively assumed that the selected GCL will experience a number of defects and ignores any self-healing properties of the bentonite clay. It is estimated that this liner can sustain up to 460 equally spaced damages, or 10 defects per acre and reservoir losses would still be limited to approximately 1.5 feet per year.

Embankment Liner. A similar GCL liner (CETCO Bentomat CLT) is utilized to line the embankment upstream (interior) slopes to reduce seepage through the embankment (i.e., serve as the waterstop in the absence of a clay core). The liner has similar or better seepage characteristics as the CL product utilized in the reservoir bottom, but utilizes a roughened surface to provide the necessary friction angle to adhere to the slope (see Appendix F for manufacturer’s literature). Seepage reduction in the embankment is necessary for several reasons. First, no source of low permeability material suitable for constructing an embankment core (e.g., clay) has been identified within an economic haul distance. Most of the onsite material available for use as embankment fill has the potential to be moderately to highly permeable. This would likely result in more significant seepage through the
embankment requiring enhanced filter protection at increased cost to mitigate the potential risk of piping failure of the embankment. In addition, greater seepage collection capacity including a pumpback system would be necessary to avoid excess loss of stored water. Lining the slopes is intended to significantly reduce this seepage to tolerable levels.

Filter, Drains and Seepage Collection Pipes. Although the reservoir and embankment slope liners are expected to significantly reduce reservoir seepage, there remains a potential that damage to the liner in localized areas could result in reaches where seepage is significantly increased through the embankment and foundation. The toe of the embankment features a filter/drain zone to collect, filter and route this seepage to a collection pipe that captures the bulk of the seepage and drains the downstream toes of the east and west sides of the reservoir embankment towards the north where the collected seepage has the potential to be routed to beneficial use or pumped back to storage. The toe drain pipe is designed to be accessible for cleanout and replacement if necessary. The design also features a conventional granular embankment toe drain outlet “backup” to eliminate the dependence on the pipe functionality as the only seepage collection component potentially critical to dam safety.

Seepage rates are expected to be low and groundwater quality potentially impacted as described below such that collecting this seepage for beneficial use is expected to be uneconomic. In the event that seepage could be collected economically, it is recommended that several years of operational experience with actual seepage flow rates be accumulated prior to constructing any additional infrastructure to utilize this seepage.

Seepage Interceptor Systems. The embankment design also features a collection system for potential incoming groundwater seepage to the reservoir from the gravel terraces to the south and southeast. Along the south side of the reservoir, the system is necessarily buried in the embankment as illustrated in Sheets 7.1 and 7.4. Along the southeastern side, the interceptor transitions to a trench drain (Sheets 7.1 and 7.4) that eventually emerges to the surface in a pipe. The need to intercept this seepage is two-fold. First, seepage in significant quantity and sufficient head could destabilize or lift the reservoir/embankment liner when the reservoir is at low pool levels. While such a condition is not a dam safety concern, it could result in significant effort and/or costs to repair any resulting tears in the liner. Second, there is a potential for contamination (e.g., fecal choliform) from groundwater seepage into the reservoir.

Slope Stability. Slope stability analyses were conducted utilizing the limit equilibrium program XSTABL (Version 5.2 developed by Interactive Design Inc., 1996) which is based on the original STABL program developed at Purdue University. XSTABL is a full-featured slope stability program to perform two-dimensional limit equilibrium analysis and calculate factor of safety using well-recognized computational methods. XSTABL has routines to evaluate stability for both circular failure (via the Bishop method) and block failure (via the simplified Janbu method). The program uses a general equilibrium method satisfying both moment and force equilibrium to calculate the factor of safety for failure surfaces. In addition, specialized
slope stability computations were performed for the reservoir liner on the upstream slope using design procedures recommended by a potential liner supplier, CETCO, in Technical Report 319, revised 12/00.

Input was developed to conservatively represent the known and estimated conditions at the site, including slope geometry (ground surface profile and subsurface soil unit boundaries), soil properties (unit weight, shear strength), and seepage conditions. The analyses assumed fully drained and isotropic stress conditions. The simplified Janbu method for circular potential failure surfaces was used in all analyses. The model input parameters for each case analyzed and described below are provided in the program input/output files in the Project Notebook.

As discussed in Section 4.0, foundation materials consist of a thin layer of sands and gravels in a medium dense state overlying dense residual soils derived from siltstone and sandstone, as well as weathered bedrock. While bedrock materials are included in the stability analyses, they are estimated to have strengths high enough such that they are not critical. A conservatively low value of effective friction angle of 30 degrees and no cohesion has been assumed for the foundation materials in the critical section. While residual siltstone materials may have lower friction angles, these materials are not present near the critical section or where the embankment section is high. The fill materials are estimated to be stronger than the foundation materials due to their typically coarser and well-graded gradation and because they will be compacted during placement. A conservative value of friction angle of 35 degrees has been assumed for these materials.

For stability analyses of the embankment, steady seepage and pseudo-static cases were analyzed. A probable seepage line has been estimated for the embankment using flownets. Materials utilized in embankment construction are believed to be sufficiently free-draining so that end-of-construction analyses are not necessary at this level of study. Rapid-drawdown was not analyzed at this level of study due to the shallow upstream slope, the presence of the upstream liner, and the relatively free-draining materials used in embankment construction, but rapid drawdown stability should be verified in final design. Liquefiable materials are not believed to be present at the site or are assumed to be present in small quantities that would be remediated or removed during construction, so that post-cyclic stability (i.e., liquefaction) analyses have not been performed. At this level of study, given the relatively high freeboard and characteristics of the embankment (relatively low height, relatively high friction angles, low internal phreatic surface, etc.), seismic deformation is not expected to be a controlling factor in design. However, given the recently increased probabilistic seismic ground motions applicable to the site area (see Section 4.2.3), a simplified deformation analysis should be performed in final design when more refined materials properties are available.

The GCL layer is the critical material in terms of shear strength for the upstream slope. CETCO Bentomat CLT has been chosen as the representative liner material for design of the sideslopes. GCLs can exhibit strong differences between peak and post-peak (residual) internal friction angles. Many GCLs are manufactured to provide internal friction angles as
high as 30 to 60 degrees, which is substantially above the 6 to 8 degree friction angle of the contained bentonite clay. Laboratory research (Trauger, 1996) indicates that the needlepunched reinforcement can sustain long-term shear loads. In addition to the laboratory research referenced above, field-scale testing (Koerner, 1996) and actual project experience have yielded similar conclusions. In addition, Bentomat CLT has a 20 mil textured liner which should be resistant to long term creep and strength degradation. The lower textured liner as well as the upper fabric surface of Bentomat CLT provides reported high peak friction angles against sand layers of 38 to 40 degrees, with little reduction due to strain. The manufacturer reports that additional stability can be gained by mounting the liner “upside-down.” Stability of the sloped liner depends on slope length and thickness of cover, among other factors, and analyses of the worst-case section indicate 26- and 17.5-degree friction angles are required to achieve factors of safety of 1.5 and 1.0, respectively. It is recommended that in final design, the ability of the liner to achieve a long-term friction angle within this range be verified.

Results of the embankment stability analyses are presented in Figures 7.1-3 and 7.1-4 for the steady seepage and pseudo-static cases, respectively. The results of the analyses indicate that:

- The design meets minimum factor of safety criteria of 1.5 for the steady seepage case, with a factor of safety of 1.73 for the critical (maximum) section; and
- The design meets minimum factor of safety criteria of 1.1 for the pseudo-static case, with a factor of safety of 1.34 for the critical (maximum) section.

**Instrumentation.** Design of specific instrumentation to monitor the embankments is appropriate for Level III and was not included at this level of study. However, cost estimates described in Section 7.2 include both capital and operations and maintenance costs for monitoring the following instrumentation required by the Wyoming Safety of Dams rules and regulations for a Class I or II dam:

- Dam deformation monuments
- Piezometers
- Reservoir stage (pool level) measurement
- Flow measurement weirs for collected seepage from the toe drains

**Erosion Protection.** In order to protect the embankment from potentially erosive wave action, the upstream slope will include a layer of properly graded riprap and bedding. The size and gradation of rock was determined using the method developed by the U.S. Department of Agriculture Soil Conservation Service, summarized in Technical Release No. 69 – “Riprap for Slope Protection Against Wave Action” (USDA/SCS, 1983).

This method is used to determine the basic characteristics of the riprap aggregate (size, shape, gradation, etc.) by first providing a means to calculate the severity of wave action that must be protected against. This severity can be measured by estimating the maximum wave height that is likely to occur.
within the reservoir. The height is assumed to be a factor of the maximum basic wind velocity and the effective fetch on the reservoir measured from the point at which the riprap characteristics are to be determined. The wind velocity was found using available climatologic data for the 50-year recurrence interval. The effective fetch is the estimated distance the wave would travel before reaching the embankment. In this case, the reservoir is orientated such that the effective fetch is longer in the north-south direction than it is in the east-west direction.

After the wind velocity and effective fetch are determined, a series of calculations yields a riprap gradation based around the $D_{50}$ rock size. The thickness of the riprap layer is intended to be at least twice the size of the $D_{50}$ rock, and the top elevation of the riprap is to account for the maximum wave run-up, which is a factor of the maximum wave height.

In the current design, it was determined that two different sizes of riprap would adequately protect the embankment, and would most efficiently use the available coarse (i.e., oversize) fraction of the onsite terrace materials. A smaller sized riprap can be used for certain stretches along the east and west sides of the embankment where the effective fetch is shorter, and thus the maximum wave height is less. Also, the smaller riprap can be applied near the bottom of the embankment where waves would be less significant due to smaller size of the reservoir water surface when drawn down to that level. Therefore, the combination of an approximately 9-inch $D_{50}$ and a 4-inch $D_{50}$ are used around the embankment up to an elevation of 7068.5, which is 2.5 feet above the normal high water level. Where necessary, the 9-inch $D_{50}$ riprap will be placed at a 1.5 foot thickness, with a 6-inch thick riprap filter layer between the riprap and the liner cushion (the smaller Type G riprap is designed to meet filter criteria for the larger riprap). In the areas that require less protection, the 4-inch $D_{50}$ riprap will be placed at 8-inch thickness with no filter layer underneath. A total of 17,000 cy of the larger riprap is required, and 10,000 cy of the smaller riprap/filter.

### 7.1.4 Site Drainage

The crest of the dam (i.e., the roadway surface) will be sloped to drain inward to the reservoir. External, off site, drainage from adjacent properties will be directed around the reservoir. Drainage from the south will be primarily directed toward the existing drainage swale located along the east side of the reservoir. To facilitate this function a diversion berm would be constructed along the south end of the reservoir (where a topsoil stockpile is presently located), and the drainage swale along the east of the reservoir would be graded as necessary to provide the required capacity and control of the runoff from the upgradient drainage area.

### 7.1.5 Water Truck Fill Station

At the request of the BVJPB a conceptual design was developed for a water truck fill station located near the existing WTP to allow rapid filling of water trucks with raw water. The conceptual layout of the fill station is shown on Sheet 7.2. The fill station would be designed to provide a fill rate of approximately 300-400 gpm. As shown on Figure 7.2, the fill station components include: a 14x14x6-inch tee on the existing 14-inch AC pipeline entering the WTP; buried 6-inch ductile iron pipe (DIP) to route raw water...
flow to a convenient location for water truck access near the WTP; a vertical 4-inch steel pipe riser extending above ground with a supported horizontal arm and downspout section; a 2-inch PVC pipe drain to daylight; and a total of four (4) appropriately-sized valves to control filling and system drainage.

7.2 Cost Estimates

Cost estimates are summarized in this section for the Basin A site alternative, analyzed using two borrow material scenarios. All costs are developed in the WWDC format, and include land and mineral acquisition, legal fees, construction, permitting and mitigation, mobilization, etc. Cost estimates also include 10 percent for construction engineering and 15 percent for contingencies per WWDC guidelines. Permitting cost estimates consider anticipated permits, easements, and clearances necessary to construct the project. Estimates are also provided for anticipated annual operations, maintenance and replacement (OM&R) costs.

7.2.1 Capital Costs

Capital costs have been estimated for constructing the Basin A site dam and reservoir under two scenarios:

- **Onsite Borrow** - This scenario presumes that no gravel or other materials are removed from the Basin A site relative to the topography surveyed as part of this project and illustrated on Sheet 7.1.

- **Offsite Borrow** - This scenario presumes that all terrace sand and gravel within the proposed dam and reservoir footprint has been mined and removed, except for an average one-foot thick layer in areas of current deposits. Due to the assumed removal, an additional 181,000 cubic yards of sand and gravel would be acquired and processed from an assumed borrow area in the vicinity of the Basin B site to provide a materials balance.

These two scenarios provide an estimate of the contingency necessary to account for ongoing gravel mining operations at Basin A, which from a cost standpoint is one of the biggest unknowns. Key assumptions regarding material properties, foundation conditions, flow rates and other factors have been discussed previously in Section 7.1.

The basis of the construction costs is take-off quantity times estimated 2008 unit prices, with lump sums estimated for certain items. Quantities are estimated from takeoffs of the design presented in Sheets 7.1 to 7.4 and unit prices and/or lump sum prices are derived from industry standard references such as Means Cost Data, current and past work on similar projects, and engineering judgment. The precision of these estimates is judged adequate and appropriate for budgeting for Level III. It is understood that the estimates will be refined during final design when currently unavoidable unknowns such as the final quantity and characteristics of the borrow remaining at the Basin A site at the start of construction become known in greater detail.

A summary of the estimated capital costs for both scenarios is presented in Table 7.2-1. For convenience, total project costs for both scenarios have been escalated to a presumed earliest possible construction date of 2011.
assuming a four (4) percent inflation rate. Table 7.2-2 provides a detailed breakdown of key cost components of the estimate in Table 7.2-1.

7.2.2 Operations, Maintenance and Replacement Costs

Operations, maintenance and replacement (OM&R) costs have been broken out separately for the embankment and pump station/inlet/outlet facilities and annualized to 2008 dollars. In annualizing costs, it is assumed that water service fees will be escalated annually with inflation and reserved in interest-bearing funds until needed for specific OM&R.

Embankment. Annual OM&R costs for the embankment are based on previous experience with high hazard dams. The Bridger Valley Reservoir Project will require monitoring of dam instrumentation (settlement monitors, piezometers, toe drains, etc.) by a technician, as well as periodic inspections by a qualified engineer experienced in dam design and dam safety; maintenance to control adverse vegetation growth and burrowing animals; and maintenance and occasional upgrades and replacement of monitoring instrumentation, mechanical equipment (valves, gates, etc.), liner patching and erosion protection. Embankment OM&R costs include the following assumptions:

- Routine Inspection and monitoring is conducted by BVJPB WTP personnel and reviewed periodically by a qualified Professional Engineer; periodic complete dam safety inspection by a Professional Engineer specializing in dams and appurtenances
- Costs for addition of pumpback or routing of intercepted seepage collected in the embankment toe drain outlet (Sheet 7.1) to the WTP have not been included. It is assumed that the collected drainage will be of insufficient quantity to justify the cost of pump back to the reservoir or providing a tap to the treatment plant pipeline.

Annual OM&R costs for embankment-specific items are summarized below:

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine Inspection</td>
<td>$8,200</td>
</tr>
<tr>
<td>Monitoring</td>
<td>$2,200</td>
</tr>
<tr>
<td>Dam Safety Inspection</td>
<td>$2,000</td>
</tr>
<tr>
<td>Maintenance</td>
<td>$8,000</td>
</tr>
<tr>
<td><strong>Total Annual OM&amp;R</strong></td>
<td><strong>$20,400</strong></td>
</tr>
</tbody>
</table>

Pumping Station/Inlet/Outlet Facilities. OM&R costs for the pumping station and other inlet and outlet piping and structures were estimated based on the following assumptions:

- Pumping the entire 700 acre-feet of storage from Stateline Reservoir into the new storage reservoir over a four-month period
- The pumping station would be idle for the remainder of the year
- The Bridger Valley Electric Association rate structure for Large Power – 350 KVA or less was used to calculate power charges
- Power costs assume “customer”, “demand” and “energy” charges for four months of the year and only “customer” charges for the remaining twelve months; the power cost calculated equates to $0.07 per kwh
A total of 68 hours per year at a labor rate of $30 per hour was assumed; inspection and maintenance of the pumping station and associated facilities is assumed to require an average of 15 hours per month for the four-month operational period; inspections during the remainder of the year are assumed at one hour per month.

Replacement of mechanical and electrical equipment after 20 years is assumed.

Based on the above assumptions, annual pumping station/inlet/outlet OM&R is estimated as follows:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>$4000</td>
</tr>
<tr>
<td>Labor</td>
<td>$2000</td>
</tr>
<tr>
<td>Replacement</td>
<td>$4000</td>
</tr>
<tr>
<td>Total Annual OM&amp;R</td>
<td>$10,000</td>
</tr>
</tbody>
</table>

Savings in operations at the WTP were not quantified or considered in this evaluation. It is understood that the WTP would expect a reduction in chemical and solids handling costs as a result of avoiding having to treat high turbidity water during spring runoff months. If quantified, those reductions would in part offset the costs of the pumping station and associated facilities.

8.0 Economic Evaluation of Proposed Designs

This section of the report provides an economic evaluation of the proposed project design including estimated cost impacts to the end users. Capital and operation, maintenance and replacement (OM&R) cost estimates are provided in Section 7.2. Potential funding sources are presented and characterized in Section 12.0. Although alternative sources for funding may ultimately prove to be available, the current uncertainties regarding project eligibility and/or potential grant amounts for those sources lead to the assumption in this analysis that all funding would come from the WWDC New Development Program.

End costs calculated assuming grant and loan financing from WWDC are the basis of evaluations of the impacts to end users (i.e., BVJPB water customers). As discussed further in Section 12.0, two funding scenarios are evaluated based on grant/loan ratios of 67/33 percent and 75/25 percent. Both scenarios include a thirty-year loan term at 4.0 percent interest and an option of a fifty-year loan at 4.0 percent for repayment of project costs not included in the assumed grants of 67 percent and 75 percent. Post-construction costs to the BVJPB include both the annualized debt share for the project costs plus annual OM&R costs.

The analysis considered the two loan/grant mix funding scenarios and the two potential earthfill borrow source alternatives described in Section 7.0, one assuming borrow may be obtained onsite and the other assuming offsite borrow, resolution of which could depend on project timing and/or negotiations with landowners. Construction cost estimates are inflated to a projected 2011 cost basis. This information is provided in Table 8.0-1. OM&R costs are estimated to total $30,400 per year ($10,000 pumping/inlet/outlet and $20,400 embankment) as presented in Section 7.2.
Table 8.0-2 provides a tabulation of estimated sponsor cost, and annualized debt service cost share assuming both a 33 percent sponsor cost and a 25 percent sponsor cost (67 percent and 75 percent grants, respectively). Annualized debt share is based on a loan at 4.0 percent interest and loan periods of 30 and 50 years. For the above assumptions, the sponsor share of capital cost is estimated to range from a low of $2,182,000 for onsite borrow at a 75 percent grant to a high of $3,266,000 for offsite borrow at a 67 percent grant. Using the above range in capital share, the estimated annualized sponsor’s debt share would range from a low of $101,600 for a fifty-year loan (onsite borrow, 75 percent grant) to a high of $188,900 for a thirty-year loan (offsite borrow, 67% grant). The estimated total annual sponsor cost including OM&R for the same conditions would range from $132,000 to $219,300.

Potential sources of local revenue to repay the loan include the following:

- Service fees (i.e., water rates)
- Tap fees
- Plant investment fees (PIF)
- Capital facilities tax (sales tax)

At this time, and for simplification, only an increase in monthly service fee is assumed in the ability to pay analysis. Also, for simplification, and for providing a conservative estimate, potential increases in revenue due to growth are not included in the base case. For comparison, an estimate is also provided of the average monthly service fee increase assuming a growth rate of 1.5 percent per year. There are currently estimated to be approximately 1800 connections to the system. This estimated number of users is based on 518 direct bill users in the BVJPB service area, 720 users in the Town of Lyman, 504 users in the Town of Mountain View, and 50 users as part of Lower Bench per LaDonna Bugas/BVJPB (Personal communication, June 10, 2008). See Appendix G for current rate structure and related information provided by BVJPB.

Using the assumptions stated above, Table 8.0-3 illustrates the potential range of service fee increases to the individual customers. For the existing 1800 customers and assuming no growth, the calculated range of increase is from a low of $6.11 per month (onsite borrow, 50-year loan, 75 percent grant) to a high of $10.15 per month (offsite borrow, 30-year loan, 67 percent grant).

The required monthly service fee would decrease if/as growth occurs. For illustration, at an assumed growth rate of 1.5 percent per year, the corresponding monthly rate increases would be $4.39 and $7.98. In considering revenue from additional growth, it should be noted that an initial base fee increase may have to be considered using the increase calculated from the current 1800 taps. Otherwise, an additional source of revenue may be necessary to compensate for revenue deficiency during the initial years until growth is adequate to provide revenue meeting the amortization schedule.
9.0  Develop Multiple Use Benefits for the Selected Reservoir Site

A variety of potential multiple use benefits for the Bridger Valley Reservoir Project were identified during the early to mid stages of the project, including through discussions with BVJPB members, other stakeholders, and WWDO staff. These potential benefits were developed and evaluated at the conceptual level, compiled, and presented at a project meeting with BVJPB in Mountain View on December 12, 2007. The potential benefits considered are summarized as follows:

- Day Use Area – picnic/restroom area
- Walking Trail(s) – along embankment crest and outside toe
- Scenic Overlook – view of Smiths Fork/Blacks Fork Valley
- Non-motorized Boating – canoe, rowboat, raft
- Swimming – south (shallow end)
- Fishing/Fishery – no connection to river; handicap access
- Constructed Wetlands/Natural Wetlands Fringe
- Tree/Shrub Plantings – avoid roots in embankment
- Waterfowl Enhancement

During discussion of this topic at the December 12, 2007 project meeting, concerns were expressed by some BVJPB members regarding multiple uses and associated facilities. These concerns included cost (capital and OM&R), potential liabilities and costs associated with public access, and expansion of BVJPB’s responsibilities beyond providing treated water to their customers.

The main overall benefit to including multiple uses in the project expressed at the meeting was the possibility of receiving a higher grant-to-loan ratio under legislatively authorized Wyoming Water Development Commission (WWDC) funding. Based on further review and discussions with WWDO, it appeared that potential multiple use options which could enable securing higher grant-to-loan funding for the currently proposed 750 acre-foot reservoir/basin were limited, if any. The reduced size of the basin (compared to the capacity envisioned at the Jack Hollow site) and the need to dedicate all of the stored water to its municipal purposes (as opposed to reserving/dedicating a portion to one or more multiple uses) eliminate options such as a fishery that might have involved other parties. An additional consideration was that current adjacent properties including the trucking operation (Rinker property) and salvage yard (Fausett property) may be incompatible with certain potential beneficial uses.

At their February 13, 2008 Board meeting, the BVJPB requested that multiple purposes for the Basin A reservoir not be further considered. In accordance with the BVJPB’s request and as directed in a memorandum dated February 27, 2008 from WWDO Project Manager Steve Muth (WWDO, 2008), facilities to provide or support potential multiple use project benefits were not included in the design or cost estimate described previously in Section 7.0.
10.0 Rights-of-Way

Rights-of-way, easements, temporary use permits, and/or land purchases necessary to construct and operate the Bridger Valley Reservoir Project were identified and generally characterized as part of this study. In accordance with direction received at the scoping meeting and subsequent project meetings, BVJPB was to take the lead role in contacting private land owners regarding the potential interest of the Board in purchasing land and/or acquiring easements for the project, and estimating land purchase and easement costs for inclusion in the total project cost presented in Section 7.2.

10.1 Reservoir Site

**Land Purchase.** Nearly all of the land required to construct and operate the proposed Bridger Valley Reservoir at the Basin A site is currently owned by Blaine J. Rees (or Blaine J. Rees dba Rees Enterprises). The Rees property is leased by Kevin Kondus. The southern portion of the site is currently operated as a commercial sand and gravel pit; the northern portion is either reclaimed or in the process of being reclaimed. The land at the proposed pumping station site (approximately 0.15 acres) is owned by the Swearengin Trust. The total land purchase required is approximately 73 acres.

The terms and conditions of a land purchase would be negotiated between the property owner at the time of purchase and BVJPB. Several special considerations in a land purchase negotiation include, but are not limited to the following:

- Requirement that the seller pay for an environmental audit of the site by an independent qualified consultant agreeable to both seller and buyer
- Agreement that the seller retains responsibility for any existing but undetected environmental liabilities at the site to the extent allowed by law
- Seller to compensate buyer at time of closing for any remaining reclamation liability with Wyoming Department of Environmental Quality (WDEQ) through the existing mining permit

As discussed previously in Section 7.0, the future disposition of the currently remaining sand and gravel resources on the property of interest is unknown. Given the potential significant cost and project schedule impacts of having to borrow large quantities of embankment fill material from off-site (assumed from the Basin B site area), BVJPB may want to consider negotiation of an option with the current property owner to limit or cease altogether further extraction of sand and gravel at the site to preserve this material for future embankment construction. In concept, BVJPB would pay the current owner for the negotiated profit lost by not continuing operations until either the property has been purchased by BVJPB or the agreement has been terminated, whichever occurs first.

**Temporary Use Permit.** If the Contractor constructing the Bridger Valley Reservoir Project desires to use any portion of the approximately 100-foot wide Wyoming Department of Transportation (WYDOT) right-of-way along Highway 410 on the east side of the site, a temporary construction use permit
would be required. See Section 10.3 below under Temporary Use Permit for additional relevant discussion.

10.2 Pumping Station/Pipelines Access
Access to the proposed new pumping station, and portions of the new inlet and outlet pipelines would require modification of existing and/or negotiation of new easements with the affected private property owners and of the approximate dimensions as follow:

- Swearengin Trust – Outlet pipe, discharge pipe to river, access road to pumping station; 2.6 acres
- Landers, Gregg – Outlet pipe, connection to existing piping; 0.2 acres
- Earhart, Jeannine – Access road; 0.7 acres

The terms and conditions of these easements would be as negotiated between the parties in conformance with applicable laws.

10.3 Potential Basin B Borrow Area
Sand and Gravel, Borrow Material, and Rip-rap Rock Lease. If it is necessary to borrow and process various embankment fill materials from the Wyoming Department of Transportation (WYDOT)-owned portion of the currently-designated Basin B site as discussed previously in Section 7.0, then it would be necessary to acquire a lease pursuant to Chapter 25 – Leasing of Sand and Gravel, Borrow Material, and Rip-rap Rock of the Rules and Regulations of the Wyoming Board of Land Commissioners.

This lease would require an annual rental payment of one dollar ($1.00) per acre and royalties as follows:

- Sand and gravel - $0.60/ton or $0.90/yd$^3$
- Borrow material/common fill dirt - $0.25/yd^3$
- Rip-rap rock - $1.50/ton

A lease bond must be posted in an amount found by the Board to protect and indemnify the State of Wyoming, or a corporate surety bond in the amount of $100,000 may be allowed covering all of the lessee’s state leases.

The primary term of this type of lease is two (2) years; an extension can usually be granted if necessary. Proper care must be taken to prevent pollution of soil, surface water or groundwater, and all disturbances must be reclaimed as near as practicable to the original condition of the land prior to operations. Existing topsoil must be salvaged, protected and replaced, or a cover soil must be placed and revegetated. Existing drainages must be protected and pits or impoundments removed unless they can be converted into viable wetlands.

Temporary Use Permit. Depending on the specific amount and type of material required, however, it may be possible or preferable to avoid borrowing and processing material on WYDOT property. However, avoiding use of the existing access road on WYDOT property would require significant additional cost to design, permit and construct a new access road, and was thus not considered as an option in this study. Thus, at a minimum,
it is assumed that a Temporary Use Permit (pursuant to Chapter 14 of the above cited rules and regulations) would be required to use the existing WYDOT access road.

This permit would have a term of one (1) year if issued as a construction permit, or five (5) years if issued as a roadway permit. Permit fees are negotiated on a case-by-case basis; the minimum permit fees are as follows:

- Construction activities - $10/acre affect or $100, whichever is greater
- Roadways - $1.00/linear rod/year or $100, whichever is greater

If the existing access road is currently leased by a private lessee, then a surface impact payment must be made directly to that lessee in accordance with a schedule maintained by the Office of State Lands and Investments (OSLI).

Upon completion of use of the road, the road and any other disturbed land must be restored to a condition reasonably similar to its original condition.

**Easements.** If borrow materials are to be excavated from and processed on private property at or in the vicinity of the Basin B site, then a temporary easement/right-of-way would need to be negotiated with the owner(s) of the affected property. The terms and conditions of such an easement/right-of-way, including any royalty payments, would be as negotiated between the parties, in accordance with all applicable laws.

11.0 Permitting and Mitigation

The evaluation of permitting and potential mitigation requirements for the Bridger Valley Reservoir Project involved the following subtasks:

- Description of the proposed project/action
- Description of existing conditions at and adjacent to the site
- Identification and characterization of known or potential environmental issues
- Assessment of the applicability of NEPA and/or state environmental assessment processes to the project, and characterization of any known or potential required mitigation
- Identification and characterization of other required non-environmental permits

The proposed project and operations are described in Sections 4.0 through 7.0 and 10.0 in this report. The remainder of the above subtasks is each discussed in turn in the following subsections.

Note that rights-of-way, permits and easements related to temporary or permanent project land uses are discussed in Section 10.0.

11.1 Existing Conditions

The site is located on an older terrace surface approximately 80 feet above the younger terrace along the Smiths Fork River to the west. The slope from the dam and reservoir site to the younger terrace is inclined at approximately
2H:1V.  The original and modified existing older terrace surface slopes gently to the north at approximately 1-1.5 percent.

Historic land use at the dam and reservoir site likely included livestock grazing and/or cultivation of grass hay, and may have included operation of a small sawmill for some period of time.  Current land uses at the site are dominated by still active aggregate mining and trucking operations and a salvage yard operation of uncertain status.

No perennial or intermittent water courses traverse the site. There is a small ephemeral drainage swale along the eastern side of the site which has been locally modified by grading associated with the existing land uses (including two culverted access road crossings).  This swale gradually widens toward the north and then traverses down the slope at the north end of the site area where it merges with a wider portion of the younger terrace along the Smiths Fork River.

Much of the site area is unvegetated due to the disturbance associated with the existing land uses.  The northern approximately one-half of the aggregate pit has been minimally reclaimed with a thin cover of available growth media (silty to gravelly soil) and revegetation with grasses.  Undisturbed areas are typically characterized by sagebrush and natural grasses/forbs.

Access to private properties on the younger terrace along the Smiths Fork River below the site is via an existing unpaved road that traverses the slope from the north end of the site to and then along the younger terrace surface to a point downslope of the south end of the project site.  This road also provides access via easement to the existing BVJPB pipelines from the diversion structure to the south to the WTP to the north.

11.2 Environmental Issues

11.2.1 Overview

Potential issues considered in the environmental analysis of the Bridger Valley Reservoir Project conducted for this study included impacts to: aquatic resources; wetlands; riparian areas; threatened, endangered or sensitive species; crucial big game habitat; and cultural resources.  No significant impacts to any of these resources were identified with the exception of a minor local impact to wetlands at the proposed pumping station location.

The overall preliminary finding of no or insignificant impacts for all but wetlands was due in large part to the site setting and current and historic land uses described above in Section 11.1 in relation to the proposed project construction and operation.  Nearly all of the proposed temporary and permanent areas of disturbance at the dam and reservoir site lie within areas already disturbed to one degree or another.  Proposed inlet and outlet pipeline alignments traverse natural slopes that are predominantly vegetated with sagebrush and natural grasses.

Flows in the East Fork of the Smiths Fork River above the existing BVJPB diversion are not anticipated to change from their historic patterns with the construction and operation of the Bridger Valley Reservoir Project unless changes in the policy and practice of releases from BVJPB’s storage account.
in Stateline Reservoir were implemented by agreement of the parties to the
governing contract and associated agreements. Flows downstream of the
BVJPB’s diversion will be periodically reduced below their historic rates
during times when the new reservoir is being filled to the degree that the
flows to be stored were not diverted to the WTP in the past. Assuming that
the baseline for historic flows below the diversion is adjusted to
appropriately account for the full permitted diversions to the WTP (whether
those diversions were actually made or not), then the proposed construction
and operation of the project will have no impact on those baseline flows and
associated resources (i.e., aquatic life, wetlands, riparian corridor).

11.2.2 Wetlands

Given the proximity of portions of the existing access road, proposed
pumping station pad/turnaround area and a portion of the inlet pipeline to the
Smiths Fork River, a preliminary field survey was made of the easternmost
extent of adjacent wetlands judged likely to be found jurisdictional by a
formal delineation. This mapping included a small area of isolated wetlands
adjacent to the northeast corner of the site near a reach of the proposed
alignment of the outlet pipe. The approximate boundaries of these wetlands
areas are shown on Figure 11.2-1.

As shown on the inset detail on Figure 11.2-1, the preliminary layout of the
access road/turnaround area, pumping station pad, and a portion of the inlet
pipeline infringement on the mapped wetlands in this area. Based on the
preliminary field survey conducted for this study, this wetland area is
characterized exclusively by grasses/forbs (i.e., bushes and trees are not
present) and the area has been severely impacted by cattle grazing. These
conditions lead to the judgment that the quality and value of the wetlands in
this area is low. The total area of permanent disturbance of the preliminarily
mapped wetlands for the currently proposed layout is approximately 0.15
acres. The length of inlet pipeline outside the footprint of the access
road/turnaround/pad area is approximately 100 feet.

See Section 11.3.3 for relevant discussion of a potential wetlands issue if it
becomes necessary to borrow substantial quantities of fill from the Basin B
site.

11.3 Environmental Permitting

The required nature and scope of environmental permitting for the Bridger
Valley Reservoir Project was evaluated as part of this study as documented
in the following subsections.

11.3.1 NEPA

Assuming the absence of direct federal funding of the project in whole or in
part, there will not be a sufficiently direct federal nexus to require permitting
under the National Environmental Policy Act (NEPA). In the event that
project financing were to come in whole or in part from the U.S. Department
of Agriculture (USDA) Rural Utilities Service (RUS) or another federal
source, then a nexus would be established and a NEPA process would be
triggered.
In the case of RUS funding an Environmental Report would be prepared and submitted by BVJPB. This document, upon review and acceptance, would serve as RUS’s Environmental Assessment (EA) under NEPA. Although judged unlikely in this case, there could be a requirement for public notice and an opportunity for public review and comment on the project. The NEPA process would then be concluded by RUS either with a Final Notice approving the project and/or a Finding of No Significant Impact (FONSI).

11.3.2  **State Environmental Assessment**

If project financing in whole or in part will come from Mineral Royalty Grants, the application will be circulated by the Office of State Lands and Investments (OSLI) for review by other appropriate and relevant state agencies including those with environmental and/or other permitting authority over the project.

Financing in whole or in part by the Drinking Water State Revolving Fund (DWSRF) requires an environmental review process involving the following steps:

- Preparation of an environmental assessment report
- Environmental review by appropriate and relevant agencies
- Issuance of a Categorical Exclusion (CAT EX) or Findings of No Significant Impact (FONSI)

Financing in whole or in part by the Wyoming Water Development Commission (WWDC) requires that all state and federal permits and clearances necessary to construct the project have been identified, and that an environmental analysis, including environmental assessments, etc. of the proposed project’s operation and configuration has been performed.

Regardless of the funding sources involved, it is the project sponsor/applicant’s responsibility to ensure that all the necessary permits and clearances are acquired and all of the associated requirements are met.

11.3.3  **Section 404/CWA**

**Consultation.** Preliminary consultation was held with Matt Bilodeau of the Corps of Engineers Cheyenne Field Office (Bilodeau, 2008; see email included in Appendix H) to evaluate the likely regulatory process under Section 404 of the Clean Water Act (CWA) and potential mitigation for the minor wetlands impact described above in Section 11.2. Based on this consultation and on review of the 2007 Nationwide Permits, Conditions, Further Information, and Definitions (with corrections) available at: [http://www.usace.army.mil/cw/cecwo/reg/nwp/nwp2007_gen_conditions_def.txt](http://www.usace.army.mil/cw/cecwo/reg/nwp/nwp2007_gen_conditions_def.txt), it appears most likely that Nationwide Permit NWP 12 – Utility Line Activities will apply to the proposed activity. Relevant language from NWP 12 regarding its applicability to this activity includes the following extracts (with emphasis added):

> “**Utility Line Activities:** Activities required for the construction, maintenance, repair, and removal of utility lines and associated facilities...provided the activity does not result in the loss of greater than ½ acre of waters of the United States.”
“Utility lines: This NWP authorizes the construction, maintenance, or repair of utility lines...and the associated excavation, backfill, or bedding for the utility lines...provided there is no change in pre-construction contours. A “utility line” is defined as any pipe or pipeline for the transportation of any...liquid...for any purpose...”

“Utility line substations: This NWP authorizes the construction, maintenance, or expansion of substation facilities associated with a power line or utility line...provided the activity, in combination with all other activities included in one single and complete project, does not result in the loss of greater than \( \frac{1}{2} \) acre of waters of the United States...”

“Access roads: This NWP authorizes the construction of access roads for the construction and maintenance of utility lines...provided the total discharge from a single and complete project does not cause the loss of greater than \( \frac{1}{2} \) acre...Access roads must be constructed so that the length of the road minimizes any adverse effects on waters of the United States and must be constructed so that the length of the road minimizes any adverse effects...and must be as near as possible to pre-construction contours and elevations...and...properly...culverted to maintain surface flows”.

The proposed facilities are interpreted to qualify under this NWP as follows:

- The inlet pipeline qualifies as a “utility line”
- The access road, including the necessary turnaround at the pumping station site, qualifies as an “access road”
- The pumping station qualifies as a “substation facility associated with a...utility line”

Final design of the pipeline, access road and pumping station pad must be performed in accordance with all of the applicable requirements of NWP 12. In addition, best management practices (BMPs) and other appropriate measures must be implemented to prevent erosion and sedimentation impacts to waters of the U.S.

A pre-construction notification must be submitted to the Corps district engineer prior to commencing the proposed activity because the activity as currently designed will result in “the loss of greater than 1/10 acre of waters of the United States”.

Mitigation. Based on preliminary consultation with Matt Bilodeau as noted above, it is understood that mitigation will be required for any permanent disturbance in jurisdictional wetlands greater than 0.1 acre and up to 0.5 acre (the limit of applicability of NWP 12). The specific nature and scope of mitigation required will be negotiated with the Corps at the time of application for an NWP. Based on the characteristics of the wetlands in the area of the proposed pump station/access road described in Section 11.2 above and the preliminary consultation with the Corps, it is likely that one-to-one, in-kind mitigation will be required.
The likely mitigation for the wetland disturbance associated with the inset layout on Figure 11.2-1 would involve the following actions:

- Salvage existing hydric soils from area of disturbance
- Grade mitigation area adjacent to existing similar wetlands near the area of disturbance to proper elevation to achieve in-kind hydrologic function
- Place salvaged soil in prepared graded mitigation area
- Revegetate mitigation area with appropriate wetland species at least comparable to existing conditions in disturbed area

A potential area for mitigation of the currently proposed wetland disturbance is shown on the inset on Figure 11.2-1.

As noted above, mitigation could be avoided if a site for the access road/pumping station was found that, with appropriate site design, resulted in no more than 0.1 acre of permanent disturbance. However, any site further north than currently proposed (e.g., at the potential mitigation site described above) would require a longer pipeline (to retain the required inlet point at the south end of the reservoir) with the associated greater construction, OM&R and pumping costs. It was concluded that mitigation of the type and scale described above would be significantly more economical than relocating the pumping station/access road site further north. If for some reason the required permitting and/or mitigation for the currently selected site proved substantially more complicated and costly than assumed herein, this decision can be reconsidered during final design.

Potential Basin B Borrow Site. If it becomes necessary to borrow a significant amount of material for embankment construction from the Basin B site (or contiguous or nearby ground), then substantial enlargement of the existing access road to the Basin B site area would be required to support heavy two-way materials hauling. The grading associated with such an enlargement would encroach on the adjacent drainage. Thus, it will be necessary to survey the intermittent drainage at that site for the presence of jurisdictional wetlands. If wetlands are present, then an evaluation will have to be made of the potential to impact those wetlands with the access road improvements. The type of Section 404 permit required (NWP versus individual, if any) is unknown pending clarification as to the amount of borrow (if any) that will need to come from off-site, and details as to the location and conditions at the selected borrow site and along the site access road corridor.

11.4 Other Permitting

11.4.1 Cultural Resources

Consultation with the State of Wyoming Historic Preservation Office (SHPO) should be made as part of the overall permitting effort if the project advances. This consultation and any resulting mitigation (if any) will be required by Section 106 of the National Historic Preservation Act (NHPA) if the project is permitted under NEPA, or by various state statutes (including the Wyoming State Antiquities Act) if permitted through a formal state environmental review process.
No cultural resources were identified in the immediate vicinity of the Basin A or Basin B site during a previous Class I survey of the surrounding vicinity (Forsgren, 1995) or from review of a map of cultural sites in Wyoming reported by EC1 (2004). The absence of previously documented sites and the significant surface disturbance of most of the Basin A and Basin B sites associated with their past and current land uses suggest that the likelihood of encountering significant cultural resources is low. It is assumed, however, that a Class III cultural resources survey will be required for the project. That survey will be reviewed by SHPO, and if approved, an archaeological clearance will be issued. Based on information available at this time, no cultural resources mitigation is assumed necessary for the Bridger Valley Reservoir Project.

11.4.2 Surface Water Appropriation

At least one and possibly two or more water rights permits will be required for the Bridger Valley Reservoir Project depending on what source(s) of supply to the reservoir the BVJPB intends to use. At a minimum, a new reservoir storage right will be required for storage of water released from the BVJPB storage account in Stateline Reservoir. If the option of filling the reservoir in whole or in part from time to time with currently unappropriated flows in the East Fork of Smiths Fork River and/or the Blacks Fork River is desirable, then an enlargement of one or more of the BVJPB’s existing direct flow water rights would be required.

Storage Permit. Storage of water in the proposed new Bridger Valley Reservoir will require obtaining a Permit to Appropriate Surface Water (Reservoir) from the Wyoming State Engineer’s Office (WSEO). A copy of the reservoir permit application form is included in Appendix H. Key information required in the application includes, but is not limited to:

- The use to which the water is to be applied (municipal in this case)
- The source of the proposed appropriation (Stateline Reservoir and possibly through an enlargement with current date priority of one or more of BVJPB’s existing direct flow rights)
- Method of filling the reservoir
- Information about the dam design/construction
- A map showing the location and layout of the dam, the point of diversion for the appropriation to fill the reservoir, and the conveyance from the diversion to the reservoir, among other required information

Upon approval of the application, WSEO will issue a permit for developing the proposed project. The project must then be completed within the permitted time frame, and notification must be provided to WSEO when construction is complete and water is put to beneficial use. The final step in the permit process is submittal of a final proof of appropriation and construction to the State Board of Control.

Direct Flow Permit Enlargement. If it is desired to have the flexibility to fill the new reservoir with currently unappropriated water in whole or in part, it will be necessary to file an application for a Permit to Appropriate Surface Water (Enlargement). A copy of the direct flow enlargement permit
application form is included in Appendix H. Key information required in this application includes but is not necessarily limited to:

- The use to which the water is to be applied (municipal)
- Source of the proposed appropriation (Stateline Reservoir releases and possibly through enlargement of one or more of BVJPB’s existing direct flow rights)
- Information about the existing diversion including its current permitted capacity, the desired enlarged capacity, and if the enlargement requires physically enlarging or extending the facility being enlarged, information about the physical enlargement
- Estimated time to complete any required construction and/or time to complete application of water to the beneficial use for which the enlargement is sought

The additional direct flow water right under an enlargement will have a priority date of the time of adjudication of the right (i.e., a junior right and not the priority date of the right being enlarged). It will be necessary to provide a means to account for diversions under the different priorities.

**Key Surface Water Permit Considerations.** Several potentially important considerations in planning and implementing a water rights strategy or approach for the proposed Bridger Valley Reservoir Project have been preliminary identified in the course of the present study. These include, but are not necessarily limited to:

- *Wyoming one-fill rule* - a reservoir is entitled to be filled in priority once each year if water is available; any unused water remaining at the end of the normal use period is designated as carry-over storage and counts toward providing water to meet the following year’s supply for appropriation
- *Protection of water released from Stateline Reservoir* – consultation and coordination with WSEO, and if/as necessary the Utah State Engineer’s Office (USEO), is recommended to ensure protection of releases from storage from Stateline Reservoir from diversion by others
- *Use of reservoir for seasonal pass-through of flow diverted to WTP for turbidity reduction* – consultation with WSEO is recommended to confirm requirements, if any, for pass-through operation for turbidity control including any required monitoring of flows

It is understood that development and/or implementation of a water rights approach/strategy is not within the scope of the present study, and that BVJPB will lead this effort if/as the project advances. The considerations noted above are only offered in the interest of assisting in that effort.

### 11.4.3 Water Quality

**Section 401 Certification.** Section 401 of the Clean Water Act requires the State of Wyoming to certify any federally licensed or permitted facility which may result in a discharge into the waters of the state. In this instance, the 401 certification relates to the required Section 404 Dredge and Fill Permit required from the Corps of Engineers (see discussion in Section
11.3.3). NWP 12, the nationwide permit believed applicable to the Bridger Valley Reservoir Project, under Section 404 is certified for use by the State of Wyoming at this site as the potentially receiving waters are not Class 1 waters (Corra, 2007).

The Section 401 certification will require the applicant (in this case the construction contractor) to:

- Submit a Pollution Control Plan
- Identify an on-site Pollution Control Officer
- Perform water quality monitoring for turbidity
- Provide for safe handling of all hazardous materials located on-site
- Provide for adequate water supply, sanitary, and trash facilities for construction camps located on-site

The Section 401 certification also outlines the additional permits required prior to the initiation of construction activities, including if/as applicable:

- Wyoming Pollution Discharge Elimination System (WYPDES) Storm Water Permit
- WYPDES Point Source Discharge Permit(s)
- Spill Prevention, Control, and Countermeasures (SPCC) Permit

An SPCC plan and permit will be required if above ground storage of petroleum products exceeds 1,320 gallons in total or more than 660 gallons in a single tank as part of construction activities at the Basin A site and at the Basin B borrow site, if utilized.

**WYPDES Individual Storm Water Permit.** The proposed Bridger Valley Reservoir Project is classified as a large construction activity for purposes of storm water permitting since the overall area of land disturbance is greater than five (5) acres. As a result, an individual WYPDES discharge permit from WDEQ will be required. The application and implementation requirements for this permit are provided in W.S. 11-10-2004, Chapter 2 – Permit Regulations for Discharges to Wyoming Surface Waters which is available at: [http://soswy.state.wy.us/RULES/5680.pdf](http://soswy.state.wy.us/RULES/5680.pdf). The required permit application requires the following information:

- Location and nature of the construction activity
- Total site area and area expected to undergo excavation during the life of the permit
- Proposed measures, including BMPs, to control pollutant discharges during construction, and a brief description of the applicable state and local erosion and sediment control requirements
- Increase in impervious area after construction, nature of fill material, and existing data describing the soils or the quality of the discharge
- Name of the receiving water (in this case, the East Fork of the Smiths Fork River)
The permit application is typically prepared by, and the permit issued to, the construction contractor.

**WYPDES Mineral Mining General Permit for Storm Water Discharges Associated with Mineral Mining Activities (Except Fuels).** This general permit applies to storm water discharges from the aggregate mining and processing operations envisioned for the Bridger Valley Reservoir Project. Point source discharges from these operations (i.e., process waters) require a separate permit as discussed in the following subsection.

The operator (in this case the construction contractor) must prepare a Storm Water Pollution Prevention Plan (SWPPP) and submit a Notice of Intent (NOI) to WDEQ at least 30 days prior to beginning any construction activities. The SWPPP describes potential pollution sources and the Best Management Practices (BMPs) that will be implemented to prevent pollution. The operator must periodically inspect and maintain the BMPs until the site is finally stabilized at which time a Notice of Termination (NOT) is submitted to WDEQ. This permit requires payment of a $100 annual fee.

**WYPDES Point Source Discharge Permit(s).** One or more individual WYPDES permits may be required for point source discharges to surface waters not related to storm water runoff. These could include discharges from aggregate processing operations involving washing of fines from the aggregate, vehicle or machinery washing, or other construction related operations resulting in specific non-storm water discharges.

Any required individual point source discharge permit would be the responsibility of the construction contractor. Requirements for the application for and implementation of these permits are provided in W.S. 11-10-2004, Chapter 2 – Permit Regulations for Discharges to Wyoming Surface Waters (http://soswy.state.wy.us/RULES/5680.pdf).

### 11.4.4 Dam and Reservoir Safety Review and Construction

As discussed in Section 7.0, the embankment dam for the proposed Bridger Valley Reservoir Project is a jurisdictional Class I dam under the Wyoming Safety of Dams law. As a result, a dam safety review by the Wyoming State Engineer’s Office (WSEO) of the embankment and hydraulic facilities design will be required. This will require submittal of the following documents or information:

- Complete construction plans and specifications
- A classification report, including dam failure inundation maps, supporting calculations/data, and an assessment of the downstream impacts of dam failure
- A hydrology report (in this case only an evaluation of direct precipitation is required as the reservoir is completely off-channel)
- A geotechnical report, addressing site geology, stability/settlement (foundation and embankment), and seismic stability
- A design report including all information necessary to support any assumptions made in the design of the dam and appurtenances
Instrumentation plan
Upon review and approval of these submittals the WSEO will issue a Permit to Construct for the dam and its appurtenances. During construction the owner must:

- Identify an engineer who will be responsible for construction supervision
- Submit weekly construction progress reports
- Submit plans for major changes to the design
- Provide a certified notice of completion in writing
- Prepare and submit a summary report with Record Drawings
- Submit a schedule for first filling, including inspecting and monitoring the dam

The dam and appurtenances designs must be prepared under the supervision and responsible control of an appropriately qualified engineer licensed in Wyoming.

11.4.5 Mining
A mining permit will be required from the Land Quality Division (LQD) of WDEQ if it is necessary to borrow and/or process earth fill, riprap and/or aggregate materials from the Basin B site or another off-site location. The specific permit required would depend on the area of disturbance and/or the volume of material borrowed.

A Limited Mining Operation (also referred to as an ET or Ten-Acre Exemption) permit would be applicable if the amount of overburden removed is less than 10,000 cubic yards and the area of affected land is less than 10 acres, both in any one year. Based on the current earthwork quantities provided in Section 7.0 and the available data on the terrace deposits at the Basin B site (ECI, 2004), this type permit would likely be applicable for all but a volume of required off-site borrow approaching the maximum of approximately 181,000 cubic yards. If the maximum amount of off-site borrow is required, the terrace gravels are thinner than about 10 feet, and/or the overburden is greater than about 6 inches, then a regular mining permit may be required. (Note that the current permit for the sand and gravel pit at the Basin B site is a Ten-Acre Exemption.)

A notification to LQD is required prior to commencing operations for a Ten-Acre Exemption permit. Information required with the notification includes:

- Contact information for the operator (in this case the construction contractor or a subcontractor)
- Written consent from the surface land owner and lessee, if any, of the land affected
- Location of the area by legal subdivision, section, township and range
- The mineral to be mined (sand and gravel in this case)
- The proposed commencement and completion dates
- A copy of the applicable USGS topographic quadrangle map with required information shown

- A description of the proposed mining operation

- A sworn statement that all information is true and correct to the best knowledge of the operator

Other requirements for this type of permit include, but are not necessarily limited to: bonding, annual reports, and site signage. Reclamation is required, including grading to stable slopes suitable for revegetation, topsoiling, tilling, and seeding.

The application and implementation requirements for a Regular Noncoal Mine Permit are similar in type but substantially more detailed than for the Ten-Acre Exemption permit. Also, consultation with the Wyoming Game and Fish Department (WGFD) and the U.S. Fish and Wildlife Service are required under the regular mine permit. If the threshold values of annual overburden removal and/or affected surface area are only slightly exceeded, it is recommended that a request for a waiver be made to still permit this temporary mining operation under the Ten-Acre Exemption to avoid the very significant additional effort and cost that would be required to fully comply with the requirements of a Regular Noncoal Mine Permit.

### 11.4.6 Other Permits

Various others permits and clearances will or may be required related to construction activities as briefly described in the following subsections.

**WDEQ Permit to Construct.** If partial project financing is provided by the DWSRF it may be necessary to obtain a Permit to Construct from WDEQ pursuant to W.S. 35-11-101 and -103. This permit requires that all relevant and applicable conditions of the Water Quality Rules and Regulations, Chapter 12 – Design and Construction Standards for Public Water Supplies be followed.

**Other Construction Permits.** Permits or clearances may be required for various other temporary construction related activities including, but not necessarily limited to:

- Air emissions from material processing facilities and operations; permit required from WDEQ Air Quality Division (AQD)
- Overweight hauling on public roads (e.g., WYDOT, Uinta County)
- Burn permit if trash and/or construction debris is to be burned on site (Uinta County)

These permits are typically acquired and implemented by the construction contractor under the terms of the construction contract.

### 12.0 Project Financing

Potential project funding sources identified and evaluated for the Bridger Valley Reservoir Project include the following:

- Wyoming Water Development Commission (WWDC) New Development Program
Each of these potential funding sources are described and evaluated in the following subsections. It is important to understand that the potential sources identified herein are not necessarily the only resources that may be available, that existing programs change and sometimes disappear over time, new programs arise, funding levels vary year to year, and competition for funding may be significant. Also, contact information for various programs and key people can also change.

Two other financing sources were briefly reviewed but found not sufficiently applicable to the Bridger Valley Reservoir Project to pursue further at this time. Although potentially applicable to dams and reservoirs, Community Development Block Grants (CDBG) are intended for significantly economically deprived areas and are limited to a maximum of $300,000 per project. Loans that might be available for the project under the Joint Powers Act (JPA) currently carry a 5.31 percent interest rate and a one (1) percent loan origination fee and thus are not competitive with the loan terms otherwise available from the WWDC. It is recommended that these programs be reviewed again later if the project advances to determine if eligibility requirements and loan terms (for the JPA loans) are more favorable at that time.

12.1 WWDC New Development Program
The Wyoming Water Development Commission (WWDC) through the Wyoming Water Development Office (WWDO) administers the Wyoming Water Development Program encompassing new development, rehabilitation, water resources planning and master planning. Of most relevance to the Bridger Valley Reservoir Project is the New Development Program described below. More information on this and other WWDC programs is available at the main WWDC website: [http://wwdc.state.wy.us](http://wwdc.state.wy.us). Operating Criteria of the Wyoming Water Development Program are available at: [http://wwdc.state.wy.us/opcrit/final_opcrit.pdf](http://wwdc.state.wy.us/opcrit/final_opcrit.pdf) and a form titled Information for New Applicants is available at: [http://wwdc.state.wy.us/projappl/New_Ap_Info.pdf](http://wwdc.state.wy.us/projappl/New_Ap_Info.pdf).

**New Development Program.** The New Development Program provides technical assistance and funding (as a grant/loan mix) to develop waters of the state that are unused and/or unappropriated at present. Relevant provisions from the current Operating Criteria applicable to the eligibility of the Bridger Valley Reservoir Project for the New Development Program follow:
II.A.1. Projects developing water for present and future needs of the project sponsors. “These projects can be pursued through the study and the preliminary design phases if the project sponsor has a legitimate need for the water and has a desire to pursue the project. These projects can be constructed if the sponsor has the ability and willingness to pay a portion of the development costs and all of the operation, maintenance and replacement costs. All projects should be designed to accommodate anticipated future demands of the sponsor during the life of the project. Population projections and other related tools should be used to define realistic future needs of the sponsor.” [Emphasis added]

II.D.2. Storage Projects – “Dam and reservoirs that store water during times of surplus for use later when needed shall be a program priority. Dams and reservoirs can also serve to re-regulate existing water supplies to meet the demands of the water users in a more efficient and effective manner. Proposed new dams with storage capacity of 2,000 acre feet or more and proposed expansions of existing dams of 1,000 acre feet or more qualify for the Dam and Reservoir Program. Smaller storage projects qualify for funding under the New Development Program. Repairs and improvements to existing storage projects qualify for funding under the Rehabilitation Program.” [Emphasis added]

Note that the Bridger Valley Reservoir Project does not qualify for the Dam and Reservoir Program noted in the paragraph above due to the proposed storage capacity of 750 acre-feet. Enlargement of this proposed storage capacity by 1250 acre-feet to meet the threshold 2000 acre-feet to qualify for the program cannot be justified by the needs evaluated in the prior Level II studies (ECI, 2004; Gannett Fleming, 2006).

Financial Plan. The current standard terms of the Wyoming Water Development Program financial plan are summarized as follows:

- Project budget shall include costs for project permitting, design, land acquisition, construction engineering, and construction
- Preliminary grant recommendation of sixty-seven (67) percent grant to thirty-three (33) percent loan mix; WWDC may recommend loan/grant mix based on sponsor’s ability to pay a portion of project costs and all operation, maintenance and replacement costs
- Minimum four (4) percent loan interest rate (current rate is 4 percent, but legislature may increase rate)
- Maximum 50-year term of loans; standard term of loan is 30 years; term shall not exceed economic life of project
- Payment of loan interest and principal may be deferred up to 5 years after substantial completion at WWDC’s discretion under special circumstances (providing total loan term with deferment does not exceed 50 years)

In the document titled Information for New Applicants the following additional relevant information is provided regarding financial terms:

- “The best available project financial terms include a grant for Level I and Level II expenses, a grant of 75% of the Level III costs, a loan of
25% of the Level III costs with an interest rate of four percent (4%) and a term equal to the economic life of the project/improvements or fifty (50) years, whichever is less. Principal and interest payments may be deferred for five (5) years after project completion. However, these favorable terms will be granted when a project is essential and the project sponsor has a very limited ability to pay.”

“Those sponsors who feel more favorable terms are warranted due to a limited ability to pay must make a formal presentation to the Commission documenting their case. Sponsors electing to pursue this option should be aware that the Commission is reluctant to deviate from this standard and such requests will be denied unless they are clearly documented and justified.”

**Recommendation Process.** The Level II project report will be reviewed by WWDO. This review is typically completed no later than in October. A recommendation will be made by the WWDO Director as to whether the project warrants advancement to Level III. WWDC will take preliminary action on the recommendation at its November meeting. If deemed necessary, WWDC may solicit input at a public meeting regarding the project prior to finalizing its recommendation. A formal public hearing will be held if the project is recommended for Level III Final Design and Construction. With ongoing coordination with the Governor, WWDC will meet in December or early January to finalize its recommendation as to legislative funding of the project. The Sponsor and other interested parties who disagree with WWDC’s recommendation will be provided an opportunity to address the Commission with their concerns at that meeting. This presentation must address the need for the project, the direct and indirect benefits of the project, and any other information the Sponsor feels is relevant to the Commission’s final decision.

**Legislative Process.** If the project is recommended by WWDC, the Select Water Committee of the legislature will review the WWDC’s recommendation and the proposed project budget. If they concur, the project will be included in the Omnibus Construction Bill for consideration by the legislature as to allocation of funds from the appropriate water development account to design and construct the project.

**Recommendation.** WWDC New Development Program funding is recommended as the primary funding source for the Bridger Valley Reservoir Project. Based on the current WWDC criteria, the economic analyses in Section 8.0 include two WWDC grant/loan mix funding scenarios: 67 percent/33 percent and 75 percent/25 percent.

### 12.2 Mineral Royalty Grants

The Wyoming Office of State Lands and Investments (OSLI) as the administrative agent for the State Loan and Investment Board (SLIB) administers the various mineral royalty grants (MRGs) available pursuant to Chapter 48 – General Government Appropriations, Sections 328 and 329, Local Government Distributions I and II, respectively.
Eligibility. Potential eligibility of the Bridger Valley Reservoir Project for MRG funding is based on the following excerpt from the SLIB rules and regulations:

- **Chapter 22, Section 5. Grant Eligibility** “Purposes. Pursuant to W.S. 9-4-604 and Laws 2006, Chapter 35, Section 317(c) the Board shall provide grants in the general categories of transportation, including roads, bridges, streets, traffic and drainage; utilities, including water, wastewater, solid waste and electricity; public safety, including county jails, law enforcement, fire protection and animal control; medical, including hospitals, clinics and ambulances; and other categories, including but not limited to, local government buildings and public use facilities.” [emphasis added](http://soswy.state.wy.us/RULES/6731.pdf)

Contact was initially made with Debra Dickson/SLIB Grants & Loans Lead Worker regarding this and other questions regarding the MRG program. Ms. Dickson indicated that she believed that this type of project may be eligible for consideration for inclusion on the Uinta County consensus list (Personal Communications, June 4, 2008). Follow-up contact was made with Chris Gillett/SLIB to further pursue the question of project eligibility (Personal Communications, June 6, 2008). Ms. Gillett was not aware of any specific exclusion of a reservoir project from MRG funding, but indicated that she was also not aware that any such project had been funded previously. She suggested submitting a written request for clarification to Director Rob Thompkins, but noted that his schedule would likely not permit him to respond until some time in July.

Funding Available. The MRG program provides grant funding for up to 50 or 75 percent of the total eligible project costs depending on the criteria of the specific grant program for which application is made. Eligible costs are defined as total project costs less ineligible costs. Ineligible costs most relevant to the Bridger Valley Reservoir Project include, but are not necessarily limited to, the following:

- Costs for tap, water, and plant investment fees
- Engineering fees, including design, inspection and contract administration costs (including costs incurred before grant award), over 20 percent of project cost
- Costs for preparation or presentation of grant/loan applications
- Legal fees
- Costs related to issuance of bonds
- Costs for real property in excess or fair market value or of that needed for the project
- Contingency or extra work costs in excess of 10 percent of estimated construction costs

There is no specific limit to the amount of grant funding that can be provided by the county for a given project. The county determines the distribution and priority of their allocated share of these funds. The amount of total grant
funding and its distribution among the counties varies with each biennial legislative session. Most of the grant funds provide specifically that no preference for one use or project type over another shall be made.

**Application Process.** An application for an MRG grant is first prepared and submitted to Uinta County for inclusion on the County’s Consensus List. The Consensus List, including all required application forms and attachments, is then be submitted to SLIB for consideration at a regular meeting. The key information required in the application includes, but is not necessarily limited to, the following:

- Project summary (bullet format preferred)
- Grant amount requested and percentage of total project costs the grant would pay
- Full description of the project
- Detailed project budget
- Licensed engineer’s statement of the feasibility of the project
- Geographic area and population served directly and indirectly
- Description of other project funding sources, the portion of the project cost expected to be funded from each source, and evidence of commitments of such funding
- Financial statement
- Written statement of basis if a reduction in required match percentage (i.e., 25 or 50 percent) is requested

Grant requests for more than 50 percent of eligible project costs for water facilities must also include the following information:

- Whether water meters have or will be installed
- Whether the applicant will require owners of new additions of land to the service area to pay all costs of expanding the water system within and to the boundaries of the addition
- Whether water rates, tap fees, and plant investment fees are in effect or to be adopted, and an analysis of the adequacy of water rates to finance system operations and maintenance

**SLIB Review.** If the project is found eligible a determination of the completeness of the application will be made by SLIB within 45 days. The applicant then has 10 days to submit any additional required information. The SLIB Board will then consider the application and establish the maximum amount of the grant and the percent of eligible project costs that will paid by the grant.

The key relevant evaluation criteria applied by SLIB in review of an application include, but are not limited to, the following:

- Extent of matching funding from all sources
- Degree of commitment of local resources to the project
- Extent of matching funding from other than other state grants
- Appropriateness of sizing of project relative to population to be served
- Relative urgency of the project
- History of applicant’s repayment of obligations to SLIB
- Financial need of the applicant
- Percentage of applicant’s population directly served by the project
- A review of BVJPB by Uinta County and all towns within 5 miles of the service area relative to ability to pay, any potential negative effects on needs, plans or general welfare of the County, and history of meeting County standards.

Recommendation. Given the uncertainty of eligibility of the Bridger Valley Reservoir Project for MRG funding, and if eligible, the amount of funding that might be available, this source of funding was not included in the economic analyses presented in Section 8.0. It is recommended, however, that BVJPB request clarification from SLIB as to project eligibility as part of a decision as to proceeding to Level III final design and construction. If the project is eligible, then discussions should be held with Uinta County to include the Bridger Valley Reservoir Project on the County’s Consensus List. Discussions should include the amount of grant funding that might be available considering any other applications already received by the County.

12.3 Drinking Water State Revolving Fund

The Wyoming Office of State Lands and Investments (OSLI) administers the Drinking Water State Revolving Fund (DWSRF) with input and assistance from the Wyoming Department of Environmental Quality (WDEQ) and Wyoming Water Development Office (WWDO) as appropriate relative to compliance with federal “cross-cutting” requirements.

Review of the DWSRF program relative to the Bridger Valley Reservoir Project indicates that raw water storage reservoirs are not considered as eligible components of a water supply system in the Safe Drinking Water Act (SDWA) which is the underlying federal authorizing law for the program. Following are relevant excerpts from Wyoming Statutes and EPA’s DWSRF Program Operations Manual:

- **16-1-301. Definitions (a) (xviii)** “Water supply system” means a system from the water source to the consumer premises consisting of pipes, structures and facilities through which water is obtained, treated, stored, distributed or otherwise offered to the public for household use or use by humans and which is part of a community water system or a noncommunity water system” [emphasis added]

- **16-1-305. Authorized projects; authorized financial assistance. (a)** “Subject to select water committee review and recommendation of projects, the account may be used for financial assistance for the planning, design and construction of projects on eligible publicly owned water systems which may be either community or noncommunity water systems. Eligible projects may be comprised of improvements to all components of a water supply system as appropriate and permitted by the Safe Drinking Water Act.” [emphasis added]
“Several distinct categories of funding are ineligible for assistance through the DWSRF program. According to formal regulations, programs are not permitted to provide assistance in the following project areas: 1) the development or rehabilitation of dams; 2) the purchase of water rights (except when water rights are transferred as part of a system consolidation effort); 3) the building or rehabilitation of reservoirs (except for finished water reservoirs and reservoirs essential to the treatment process); 4) projects primarily developed for fire protection; 5) projects developed primarily to accommodate future population growth; and 6) projects that have received assistance through the Indian Tribes and Alaska Native Villages national set-aside.” [emphasis added] (U.S. EPA, undated)

The possibility of identifying selected components/functions of the overall Bridger Reservoir Project for consideration for DWSRF funding was discussed with Wade Verplancke/WWDO-DWSRF (Personal communication, June 3, 2008) and Kevin Frank/WDEQ Senior Analyst (Personal communication, June 5, 2008). Mr. Verplancke stated that it was his understanding that raw water storage dams and reservoirs were not eligible for DWSRF funding even with a subsidiary treatment function of intermittent settling to mitigate excess turbidity. Mr. Frank indicated that although not a routine practice of the program, he believed that SLIB/WDEQ would be willing to consider such a request (with, however, no assurance that the request would be granted, and if granted, limited to some funding amount commensurate with the use of the reservoir for settling versus storage).

The capital costs of facilities/functions that might be construed to fall within the definition of SDWA-eligible water supply system components include, but are not necessarily limited to, the following:

- A portion of the capital cost of the reservoir and inlet pumping and piping system representative of the portion of these facilities reasonably allocable to settling of suspended solids (i.e., turbidity reduction) and supply of “pre-treated” water to the water treatment plant; this would fall under the “treatment” component eligibility in the program.
- The capital cost of security fencing and/or security camera(s), if installed.

Operation and maintenance (O&M) costs associated with these components/functions are not eligible for DWSRF funding under any circumstance.

Two important competing factors in evaluating the merits of further pursuing DWSRF funding of these limited components are the relatively attractive available loan terms versus the significant administrative process required (and the chance of an application for this project being refused). Funding options available from the DWSRF program potentially applicable to the Bridger Valley Reservoir Project are briefly characterized as follows:

- Loans for eligible capital costs are available at typically very attractive interest rates (currently 2.5 percent), although tempered by a 0.5 percent origination fee and a maximum term of 20 years.
Purchasing insurance for or guaranteeing local debt obligations to improve credit market access or reduce interest rates

Key elements of the administrative process/requirements to apply for DWSRF funding include, but are not limited to, the following:

- Loan application must include all key information to inform SLIB of the need for the project and why the applicant believes that the state should help in the financing
- A public hearing must be held, including presentation of project alternatives
- A NEPA-compliant environmental review must be completed, including coordination with applicable agencies, preparation of an environmental assessment report, and evidence of an approved NEPA clearance (typically a Categorical Exclusion or Findings of No Significant Impact)
- Social and economic cross-cutting requirements must be met, including submittal of all relevant forms demonstrating compliance
- A detailed Budget Worksheet, Proposed Method for Paying Annual Loan Payments, last three years of financial statements, current and next year budgets, Engineer’s rate study report, governing user charge ordinance, bond or capital facility tax election documents (if applicable), and relevant Joint Powers Board documentation must be submitted with the application

**Recommendation.** Given the relatively small portion of the overall project cost that might be found eligible for DWSRF funding and the significant administrative effort required to prepare an application, it is our current recommendation that this source of funding not be included in evaluating the economic feasibility of the project as described in Section 8.0. It may, however, be worthwhile contacting SLIB/WDEQ during Level III when more precise project costs for potentially eligible components are known to make a final decision as to applying for DWSRF funding. If this funding might be pursued it is imperative that a request be made to SLIB to add the project to the Intended Use Plan (IUP) well before the funding is needed. This will identify the project to SLIB and allow the application process to proceed in a timely manner.

### 12.4 USDA Rural Utilities Service

The USDA Rural Utilities Service (RUS) administers various Rural Development Utility Programs including the Water and Waste Disposal (WWD) Loan and Grant Programs. These programs are intended to benefit rural areas defined as cities and towns with populations of less than 10,000, and/or any rural areas regardless of population. Given that the existing population of the BVJPB service area is approximately 4500, the highest projected growth rates do not result in a service area population greater than 10,000 until about 2030 (Gannett Fleming, 2006), and that population would be dispersed among the Towns of Lyman and Mountain View and surrounding rural areas, further consideration of this potential funding source appears warranted.
The proposed Bridger Valley Reservoir appears to be an eligible facility per discussions with Heidi Stonehocker/USDA B&C Program Specialist (Personal communication, June 3, 2008) and the following excerpts from 17 U.S.C. PART 1780 – WATER AND WASTE LOANS AND GRANTS:

- **§1780.9 Eligible loan and grant purposes.**
  
  “Loan and grant funds may be used only for the following purposes:
  
  (a) To construct, enlarge, extend, or otherwise improve rural water, sanitary sewage, solid waste disposal, and storm wastewater disposal facilities…”

- **§1780.7(c) Eligible Projects.**
  
  “...(2) Projects must be designed and constructed so that adequate capacity will or can be made available for to serve the present population of the area to the extent feasible and to serve the reasonably foreseeable growth needs of the area to the extent practicable…”

- **§1780.57(j) Dam Safety.**
  
  Projects involving any artificial barrier which impounds or diverts water, or the rehabilitation or improvement of such a barrier, must comply with the provisions for dam safety as set forth in the Federal Guidelines for Dam Safety…”

As part of the qualification requirements for an RUS grant and/or loan the applicant “…must certify in writing and the Agency shall determine and document that the applicant is unable to finance the proposed project from their own resources or through commercial credit at reasonable rates and terms.” (§1780.7(d) Credit elsewhere)

**Funding Available.** Both grants and loans are available from the WWD program. Loan interest rates are determined by criteria set by RUS each quarter of every fiscal year; rates are set for three classes – poverty, intermediate, and market. Based on a preliminary estimate of median household income of the BVJPB service area as compared to the nonmetropolitan median household income for the state (both on the required 2000 census basis), it appears that the Bridger Valley Reservoir Project may qualify for the intermediate rate (currently 3.75 percent). Otherwise, the project would qualify for market rate (currently 4.75 percent). The standard Wyoming RUS loan term is 30 years or the useful life of the facility.

Grant fund eligibility and amounts are determined by RUS based on a number of criteria. Grant funds are only available if the applicant can demonstrate that it cannot afford a loan for the amount being considered as grant. The RUS criteria specifically provide that grants are not available if the median household income of the service area exceeds the nonmetropolitan median household income of the state or when other loan funding for the project is not at reasonable rates and terms. At present, a typical grant/loan mix for an eligible project of this type is 80 percent/20 percent per Heidi Stonehocker (Personal communication, June 3, 2008).
WWD loan or grant funds can be used for many of the costs applicable to the Bridger Valley Reservoir Project, including but not necessarily limited to the following:

- Reasonable fees and costs (legal, engineering, administration, fiscal advice, recording, environmental analyses and surveys, salvage or mitigation, planning, establishing or acquiring rights)
- Costs of acquiring interest in land; water rights, leases, permits, rights-of-way; other “evidence of land or water control or protection necessary for development of the facility” (which may be applicable to royalty costs for existing gravel resources at the Basin A site)
- Purchasing or renting equipment necessary to install, operate, maintain, extend or protect facilities (e.g., pump station)

Application Process. An application may be filed at any time. Within 60 days of filing, the applicant must publish public notice of the application in a newspaper of general circulation in the area proposed to be served by the project. If authorization by the applicant for the project does not require a vote or public referendum, then a public meeting must be held sometime before loan or grant approval to inform the public of the project.

If an application is made it must include at least the following information:

- Form SF 424 2 (application form)
- State intergovernmental comments or filed application for such review
- Preliminary engineering report (PER) (prepared in accordance with detailed guidance in Bulletin 1780-2 (USDA, 2003)
- Written certification that other credit is not available
- Supporting documentation for eligibility determination (e.g., financial statements, audits, existing debt instruments, etc.)
- Environmental Report
- Applicants IRS Taxpayer Identification Number
- Other forms and certifications

The RUS processing office will notify the applicant of any additional information required within 15 federal working days of the original application. The processing office and the approval offices (likely the State Director’s office or designee) will then coordinate their reviews and those of other agencies to ensure the applicant is advised about project eligibility and fund availability within 45 days of receipt of a completed application.

Applications for RUS WWD funding are prioritized if/when funds are limited based on several key criteria. Those criteria that may favor the Bridger Valley Reservoir Project are briefly summarized as follows:

- Proposed project will enlarge, extend, or otherwise modify existing facilities to provide service to additional rural areas
- Amount of other than RUS funds committed to the project is 50 percent or more (assuming at least 67 percent WWDC funding)
Proposed project will serve an area that has an unreliable quality or supply of drinking water

**Recommendation.** Based on the above discussion and information regarding potential project eligibility and applicable WWD funding terms and conditions, this funding was not considered in the economic analyses presented in Section 8.0. Given the complexity and potential for changes of some of the eligibility requirements for RUS WWD funding, it is recommended that BVJPB make a written request for an eligibility determination before considering preparing a formal application. This will provide a firm basis on which BVJPB can first confirm eligibility, and if eligible, weigh the potential benefits of WWD funding against the administrative time and cost to apply for and manage the funding and the then available WWDC loan funding.

**12.5 Bureau of Reclamation Water 2025 Challenge Grant Program**

The U.S. Bureau of Reclamation (Bureau) administers the Water 2025 Challenge Grant Program. This program provides matching grant funding up to a maximum grant of $300,000 on a competitive basis for projects focused on water conservation, efficiency and water marketing. Most of the 122 projects funded to date have involved seepage/water loss reduction (typically canal lining or conversion to pipe) and enhanced water conveyance and distribution control through SCADA, metering, etc. To date, awards have been made to two projects for the Casper-Alcova Irrigation District involving conversion to pipe from unlined canal and various control and instrumentation improvements/additions to the system. The only other Wyoming award was to the WSEO for instrumentation of 43 irrigation diversions around the state.

Contact by Steve Muth/WWDO with Miguel Rocha/Bureau of Reclamation (303.445.2841) suggests that the reservoir lining and instrumentation/controls for the proposed Bridger Valley Reservoir Project may be eligible for the Water 2025 program as conservation and delivery efficiency measures, respectively. Additional information on this program can be found at: [http://www.usbr.gov/water2025/](http://www.usbr.gov/water2025/). Key information on this program is summarized below.

BVJPB qualifies as an eligible applicant by virtue of having water delivery authority and being located in the western United States as defined by the Reclamation Act of 1902. Application for this program is made by responding to a formal Request for Proposal (RFP) issued by the Bureau. Typically an RFP is issued each federal fiscal year with the proposal/application due in early December. For example, the proposals for FY08 were due December 4, 2007. A total of $4.5M was awarded to 15 projects for FY08. In reviewing applications, the Bureau gives preference to projects that can be completed within 24 months that will help to prevent crises over water in areas identified as “hot spots” where potential for conflict is judged to be moderate to highly likely by 2025 (including, for example, the two Casper-Alcova Irrigation District projects noted above). Although the Bridger Valley Reservoir Project is not located in a hot spot, this does not preclude the project from applying to the program.
**Recommendation.** Given the uncertainty as to whether the project would receive these competitive matching grant funds, this funding source was not included in the economic analyses described in Section 8.0. However, it is strongly recommended that consideration be given to applying for matching funding under this program should the Bridger Valley Reservoir Project move forward to Level III final design and construction.

### 12.6 Municipal Bonds

Joint powers boards may finance projects by issuing bonds of one or both of the following types:

- Bond issues by one or more participating agencies to construct, improve or acquire interest in any facility in the same manner as bonds may be issued by the individual agency for its construction, improvement or acquisition of such a facility (e.g., general obligation bonds)
- Revenue bonds to be repaid solely from revenues received by the joint powers board from the ownership, lease or operation of property or interest in property owned, leased or controlled by the board

It is assumed that BVJPB would likely not issue general obligation bonds as that would require putting up the full faith and credit of the participants in the JPB as collateral for the bonds.

Triple-A rated, tax-exempt insured 20- to 30-year municipal revenue bonds are currently yielding about 4.5-4.75 percent; lower A-rated bonds, if buyers can be found, would pay higher yields currently at about 5.0 percent. Note that bond yield, which would have to be paid by BVJPB to the bond holders, is analogous to the interest rate on a loan to be repaid by BVJPB such that a higher yield is less attractive than a lower yield.

**Recommendation.** Given the current yields greater than WWDC loan rates, uncertainties in the municipal bond market due in part to spill-over from the subprime mortgage crisis, and the likely very limited market for such bonds, financing the Bridger Valley Reservoir Project in whole or in part by bonds issued by the BVJPB was not considered in the economic analyses presented in Section 8.0. Reconsideration of this option can be made later if the project advances and conditions in the municipal bond market improve significantly.

### 13.0 Conclusions and Recommendations

#### 13.1 Conclusions

Key conclusions from this study are summarized as follows:

- Two alternative locations for construction of a new 750 ac-ft reservoir were considered. Basin A, located on the west side of State Highway 410 approximately ¾ mile south of the Bridger Valley Joint Powers Board Water Treatment Plant was found to be the most suitable for further consideration.
- Basin A was evaluated in detail and, with incorporation of appropriate design considerations, was found to be an acceptable location for construction of a new storage reservoir.
The embankment around Basin A is expected to be classified as a Class I dam (one where loss of human life is expected in the event of a dam failure) and as such must be designed according to appropriate dam safety standards.

Although Basin A is underlain by a sedimentary rock foundation (at near the level of anticipated excavation), a liner of the Basin A floor was assumed to be necessary for the following reasons:

- In this application it is critical that reservoir losses be minimized to ensure stored water is available for the intended uses when needed. To control losses to appropriate levels it is necessary that seepage be limited to one to two feet per year (equivalent to an average vertical permeability of the rock of $2 \times 10^{-6}$ cm/sec). The facility design and potential seepage are aggravated as a result of the site being located on the top of a bluff with embankment and an exposed foundation rock face (bluff slope) present over half of the reservoir perimeter. Although theoretically possible, it may not be practical to assure that the appropriate seepage limits are met without a constructed liner.

- Because of the likely Class I dam classification, dam safety is crucial. As stated, the reservoir is to be located on a bluff, approximately one hundred feet above the adjacent valley in which the Town of Mountain View is situated. The dam site is located in an area of high seismic risk which makes dam safety even more of a concern. Although we do not believe the less weathered, deeper foundation to be highly fractured (other than at the top five to ten feet – which could be cut off), it would likely eventually become saturated if a liner is not provided and could be subject to additional fracturing and significant seepage in the event of an earthquake.

The design maximizes utilization of onsite materials based on information available at the time of this study. The extent to which materials onsite when the field survey/inventory for this study was completed will still be available at the time of construction is presently uncertain. To address this situation, estimates are provided for two cases as follows:

- All materials are available onsite (onsite borrow)

- Materials that would potentially not be available onsite will be borrowed from a nearby site (Basin B site area) (offsite borrow)

The embankment design and materials types after processing are based on an assumed gradation of potential terrace borrow material using information available from prior studies (gradation tests – which excluded oversize fractions) and from visual estimates of the relative oversize fractions. Bulk samples should be collected and complete analysis of the full gradation including all oversize fractions should be performed.

Non-plastic, uncemented silty materials (including silt and mudstone/siltstone) present at the site are difficult to handle, and to control moisture to ensure adequate compaction. These materials are unsuitable for use in the construction of the embankment, and should
either be left in place (and covered with a liner if in the basin floor) or removed and disposed of offsite.

- A separate inlet and outlet arrangement provides the greatest degree of flexibility during future operations and offers the potential for increased life of the facility (in terms of population served) by not requiring that a portion of the storage be reserved for satisfying high levels of spring turbidity. The advantages of a separate inlet and outlet include:
  - Flow circulation
  - Sediment removal during periods of high turbidity
  - Flexibility in water quality drawn from the reservoir through multiple level draws (as compared to the earlier design concept)

- Groundwater seepage interception and surface water diversion should be provided to control inflows from upgradient of the proposed Basin A site.

- The extent of seepage collected from the embankment underdrain system should be reviewed during operation and the seepage recovered for municipal usage if found to be significant.

- No major obstacles relative to environmental issues or permitting were identified.

- Total project cost in 2011 dollars is estimated to range from $8,729,000 to $9,898,000 depending on the source of a majority of the embankment borrow material.

- The project should qualify for WWDC funding under the New Development Program for small (less than 2000 acre-feet) storage projects which would, at a minimum, provide a 67 percent grant with a 4 percent, thirty-year loan for the remaining costs (assuming the project life is at least thirty years). It may also be possible to secure a 75 percent grant in lieu of the 67 percent grant and/or a 50-year loan term depending on the decision of the WWDC.

- The estimated sponsor’s share of total project cost would range from a low of $2,182,000 (for a 75 percent grant with an alternative using onsite borrow) to a high of $3,266,000 (for a 67 percent grant with an alternative using offsite borrow). The corresponding maximum range in monthly service fee increase for the existing 1800 customers (assuming no growth) would be $6.11 (onsite borrow, 75 percent grant, 50-year loan) and $10.15 (offsite borrow, 67 percent grant, 30-year loan).

13.2 Recommendations

Recommendations made pursuant to this study are summarized as follows:

- Initiate the negotiation process for acquisition of Basin A land. Include consideration of retaining the existing material resources to the greatest extent practical in order to avoid or minimize offsite borrow costs.

- Initiate land acquisition for the pumping station site and access road.

- Initiate water rights applications for storage in Basin A and for an enlargement of the diversion rights at the Smiths Fork diversion.
- Develop a water rights approach/strategy to identify and address potential issues. Complete additional water rights planning and investigations relative to the new reservoir. Include consideration of the one-fill rule as it may relate to the operation of the new reservoir; identify any other potential water rights issues and constraints in operation of the new facilities.

- Resurvey the Basin A site based on conditions existing at the time mining operations are completed.

- Collect bulk samples of available terrace sand and gravel materials at both the Basin A and Basin B sites (if there is a possibility of having to borrow from the Basin B site) and complete analyses of the full gradations including all oversize fractions.

- Perform additional final design site exploration including, but not limited to, the following tasks:
  - Confirm depth to competent bedrock along the exterior toe embankment drain alignment
  - Refine/confirm geotechnical properties and available quantities of all onsite material types
  - Investigate surficial materials and underlying shallow bedrock conditions on west facing slope below site (flanking Smiths Fork River valley adjacent to site)
  - Determine depth to underlying groundwater table (likely up to 50 feet or greater depth); install and monitor piezometers below the groundwater table

- Reevaluate overall materials availability and processing requirements based on resurvey of Basin A, additional site exploration, and bulk samples gradations.

- Explore further the potential for a Mineral Royalty Grant and a Bureau of Reclamation Water 2025 Challenge Grant as sources of additional project funding.

14.0 References

Bilodeau, Matt. 2008. Email to Chris Wichmann/SEH; Subject: Bridger Valley Reservoir, Level II Study; Corps of Engineers Cheyenne Field Office. June 12.


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Table 5.1-1 – Summary of Water Rights
Table 5.2-1 – BVJPB Stateline Release Schedule
Table 6.2-1 – Comparison of Inlet/Outlet Options
Table 7.2-1 – Final Cost Estimates
Table 7.2-2 – Final Cost Estimates – Detail
Table 8.0-1 – Summary of Estimated Project Capital Costs
Table 8.0-2 – Project Financing Summary
Table 8.0-3 – Estimated Rate Increases per Tap per Month
Table 1.2-1
Alternative Reservoir Site Locations

<table>
<thead>
<tr>
<th></th>
<th>Basin A</th>
<th>Basin B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latitude</td>
<td>41.2384</td>
<td>41.246</td>
</tr>
<tr>
<td>Longitude</td>
<td>110.3684</td>
<td>110.3539</td>
</tr>
<tr>
<td>Township</td>
<td>15N</td>
<td>15N</td>
</tr>
<tr>
<td>Range</td>
<td>115W</td>
<td>115W</td>
</tr>
<tr>
<td>Section</td>
<td>34</td>
<td>26</td>
</tr>
<tr>
<td>QtrQtr Section</td>
<td>SENW</td>
<td>SWSW</td>
</tr>
<tr>
<td>Property</td>
<td>Contact</td>
<td>Phone</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>--------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Rees, Blaine &amp; JDBA Rees Enterprises</td>
<td>Kevin Kondus</td>
<td>307-780-7419</td>
</tr>
<tr>
<td>Swearengin Trust</td>
<td>Donna Gourley</td>
<td>none found</td>
</tr>
<tr>
<td>Earhart, Jeannie</td>
<td>Jeannie Earhart</td>
<td>307-875-5437</td>
</tr>
<tr>
<td>Lupher, James W &amp; Myrna C Family Trust</td>
<td>James Lupher</td>
<td>370-782-6314</td>
</tr>
<tr>
<td>Hamblin, Timothy J &amp; Aimee D</td>
<td>Tim Hamblin</td>
<td>307-747-1705</td>
</tr>
<tr>
<td>Landers, Gregg</td>
<td>No contact made</td>
<td>Outlet Pipeline</td>
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</table>
Table 3.0-1
Comparison Overview of Water Storage Sites

<table>
<thead>
<tr>
<th>Factor</th>
<th>Alternative Sites</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geologic/Geotechnical (Foundation) Conditions</td>
<td>Basin A</td>
<td>Basin B</td>
</tr>
<tr>
<td>Site Topography/Earthwork Grading Requirements</td>
<td>Basin A</td>
<td>Basin B</td>
</tr>
<tr>
<td>Borrow Quality/Source Availability</td>
<td>questionable quality</td>
<td>favorable, but uncertain access</td>
</tr>
<tr>
<td>Land Ownership/Site Availability</td>
<td>favorable</td>
<td>potential issue</td>
</tr>
<tr>
<td>Water Quality Seepage Inflow Issues</td>
<td>favorable</td>
<td>potential issue</td>
</tr>
<tr>
<td>Water Delivery and Return to Treatment Plant</td>
<td>favorable</td>
<td>less favorable</td>
</tr>
<tr>
<td>Pumping Costs</td>
<td>favorable</td>
<td>less favorable</td>
</tr>
<tr>
<td>Flow Circulation to Prevent Stagnation</td>
<td>favorable</td>
<td>less favorable</td>
</tr>
<tr>
<td>Site Access</td>
<td>favorable</td>
<td>less favorable</td>
</tr>
<tr>
<td>Dam Hazard Rating</td>
<td>uncertain</td>
<td>potential issue</td>
</tr>
<tr>
<td>Loss of Irrigated Land</td>
<td>favorable</td>
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</tr>
<tr>
<td>Multiple Use Potential</td>
<td>favorable</td>
<td>potential issue</td>
</tr>
<tr>
<td>Land Cost</td>
<td>favorable</td>
<td></td>
</tr>
<tr>
<td>Total Project Cost</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Legend:
- favorable
- less favorable
- uncertain
- potential issue
Based on prior exploration/testing, expect dispersive clay in alluvium/colluvium and/or weathered claystone underlying both sites. When subject to sufficient gradient (driving force from water head) particles can migrate leading to leaks/piping and potential failure. Likely solution requires provision of a liner.

Reportedly mined to clay/claystone bottom in Basin A; expect weathered claystone overlain with terrace deposits in Basin B - both foundations potentially contain dispersive clay; Basin B may contain soft compressible soils above foundation bedrock.

Water levels in the Basins are anticipated to have a large range (full to near empty) suggesting the potential need for erosion protection for near full height of embankments (depending on embankment materials/slopes). If a membrane liner is used it may provide adequate protection. Basin A sands and gravels have been mined out leaving no onsite source for soil cement slope protection; Access to sand and gravels in vicinity of Basin B is presently uncertain but may prove acceptable for embankment erosion protection.

If embankments are constructed with dispersive clays, an embankment liner would be anticipated. If granular materials are utilized for embankment construction it may be possible to omit embankment liners depending on fines content and gradation (effect on foundation), liners are anticipated for the floor of Basins A and B and the upslope side of Basin B to limit seepage inflows.
### Table 5.1-1
Summary of Water Rights

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<tr>
<th>RKey</th>
<th>Appropriation</th>
<th>Tow</th>
<th>Ten</th>
<th>Quarter</th>
<th>Rec</th>
<th>Lots</th>
<th>Additional Description</th>
<th>Acres</th>
<th>HML Date</th>
<th>Sw Permit</th>
<th>Supply Type</th>
<th>SW Permit Facility Name</th>
<th>SW Permit Applicant</th>
<th>SW Permit Priority</th>
<th>SW Permit Amount</th>
<th>SW Permit Unit</th>
<th>SW Permit Source</th>
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<tr>
<td>P12810</td>
<td>28810D</td>
<td>15</td>
<td>N</td>
<td>153</td>
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<td>24</td>
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<td>0</td>
<td>X</td>
<td>REJ</td>
<td>ORI</td>
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<td>Bridger Valley Joint Powers Board</td>
<td>4/28/1979</td>
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<td>CFS</td>
</tr>
<tr>
<td>P13024</td>
<td>3024D</td>
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<td>N</td>
<td>153</td>
<td>W</td>
<td>24</td>
<td>1</td>
<td>NONE</td>
<td>0</td>
<td>X</td>
<td>REJ</td>
<td>ORI</td>
<td>Miller River Pipeline</td>
<td>Bridger Valley Joint Powers Board</td>
<td>4/28/1979</td>
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<td>Varies</td>
<td>Varies</td>
<td>X</td>
<td>X</td>
<td>A0</td>
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<tr>
<td>P12807</td>
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<td>Varies</td>
<td>Varies</td>
<td>Varies</td>
<td>X</td>
<td>X</td>
<td>A0</td>
<td>ORI</td>
<td>MUN</td>
<td>Miller River Pipeline - Statue Dam</td>
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<td>ORI</td>
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<td>ORI</td>
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<td>ORI</td>
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<td>Bridger Valley Joint Powers Board</td>
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<td>ORI</td>
<td>MUN</td>
<td>Miller River Pipeline - Statue Dam</td>
<td>Bridger Valley Joint Powers Board</td>
<td>4/28/1979</td>
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<td>A0</td>
<td>ORI</td>
<td>MUN</td>
<td>Miller River Pipeline - Statue Dam</td>
<td>Bridger Valley Joint Powers Board</td>
<td>4/28/1979</td>
<td>0</td>
<td>CFS</td>
<td>Smith's Fork Creek</td>
<td></td>
</tr>
</tbody>
</table>

**Legend:**

- **Status:**
  - ADJ: Adjudicated
  - AME: Amended (lands moved to new location no longer under this permit)
  - PUD: Point of Diversion (Not actual status)
  - REJ: Rejected by the State Engineer
  - TRA: Transferred to another facility
  - UNA: Unadjudicated

- **Supply Types:**
  - ORI: Original supply
  - NW: New water
  - SE: State water
  - MIS: Miscellaneous

- **Permit Uses:**
  - IND: Industrial
  - MUN: Municipal

- **Record Suffixes:**
  - D: Ditch or pipeline permit
  - E: Enlargement of a ditch or pipeline permit

**Quarters:**

- 1: NE 1/4 SW 1/4
- 2: NW 1/4 SW 1/4
- 3: SE 1/4 SW 1/4
- 4: SW 1/4 SW 1/4
- 5: NE 1/4 NW 1/4
- 6: NW 1/4 NW 1/4
- 7: SE 1/4 NW 1/4
- 8: SW 1/4 NW 1/4
- 9: NE 1/4 NW 1/4
- 10: NW 1/4 NW 1/4
- 11: SW 1/4 NW 1/4
- 12: SE 1/4 NW 1/4
- 13: NE 1/4 SE 1/4
- 14: NW 1/4 SE 1/4
- 15: SW 1/4 SE 1/4
- 16: SE 1/4 SE 1/4
**Table 5.2-1**  
BVJPB's Contractual Storage in Stateline Reservoir

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<thead>
<tr>
<th>Date</th>
<th>Maximum Reservation of Storage (ac-ft)(^1)</th>
<th>Storage Available for Release (ac-ft/mo)</th>
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<td><strong>Irrigation Season</strong></td>
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<tr>
<td>June 1</td>
<td>800</td>
<td>60</td>
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<tr>
<td>July 1</td>
<td>740</td>
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<td>August 1</td>
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<td>September 1</td>
<td>240</td>
<td>240</td>
</tr>
<tr>
<td>October 1</td>
<td>0</td>
<td>0</td>
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<tr>
<td>October 1 - June 1</td>
<td>700</td>
<td>700(^2)</td>
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<tr>
<td><strong>Non-Irrigation Season</strong></td>
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</table>

\(^1\) Values presented under "Irrigation Season" apply to 800 ac-ft irrigation season water storage only  
\(^2\) 700 ac-ft to be released between October 1 and June 1; schedule of release as agreed by parties to storage contract
Table 6.2.1
Comparison of Inlet/Outlet Options

<table>
<thead>
<tr>
<th>Factor - Criteria</th>
<th>Original Concept Single Inlet/Outlet but relocated to North end of Site</th>
<th>Proposed Concept Separate Inlet and Outlet at Opposite ends of Site</th>
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<tbody>
<tr>
<td>1</td>
<td>Enables release of low-turbidity water during spring</td>
<td>Yes - see Factor 2 qualifications</td>
</tr>
<tr>
<td>2</td>
<td>Enables release of stored water during summer/fall of dry years</td>
<td>To population 8250 with release of water in spring for high turbidity To population 11,000 if not drawn down in spring due to water turbidity</td>
</tr>
<tr>
<td>3</td>
<td>Enables release of stored water during summer/fall of normal years</td>
<td>To population 11,500 with release of water in spring for high turbidity</td>
</tr>
<tr>
<td>4</td>
<td>Ability to circulate flow</td>
<td>No</td>
</tr>
<tr>
<td>5</td>
<td>Ability to use for sediment removal in spring</td>
<td>No</td>
</tr>
<tr>
<td>6</td>
<td>Potential for increased usable release (yield) from storage as compared to prior Level II Study (including reduction to either option in yield to address estimated evaporative losses)</td>
<td>100 acre-ft net reduction</td>
</tr>
<tr>
<td>6</td>
<td>Sediment removal requirements</td>
<td>No change - addressed at WTP</td>
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<tr>
<td>7</td>
<td>Water Rights issues</td>
<td>No change</td>
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<tr>
<td>8</td>
<td>ROW requirements</td>
<td>Reduction from original plan due to relocating pumping station to north end of site</td>
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<tr>
<td>9</td>
<td>Operational Flexibility</td>
<td>No change</td>
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<tr>
<td>10</td>
<td>Power costs for pumping</td>
<td>No change</td>
</tr>
<tr>
<td>11</td>
<td>Project capital cost</td>
<td>No Change</td>
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</table>
### Table 7.2-1
**Final Cost Estimates**

<table>
<thead>
<tr>
<th>Description</th>
<th>Onsite Borrow</th>
<th>Offsite Borrow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation of Final Designs and Specifications</td>
<td>$ 630,000.00</td>
<td>$ 710,000.00</td>
</tr>
<tr>
<td>Permitting and Mitigation</td>
<td>$ 65,000.00</td>
<td>$ 115,000.00</td>
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<tr>
<td>Legal Fees</td>
<td>$ 50,000.00</td>
<td>$ 60,000.00</td>
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<tr>
<td>Acquisition of Access and Rights of Way</td>
<td>$ 609,000.00</td>
<td>$ 704,000.00</td>
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<tr>
<td><strong>Cost of Project Components</strong></td>
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<td></td>
</tr>
<tr>
<td>Access Road Improvements</td>
<td>$ 70,000.00</td>
<td>$ 70,000.00</td>
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<tr>
<td>Pump Station</td>
<td>$ 378,000.00</td>
<td>$ 378,000.00</td>
</tr>
<tr>
<td>Inlet Piping and Inlet Structure</td>
<td>$ 62,500.00</td>
<td>$ 62,500.00</td>
</tr>
<tr>
<td>Outlet</td>
<td>$ 352,175.00</td>
<td>$ 352,175.00</td>
</tr>
<tr>
<td>Liner</td>
<td>$ 1,615,485.00</td>
<td>$ 1,670,355.27</td>
</tr>
<tr>
<td>Embankment</td>
<td>$ 2,252,340.00</td>
<td>$ 2,784,219.44</td>
</tr>
<tr>
<td>Erosion Protection</td>
<td>$ 309,015.00</td>
<td>$ 357,752.16</td>
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<tr>
<td>Miscellaneous</td>
<td>$ 24,300.00</td>
<td>$ 24,300.00</td>
</tr>
<tr>
<td><strong>Construction Cost Subtotal #1</strong></td>
<td>$ 5,063,815.00</td>
<td>$ 5,699,301.87</td>
</tr>
<tr>
<td>Engineering Costs = CCS#1 x 10%</td>
<td>$ 506,381.50</td>
<td>$ 569,930.19</td>
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<tr>
<td>Subtotal #2</td>
<td>$ 5,570,196.50</td>
<td>$ 6,269,232.05</td>
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<tr>
<td>Contingency = Subtotal #2 x 15%</td>
<td>$ 835,529.48</td>
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<tr>
<td><strong>Construction Cost Total</strong></td>
<td>$ 6,406,000.00</td>
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<td>Project Cost Total (2008 $)</td>
<td>$ 7,760,000.00</td>
<td>$ 8,799,000.00</td>
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<tr>
<td>Project Cost Total (2011 $)</td>
<td>$ 8,729,000.00</td>
<td>$ 9,898,000.00</td>
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## Table 7.2-2
### Final Cost Estimates - Detail

<table>
<thead>
<tr>
<th>Description</th>
<th>Onsite Borrow</th>
<th>Offsite Borrow</th>
<th>Major Component Price</th>
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<tr>
<td>Site cost</td>
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<tr>
<td>Site Royalty</td>
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<td>9,000,000.00</td>
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<tr>
<td><strong>Cost of Project Components</strong></td>
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<tr>
<td>Access Road Improvements</td>
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<tr>
<td>SCADA</td>
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<tr>
<td>Site Grading/Fencing and surfacing</td>
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<tr>
<td>Inlet Piping/Structure</td>
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<tr>
<td>Outlet Structure/Facilities</td>
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<td>Type D1 Coarse Upper Liner Cushion</td>
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<td>91,560.00</td>
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</tr>
<tr>
<td>Type C Medium Upper Liner Cushion</td>
<td>74,970.00</td>
<td>74,970.00</td>
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<tr>
<td>Liner</td>
<td>730,500.00</td>
<td>730,500.00</td>
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<tr>
<td>Internal Drainage Channel</td>
<td>12,600.00</td>
<td>12,600.00</td>
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<tr>
<td>Type D2 Fine Upper Liner Cushion</td>
<td>45,500.00</td>
<td>45,500.00</td>
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<tr>
<td>Type D2 Fine Lower Liner Cushion</td>
<td>49,000.00</td>
<td>49,000.00</td>
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</tr>
<tr>
<td><strong>Embankment</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type D1 Coarse Upper Liner Cushion</td>
<td>103,000.00</td>
<td>122,192.03</td>
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</tr>
<tr>
<td>Type D1 (Offsite)</td>
<td>22,890.00</td>
<td>22,890.00</td>
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<tr>
<td>Liner</td>
<td>390,960.00</td>
<td>390,960.00</td>
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</tr>
<tr>
<td>Type C Medium Lower Liner Cushion</td>
<td>96,380.00</td>
<td>96,380.00</td>
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<tr>
<td><strong>Embankment</strong></td>
<td>2,252,340.00</td>
<td>2,784,219.44</td>
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<tr>
<td><strong>Clearing</strong></td>
<td></td>
<td></td>
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<tr>
<td>Foundation Preparation</td>
<td>200,000.00</td>
<td>200,000.00</td>
<td></td>
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<tr>
<td>Toe Trench Excavation and Shaping</td>
<td>46,000.00</td>
<td>46,000.00</td>
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<tr>
<td><strong>Erosion Protection</strong></td>
<td></td>
<td>3,314,402.41</td>
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<tr>
<td><strong>Water Truck Fill Station</strong></td>
<td>15,000.00</td>
<td>15,000.00</td>
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</tr>
<tr>
<td><strong>Miscellaneous</strong></td>
<td>24,300.00</td>
<td>24,300.00</td>
<td></td>
</tr>
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</table>
Table 8.0-1
Summary of Estimated Project Capital Costs

<table>
<thead>
<tr>
<th>Description</th>
<th>Onsite Borrow</th>
<th>Offsite Borrow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other Project Costs</td>
<td>$ 1,354,000</td>
<td>$ 710,000</td>
</tr>
<tr>
<td>Construction Cost Total</td>
<td>$ 6,406,000</td>
<td>$ 7,210,000</td>
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<tr>
<td>Project Cost Total (2008 $)</td>
<td>$ 7,760,000</td>
<td>$ 8,799,000</td>
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<tr>
<td>Project Cost Total (2011 $)</td>
<td>$ 8,729,000</td>
<td>$ 9,898,000</td>
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</table>
### Table 8.0-2

**Project Financing Summary**

<table>
<thead>
<tr>
<th></th>
<th>50-Year Loan</th>
<th>30-Year Loan</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Onsite Borrow</td>
<td>Offsite Borrow</td>
</tr>
<tr>
<td><strong>Total Project Capital Cost</strong>&lt;sup&gt;1&lt;/sup&gt;</td>
<td>$8,729,000</td>
<td>$9,898,000</td>
</tr>
<tr>
<td><strong>Sponsor Cost</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33% Cost Share</td>
<td>$2,881,000</td>
<td>$3,266,000</td>
</tr>
<tr>
<td>25% Cost Share</td>
<td>$2,182,000</td>
<td>$2,475,000</td>
</tr>
<tr>
<td><strong>Annualized Debt Share of Project Costs</strong>&lt;sup&gt;2&lt;/sup&gt;</td>
<td>$134,100</td>
<td>$152,000</td>
</tr>
<tr>
<td>33% Cost Share</td>
<td>$101,600</td>
<td>$115,200</td>
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<tr>
<td><strong>Operations &amp; Maintenance Costs (O&amp;M)</strong></td>
<td>$30,400</td>
<td>$30,400</td>
</tr>
<tr>
<td><strong>Total Annual Sponsor Cost - Debt Service &amp; O&amp;M</strong></td>
<td>$164,500</td>
<td>$182,400</td>
</tr>
<tr>
<td>33% Cost Share</td>
<td>$132,000</td>
<td>$145,600</td>
</tr>
<tr>
<td>25% Cost Share</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Estimates are rounded to the nearest 1000 dollars
2. Annualized cost based on 4% interest, estimates are rounded to the nearest 100 dollars
### Table 8.0-3
Estimated Rate Increases per Tap per Month

<table>
<thead>
<tr>
<th>50-Year Loan</th>
<th>30-Year Loan</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Onsite Borrow</td>
</tr>
<tr>
<td><strong>Total Annual Sponsor Cost - Debt Service &amp; O&amp;M</strong></td>
<td></td>
</tr>
<tr>
<td>33% Cost Share</td>
<td>$164,500</td>
</tr>
<tr>
<td>25% Cost Share</td>
<td>$132,000</td>
</tr>
<tr>
<td><strong>Monthly Rate Increase per Tap - 1800 Taps</strong>&lt;sup&gt;1&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>33% Cost Share</td>
<td>$7.62</td>
</tr>
<tr>
<td>25% Cost Share</td>
<td>$6.11</td>
</tr>
<tr>
<td><strong>Monthly Rate Increase per Tap - 1.5% yr growth in Taps</strong>&lt;sup&gt;2&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>33% Cost Share</td>
<td>$5.48</td>
</tr>
<tr>
<td>25% Cost Share</td>
<td>$4.39</td>
</tr>
</tbody>
</table>

<sup>1</sup> Estimates are based on 1800 taps currently on the total system
<sup>2</sup> Estimates assume 1.5% per year increase in taps from the 1800 taps currently on the total system
List of Figures

Figure 1.2-1 – Location Map
Figure 2.1-1 – Land Ownership Map
Figure 4.2-1 – Preliminary Geologic Map
Figure 4.2-2 – Seismotectonic Map
Figure 6.2-1 – Existing Pipeline Profile
Figure 7.1-1 – Elevation vs. Capacity
Figure 7.1-2 – Liner Photos
Figure 7.1-3 – Steady Seepage Slope Stability
Figure 7.1-4 – Pseudo-Static Slope Stability
Figure 11.2-1 – Preliminary Wetlands Map
## Figure 7.1-1

**Elevation vs. Capacity**

<table>
<thead>
<tr>
<th>Reservoir Surface Elevation</th>
<th>Surface Area (ac)</th>
<th>Volume (af)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7029</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>7030</td>
<td>0.6</td>
<td>0.3</td>
</tr>
<tr>
<td>7035</td>
<td>1.4</td>
<td>5.3</td>
</tr>
<tr>
<td>7040</td>
<td>5.9</td>
<td>23.6</td>
</tr>
<tr>
<td>7045</td>
<td>14.7</td>
<td>75.2</td>
</tr>
<tr>
<td>7050</td>
<td>22.4</td>
<td>168.0</td>
</tr>
<tr>
<td>7055</td>
<td>35.2</td>
<td>312.1</td>
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<tr>
<td>7060</td>
<td>39.6</td>
<td>499.1</td>
</tr>
<tr>
<td>7066</td>
<td>42.0</td>
<td>743.9</td>
</tr>
</tbody>
</table>
Bridger Valley Embankment
10 most critical surfaces, MINIMUM JANBU FOS = 1.732
Bridger Valley Embankment Pseudo Sta
10 most critical surfaces, MINIMUM JANBU FOS = 1.335
List of Sheets

Sheet 7.1 – Site Plan
Sheet 7.2 – Pumping Station and Water Truck Fill Station Plans
Sheet 7.3 – Outlet Works/Delivery Pipeline
Sheet 7.4 – Embankment Sections
EXISTING 14" AC PIPELINE FROM SMITH'S FORK DIVERSION/PROPOSED BASIN & RESERVOIR

INSTALL 14" X 14" X 8" TEE

8" TRUCK FILL LINE
(6" DIP)
+- 300 LF

TANK FILL PLAN

4" STEEL TRUCK FILL PIPE

2" PVC DRAIN

NOTE: PUMPS ARE 694 GPM AT 72 TDH, 20 BHP

PUMPING STATION PLAN

SCHEMATIC ELEVATION
Appendix A
Scoping and Project Meetings
Bridger Valley Reservoir Project
Level II Study

Scoping Meeting

Presentation for:
Wyoming Water Development Commission
and
Bridger Valley Joint Powers Board

by:
Short Elliott Hendrickson Inc.
Anderson Consulting Engineers, Inc.
Plumley & Associates, Inc.

June 13, 2007
Roles and Communication

WWDC

SEH Team

BVJPB
Primary Objectives

• Early comparison of Basin A and Basin B potential storage sites and recommendation of preferred site

• Efficient, technically sound evaluations/analyses of selected site

• Functional, cost-effective designs of water delivery and storage facilities
Key Issues/Considerations

- Geologic/geotechnical conditions
- Water quality considerations
- Water rights/availability for storage
- Multiple use benefits
- Environmental and other permitting, mitigation, and ROW requirements
- Project economics and financing
Water Supply and Storage Alternatives
## Comparison of Water Storage Sites

<table>
<thead>
<tr>
<th>Factor</th>
<th>Alternative Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Basin A</td>
</tr>
<tr>
<td>Geologic/Geotechnical (Foundation) Conditions</td>
<td></td>
</tr>
<tr>
<td>Borrow Availability/Quality</td>
<td></td>
</tr>
<tr>
<td>Earthwork Grading Requirements/Opportunities</td>
<td></td>
</tr>
<tr>
<td>Water Quality Conditions/Issues</td>
<td></td>
</tr>
<tr>
<td>Environmental Conditions/Issues</td>
<td></td>
</tr>
<tr>
<td>Multiple Use Potential</td>
<td></td>
</tr>
<tr>
<td>Land Ownership/ROW</td>
<td></td>
</tr>
<tr>
<td>Cost (Construction, Permitting, Legal, Land, O&amp;M)</td>
<td></td>
</tr>
<tr>
<td>Other factors (TBD)</td>
<td></td>
</tr>
</tbody>
</table>
Water Rights

• Direct flow rights
  – Smiths Fork River
  – Blacks Fork River

• Storage rights (Stateline Reservoir)
  – Contract terms
  – Winter releases/instream flows

• Other water users
  – Irrigation diversions
  – Multiple use potential
Water Supply Design and Costing

• Identify and characterize key system components:
  – Pump Station
  – Inlet/Outlet Piping
  – Valving
  – Controls

• Size components and select material types

• Estimate costs based on appropriate unit prices, lump sums, or percentage of construction/project costs
Geologic/Geotechnical Issues

• Fatal flaw approach

• Key issues
  – Foundation strength/settlement
  – Reservoir rim permeability
  – Seismicity
  – Water quality

Basin A

Basin B
Site Seismicity
Geologic/Geotechnical Investigations

- Geologic mapping
- Subsurface exploration
  - Drilling/in situ water loss testing
  - Test pitting
- Laboratory testing
  - Geotechnical
  - Soil/water chemistry
Storage Basin Design and Cost Estimating

• Basin configuration
  – Review Level II/Phase II concept
  – Develop most efficient/cost-effective concept

• Key design factors
  – Foundation strength/compressibility
  – Groundwater/runoff inflow
  – Seepage/leakage
  – Seismic stability
  – Slope protection
  – Flood protection

• Cost estimating
  – Appropriate unit, lump sum, percentage prices
  – Non-construction items
Basin A Alternative

BASIN A STORAGE SITE
Basin A Alternative

BASIN A CROSS SECTION
Basin B Alternative

PROPOSED LEVEL II, PHASE II LAYOUT

ALTERNATIVE LAYOUT

PROPOSED JACK HOLLOW DAM
CREST ELEV. 7045'

BASIN B STORAGE SITE
Basin B Alternative
Permitting and Mitigation

• Identify all key permits, clearances, and environmental issues
• Perform pre-application consultation(s)
• Conduct field reconnaissance
• Characterize permits
  – Application requirements
  – Environmental studies/evaluations
  – Scheduling
Project Economics and Financing

• Estimate annualized debt repayment (WWDC criteria)
• Estimate annual O&M costs
• Identify and characterize potential multiple use benefits (recreation, environmental, other)
• Develop proposed financing plan
  – WWDC loan/grant program
  – USDA Rural Utility Service program
  – Other potential partners (WGFD, Uinta County, Towns of Mountain View and Lyman)
  – BVJPB commitment (rates, tap fees)
## WORK SCHEDULE

### BRIDGER VALLEY RESERVOIR PROJECT, LEVEL II STUDY

<table>
<thead>
<tr>
<th>Task</th>
<th>Task Description</th>
<th>2007</th>
<th>2008</th>
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<tbody>
<tr>
<td>1</td>
<td>Scoping and Project Meetings</td>
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<td><img src="image" alt="" /></td>
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<tr>
<td>2</td>
<td>Access</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Obtain Geotechnical Data for Basins A and B</td>
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<td></td>
</tr>
<tr>
<td>4</td>
<td>Site Survey and Investigations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Review of Water Rights</td>
<td></td>
<td></td>
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<tr>
<td>6</td>
<td>Develop Water Delivery Systems for Basins A and B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Conceptual Designs and Cost Estimates</td>
<td></td>
<td></td>
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<tr>
<td>8</td>
<td>Economic Evaluation of Proposed Designs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Develop Multiple Use Benefits for Basins A and B</td>
<td></td>
<td></td>
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<tr>
<td>10</td>
<td>Rights-of-Way</td>
<td><img src="image" alt="" /></td>
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<tr>
<td>11</td>
<td>Permitting and Mitigation</td>
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<td></td>
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<tr>
<td>12</td>
<td>Project Financing</td>
<td></td>
<td></td>
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<tr>
<td>13</td>
<td>Discretionary Task</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Draft, Final and Executive Summary Reports</td>
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<td><img src="image" alt="" /></td>
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<tr>
<td>15</td>
<td>Project Presentation</td>
<td><img src="image" alt="" /></td>
<td><img src="image" alt="" /></td>
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</tbody>
</table>

- ![](image) Conference or meeting
- ![](image) Deliverable
- ![](image) Scheduled effort
- ![](image) Intermittent effort
- ![](image) Discretionary work per WWDC direction
Questions and Answers
## Comparison Overview of Water Storage Sites

<table>
<thead>
<tr>
<th>Factor</th>
<th>Alternative Sites</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geologic/Geotechnical (Foundation) Conditions</td>
<td>Basin A</td>
<td>potential issue</td>
</tr>
<tr>
<td></td>
<td>Basin B</td>
<td>potential issue</td>
</tr>
<tr>
<td></td>
<td>Comments</td>
<td>Due to previously reported presence of dispersive clays in foundation, liner for bottom and sides of embankments at both sites may be required - additional sampling and laboratory analysis required to confirm needs.</td>
</tr>
<tr>
<td>Site Topography/Earthwork Grading Requirements</td>
<td>Basin A</td>
<td>potential issue</td>
</tr>
<tr>
<td></td>
<td>Basin B</td>
<td>potential issue</td>
</tr>
<tr>
<td></td>
<td>Comments</td>
<td>Basin A likely will likely require extensive embankment (on 3 sides); Basin B requires major dam or multiple smaller/longer dams, either with uneven topography making liner more difficult.</td>
</tr>
<tr>
<td>Borrow Quality/Source Availability</td>
<td>Basin A</td>
<td>questionable quality</td>
</tr>
<tr>
<td></td>
<td>Basin B</td>
<td>favorable, but uncertain access</td>
</tr>
<tr>
<td></td>
<td>Comments</td>
<td>Basin A sand and gravels have been mined out leaving no onsite source for soil cement slope protection, and requiring use of potentially dispersive clays in embankments; Access to sand and gravels in vicinity of Basin B is presently uncertain.</td>
</tr>
<tr>
<td>Land Ownership/Site Availability</td>
<td>Basin A</td>
<td>favorable</td>
</tr>
<tr>
<td></td>
<td>Basin B</td>
<td>potential issue</td>
</tr>
<tr>
<td></td>
<td>Comments</td>
<td>Mining operations at Basin A are near complete; Owner at Basin B indicated other planned uses for site - possible continued gravel mining and future irrigation reservoir usage.</td>
</tr>
<tr>
<td>Water Quality Seepage Inflow Issues</td>
<td>Basin A</td>
<td>favorable</td>
</tr>
<tr>
<td></td>
<td>Basin B</td>
<td>potential issue</td>
</tr>
<tr>
<td></td>
<td>Comments</td>
<td>Less seepage inflow to Basin A &amp; easier interception; upgradient seepage to Basin B similar to Jack Hallow may require interception behind liner.</td>
</tr>
<tr>
<td>Water Delivery and Return to Treatment Plant</td>
<td>Basin A</td>
<td>favorable</td>
</tr>
<tr>
<td></td>
<td>Basin B</td>
<td>less favorable</td>
</tr>
<tr>
<td></td>
<td>Comments</td>
<td>Basin A is close to raw water transmission line; Basin B is further from transmission line and requires a highway crossing.</td>
</tr>
<tr>
<td>Pumping Costs</td>
<td>Basin A</td>
<td>favorable</td>
</tr>
<tr>
<td></td>
<td>Basin B</td>
<td>less favorable</td>
</tr>
<tr>
<td></td>
<td>Comments</td>
<td>Greater pumping head to Basin B, both elevation change and due to pipe line length.</td>
</tr>
<tr>
<td>Flow Circulation to Prevent Stagnation</td>
<td>Basin A</td>
<td>favorable</td>
</tr>
<tr>
<td></td>
<td>Basin B</td>
<td>less favorable</td>
</tr>
<tr>
<td></td>
<td>Comments</td>
<td>Easier to implement separate inlet and outlet at Basin A.</td>
</tr>
<tr>
<td>Site Access</td>
<td>Basin A</td>
<td>favorable</td>
</tr>
<tr>
<td></td>
<td>Basin B</td>
<td>less favorable</td>
</tr>
<tr>
<td></td>
<td>Comments</td>
<td>Either is acceptable, but Basin A is adjacent to existing highway.</td>
</tr>
<tr>
<td>Dam Hazard Rating</td>
<td>Basin A</td>
<td>uncertain</td>
</tr>
<tr>
<td></td>
<td>Basin B</td>
<td>potential issue</td>
</tr>
<tr>
<td></td>
<td>Comments</td>
<td>Basin A requirements still undetermined, Basin B is a High Hazard Dam(s); both sites would have jurisdictional dams.</td>
</tr>
<tr>
<td>Loss of Irrigated Land</td>
<td>Basin A</td>
<td>favorable</td>
</tr>
<tr>
<td></td>
<td>Basin B</td>
<td>potential issue</td>
</tr>
<tr>
<td></td>
<td>Comments</td>
<td>May require use of existing irrigated land as part of reservoir.</td>
</tr>
<tr>
<td>Multiple Use Potential</td>
<td>Basin A</td>
<td>favorable</td>
</tr>
<tr>
<td></td>
<td>Basin B</td>
<td>favorable</td>
</tr>
<tr>
<td></td>
<td>Comments</td>
<td>Basin B has deeper portion allowing potential for fishery.</td>
</tr>
<tr>
<td>Land Cost</td>
<td>Basin A</td>
<td>favorable</td>
</tr>
<tr>
<td></td>
<td>Basin B</td>
<td>favorable</td>
</tr>
<tr>
<td></td>
<td>Comments</td>
<td>Undetermined</td>
</tr>
<tr>
<td>Total Project Cost</td>
<td>Basin A</td>
<td>favorable</td>
</tr>
<tr>
<td></td>
<td>Basin B</td>
<td>favorable</td>
</tr>
<tr>
<td></td>
<td>Comments</td>
<td>Undetermined</td>
</tr>
</tbody>
</table>
BVJPB Meeting 8/8/07

Kent Williams Lima Co. Planning 783-031P
Bill Kelly SEH 970-484-3611
Kevin Brown Sunrise Engineering 801-523-8100
Steve Muth UWR Water Div Comm 307-777-5417
Rocky Trick BVJPB 307-782-3196
Owen Peterson Legislature 307-782-6398
Dave Darby Town of Mt View 207-782-3100
Larry Rickert Lynn 307-782-8295
Ken Walker UEST 707-789-3682
MEMORANDUM

TO: File
FROM: Bill Kelly
DATE: August 14, 2007
RE: Bridger Valley Reservoir, Level II - Project Meeting
SEH No. AWWDCO0701.00

The focus of the meeting held on 8/08/07 was presentation of a comparative analysis completed by SEH regarding Basin A and Basin B. The two basins were evaluated for a variety of factors as listed on the attached table. The two figures, also attached, were used as exhibits to orient the audience to the location of the sites being evaluated. The Bridger Valley Joint Powers Board (BVJPB) selected Basin A for continued evaluation in detail, eliminating Basin B at this time. Consistent with this decision, SEH was verbally authorized by WWDC Project Manager Steve Muth to continue work on Basin A. Although SEH has been directed to complete detailed analysis of Basin A, WWDC and the BVJPB will be notified by SEH if a fatal flaw with Basin A is identified during the course of continued work.

Comments from the BVJPB and others in attendance included the following:

- Multiple-use potential must be addressed in detail – a thorough/descriptive list of uses should be provided for review and comment (e.g., bike/walking paths, bird habitat, fishing pond, surface recreation, etc.) – this topic has the potential to alter the funding from on the order of 75% to 90%.
- Water quality entering the basin is a significant concern – the BVJPB would be interested in seeing an analysis of the quality of water upgradient of Basin A [Note: a sample of ground water accumulated in a test pit will be sampled to represent upgradient water].
- Although the Bridger Valley system has not yet experienced a shortage of water for delivery to users, it does come close in late fall (October time frame) due to shortage of actual water in the river – a condition which could worsen in the future as municipal demands increase. Also, the potential for using the basin to pretreat water during periods of high turbidity was noted.
- Acquiring additional storage rights may be necessary to store water in the basin.
- The BVJPB and staff appeared to favor the provision of separate inlet and outlet to the basin for flexibility of operation (water quality management – circulation through Basin A and settling of turbid water during runoff).
- Preliminary discussion on a variety of topics occurred (e.g., initial findings of site exploration, site access and safety, stored water quality – stagnation, existing transmission lines /pumping plant and piping arrangements, etc.).
- A decision was made by the Board to continue work without additional contact with Basin A landowner (Blaine Rees) at this time, having contacted the current lease holder for permission to access the site and complete exploration. Further contact with Rees will be made by BVJPB when potential site use is better identified.

Attachments - Presentation Exhibits, partial list of attendees

- Steve Muth
- Doug Yadon

p:azw/www/doc/070100/meetings/aug 8_07 meeting - basin comparison/meeting_08-08-07_memo.doc
Bridger Valley Reservoir Project
Level II Study

Project Meeting

Presentation for:
Wyoming Water Development Commission
and
Bridger Valley Joint Powers Board

by:
Short Elliott Hendrickson Inc.
Anderson Consulting Engineers, Inc.
Plumley & Associates, Inc.

December 12, 2007
Presentation Topics

1. Land Ownership
2. Site Geology/Geotechnical
3. Site/Reservoir Layout
4. Water Delivery System
5. Multiple Use Potential
Land Ownership

1. Reservoir Site
   • Blaine Rees
   • Stanley & Wendy Rinker

2. Pumping Station Site
   • Swearengin Trust (Donna Gourley)

3. Pipe Line Alignment / Upgraded Access
   • Swearengin Trust (Donna Gourley)
   • Jeannie Earhart
Site Geology/Geotechnical

1. Materials Encountered & Quantities
   • Gravel - 286,000 cy (total currently present)
   • Sand - 119,000 cy; Sandstone (below required excavation grade)
   • Silt - 41,000 cy; Siltstone/Mudstone/Claystone - 29,000 cy
   • Weathered/fractured to 5-10 ft below surface of rock

2. Materials Suitability
   • Gravel – embankment, slope protection (requires processing)
   • Sand – embankment, bedding, filter, soil cement fine aggregate
   • Silt – waste, possibly fishing/swimming/wetlands berm
   • Sandstone – embankment (if needed)
   • Siltstone/Mudstone/Claystone - embankment

3. Embankment Configuration/Options
   • Foundation Seepage Cutoff
   • Interior Slope Liner (seepage control)
   • Erosion Protection (riprap, geocell, soil cement)
Site & Reservoir Layout

1. Property Ownership
2. Site Topography
3. Reservoir Capacity Requirements
4. Materials Balance
5. Subsurface Conditions
6. Multiple Purpose Use
7. Surface Drainage
8. Site Access
PRELIMINARY EARTHWORK ESTIMATES:
CUT = 476,000 CY
FILL = 446,000 CY

NHWL = 7065
TOP OF EMBANKMENT = 7070

EXISTING 14" WATER PIPELINE
PUMPING STATION & PIPELINE
INLET TO RESERVOIR
OUTLET STRUCTURE & PIPELINE
SITE ACCESS/PARKING/DAY USE AREA
Water Delivery System

1. Outlet at North End
   • Topography/drain reservoir
   • Multi-level draw

2. Inlet at South End
   • Circulation – avoid stagnation and support fishing/fishery
   • Potential sediment removal during spring runoff
   • Effectively increases reservoir capacity

3. Pumping Station at South End
   • Upgrade access along water line easement
   • Property ownership - Swearengin Trust (Donna Gourley)
   • Capacity range from 1.0 to 3.0 mgd

4. Use Existing 14-inch A.C. Pipeline as Supply and Release
Multiple Use Potential

1. Day Use Area – picnic/restroom area
2. Walking Trail(s) – along embankment crest and outside toe
3. Scenic Overlook – view of Smiths Fork/Blacks Fork Valley
4. Non-motorized Boating – canoe, rowboat, raft
5. Swimming – south (shallow end)
6. Fishing/Fishery – no connection to river; handicap access
7. Constructed Wetlands/Natural Wetlands Fringe
8. Tree/Shrub Plantings – avoid roots in embankment
9. Waterfowl Enhancement
**WORK SCHEDULE**

**BRIDGER VALLEY RESERVOIR PROJECT, LEVEL II STUDY**

<table>
<thead>
<tr>
<th>Task</th>
<th>Task Description</th>
<th>JUN</th>
<th>JUL</th>
<th>AUG</th>
<th>SEP</th>
<th>OCT</th>
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<td>3</td>
<td>Obtain Geotechnical Data for Basins A and B</td>
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<td>Site Survey and Investigations</td>
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<td>5</td>
<td>Review of Water Rights</td>
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<td>Develop Water Delivery Systems for Basins A and B</td>
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<td>Conceptual Designs and Cost Estimates</td>
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<td>Economic Evaluation of Proposed Designs</td>
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<td>Draft, Final and Executive Summary Reports</td>
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- ▲ Conference or meeting
- ■ Deliverable
- ▉ Scheduled effort
- □ Intermittent effort
- ⌈ Discretionary work per WWDC direction

**12-12-07**
Questions/Comments
TO: Aaron, SEH
FAX: 970-484-4118
FROM: LADONNA
PAGES: 1
DATE: September 23, 2008

COMMENTS:

I could not find a list but this is a list that I has present:
   Bob Stoddard - Chairman
   Mick Powers - Vice Chairman
   Gary Hutchinson – Board Member
   Jarrol Jeppesen – Board Member
   Dave Dasher - Treasurer
   Ken Walker – Uinta Engineering
   Steve Hanson – Sunrise Engineering
   Steve Muth – WWDC
   Doug Yadon – SHE
   Clayton Thomas – Attorney
   Rocky Irick – System Manager
   LaDonna Bugas – Office Manager
SEH attended and presented a status update at a Project Meeting at the Bridger Valley Joint Powers Board (BVJPB) water treatment plant (WTP) meeting room at 7:00 pm on Wednesday, December 12, 2007. A copy of the PowerPoint® presentation made at the meeting is attached. Several key issues were presented and discussed at the meeting that require confirmation and/or direction from you as the Wyoming Water Development Office (WWDO) Project Manager in order for SEH to continue developing the project and meet WWDO and Bridger Valley Joint Powers Board (BVJPB) objectives. Each of these issues is summarized separately as follows:

1) **Separate Inlet and Outlet Facilities**

**Issue:** SEH recommended that separate inlet and outlet facilities be included in the project design as opposed to the single combined facility described in the Level II study by Gannett Fleming. The proposed design concept allows for operational flexibility to achieve the following benefits: a) circulation through the basin to maintain/improve water quality throughout the year by reducing potential for stagnation; and b) provide for sediment removal during periods of high turbidity in the Smiths Fork River (which in turn provides potential alternative use of the currently targeted storage capacity as discussed below).

The modification would involve relocating the pumping station upstream to the south end of the site while the outlet would be located at the downstream (north) end of the site. Additional facilities associated with the alternative would include approximately 800 ft of pipeline and an inlet structure at the basin, together with improvement to the roadway along the existing water transmission pipeline at the toe of the slope below the proposed Basin A site. Estimated additional costs associated with the modification including engineering, contingencies and ROW total $125,000.

The previous Level II study allocated nearly half of the recommended 750 acre-feet of Basin A storage capacity for release to the WTP during periods of high turbidity (as often as every year if necessary). Under this scenario, the Smiths Fork flows that would otherwise have been diverted directly to the WTP during periods of high turbidity are not available for use by the BVJPB. With the separate inlet and outlet arrangement described above it appears feasible to divert the turbid Smiths Fork flows into Basin A and use the basin as a sediment trap. Clarified water from Basin A would be “passed through” to the WTP without having to release previously stored water. Note that this concept will require consideration of potential water rights implications (e.g., minor additional losses to evaporation due to routing the diverted flows through Basin A while maintaining an increased basin level instead of the practice of releasing stored water recommended in the previous study during periods of high turbidity, including possible implications relative to Wyoming’s “one fill” rule). Preliminary estimates for total net evaporation associated with either a single inlet/outlet or separate inlet and outlet configuration suggest...
approximately a 30-inch loss (or around 100 acre-feet per year) which would have to be subtracted from the storage calculated as available for release and use by the BVJPB at the WTP. This calculation is a change from the prior Level II study.

Preliminary estimates of future storage loss due to sediment accumulation indicate that it would not be a factor (estimates suggest that even with all flow routed through the basin that sediment accumulation over a fifty-year period would be expected to be less than 10 acre-feet). Solids accumulated at the storage basin would be less than historically removed at the WTP. This is due to the need for chemical addition to the turbid flows entering the WTP. Power costs associated with pumping should be similar for the two alternatives until growth reaches the design population limit for the single inlet/outlet option. Pumping costs should be similar since approximately the same amount of water must be pumped annually regardless of the inlet configuration unless the basin is used as a flow-through system year round.

The alternative operational mode using Basin A as a sediment trap in essence “frees up” 300-400 acre-feet of stored water. This “freed up” water would then be available to compensate for evaporative losses and support growth beyond what was originally allocated in the previous Level II study. This opportunity would be unavailable with the single inlet/outlet option.

In summary, with a separate inlet and outlet additional operational flexibility would be added and additional water would be made available for future growth by not having to draw down the basin during periods of high turbidity (or alternatively run high turbidity water directly to the WTP) as would be the case if a single inlet outlet is provided. Provision of a separate inlet and outlet could thereby extend both the life of the basin and/or that of the WTP at a capital cost increase for the project of around 2 percent ($125,000).

Refer to Table 1 for a tabular comparison of the various factors described above for both the single inlet/outlet and separate inlet and outlet configuration as compared to the prior Level II Plan. Estimates of storage requirements were prepared based on the procedure, available water estimate, and usage projections included in the previous Level II study except that 100 acre-feet of storage was allocated to cover anticipated evaporative losses. The estimate assumes lining of the basin as no seepage estimate was included.

Request: Please provide guidance/direction as to whether SEH should incorporate a combined inlet/outlet or a separate inlet and outlet as recommended in our design concept.

2) Multiple Use Benefits

Issue: A variety of potential multiple use benefits were presented and briefly described in the PowerPoint presentation at the meeting. During discussion of this topic, SEH heard some concerns regarding multiple uses and associated facilities. Our understanding was that these concerns included cost (capital and O&M), potential liabilities associated with public access, and expansion of the BVJPB’s responsibilities beyond providing treated water to their customers. The main overall benefit to including multiple uses in the project expressed at the meeting was the possibility of receiving a higher grant-to-loan ratio under legislatively authorized Wyoming Water Development Commission (WWDC) funding. Based on further review and discussions with your office it appears that potential multiple use options which could enable securing higher grant-to-loan funding for the currently proposed 750 acre-feet reservoir/basin are limited, if any. The reduced size of the basin (compared to the capacity envisioned at the Jack Hollow site) and the need to dedicate all of the stored water to its municipal purpose (as opposed to reserving/dedicating a portion to a multiple use) eliminate options such as a fishery that might have
involved other parties. Based on these considerations it is our understanding that further work on multiple use potential is not warranted. However, if deemed appropriate additional common/beneficial uses of the site could be incorporated in final design. It is not believed that those uses would enable securing an increased grant funding ratio for the project. An additional consideration is that current adjacent properties including the trucking operation (Rinker property) and salvage yard (Fausett property) may detract from the aesthetics of many potential uses.

**Request:** Please provide guidance/direction as to whether SEH should continue to pursue identification and evaluation of potential multiple uses under the current scope of work or cease effort on this topic. If the direction is to proceed, please provide guidance as to which of the proposed multiple uses and facilities should be pursued (or if all should continue to be addressed) and/or if there are other uses/facilities that should be considered.

3) Existing On-Site Gravel Resource

**Issue:** As noted during the presentation, the current Basin A earthwork design utilizes approximately 286,000 cy of terrace gravel present on site as part of the most efficient earthwork balance. To the degree that this material is utilized by the ongoing gravel pit operation, an alternative source of embankment fill will be required. If the quantity of gravel lost to ongoing production is relatively minor, it could be made up by deeper excavations within the dam and/or basin footprint (although at some impact to the earthwork balance and thus higher project cost, and possibly a “dead pool” that cannot be drained without pumping). Materials excavated under this scheme could include gravel, sandstone and/or siltstone/mudstone/claystone. Gravel would be preferred if it is intended to use the oversize fraction as riprap erosion protection. Alternatively, if the quantity of existing gravel lost to ongoing production is large, consideration should be given to using the existing gravel pit at the nearby Basin B site.

In any case, it is assumed that there would be a royalty cost for any gravel materials considered as a potential resource by the current owner. If the Basin B gravel pit was used, there would also be an additional haul and thus somewhat higher cost. Other options involving more remote quarries or borrow areas would be even more expensive due to potential permitting requirements and/or greater haul distance.

**Request:**

Please confirm our current understanding that BVJPB will contact lessee/gravel pit operator Kevin Kondus and/or land owner Blaine Rees regarding this issue. Information regarding Kondus’/Rees’ plans for use and/or royalty cost of these materials would be incorporated in SEH’s project design and cost estimating and could be considered in project implementation planning by BVJPB. Key information to request includes the planned use of the existing gravel on site (including total volume to be used and the rate at which it would be used) and the potential royalty cost for any gravel not used (or reserved for later use by BVJPB if an agreement to that effect could be negotiated). Based on our recent conversation and unless we are directed otherwise, we will continue under the assumption that the 286,000 cy of gravel noted above may NOT be available for the project and that pricing will include the assumption that the additional haul cost associated with Basin B gravel will be included.

4) Preservation of Rinker Property

**Issue:** A request was made by the BVJPB to preserve the existing Rinker property (and the current trucking operation thereon) outside the footprint of Basin A. A preliminary calculation indicates a loss of
approximately 10 percent of the targeted 750 acre-feet of storage capacity by realigning the embankment crest and keeping all other embankment and basin grading as is. Although it is possible to recover this “lost” approximately 70-80 acre-feet of storage by revising the earthwork grading plan, the total cost of the project (and thus the cost per acre-foot of storage) will increase. This is due to the greater ratio of embankment volume required per acre-foot of storage with the smaller surface area of the basin necessary to preserve the Rinker property. A preliminary estimate of the additional project cost to add back the lost storage is on the order of $250,000 more than our current site layout. However, although no estimate of land value has been made, the cost to acquire this land may easily offset the cost to preserve the property.

**Request:** Please confirm our understanding that we are to revise the current grading plan to preserve the Rinker property and retain the current targeted storage capacity of 750 acre-feet.
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<tr>
<th>Factor - Criteria</th>
<th>Original Concept</th>
<th>Proposed Concept</th>
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<tr>
<td>1 Enables release of low-turbidity water during spring</td>
<td>Yes - see Factor 2 qualifications</td>
<td>Yes</td>
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<tr>
<td>2 Enables release of stored water during summer/fall of dry years</td>
<td>To population 8250 with release of water in spring for high turbidity To population 11,000 if not drawn down in spring due to water turbidity</td>
<td>To population 11,000 with routing of turbid spring water through pond</td>
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<tr>
<td>3 Enables release of stored water during summer/fall of normal years</td>
<td>To population 11,500 with release of water in spring for high turbidity</td>
<td>To beyond population 12,000</td>
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<tr>
<td>4 Ability to circulate flow</td>
<td>No</td>
<td>Yes</td>
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<tr>
<td>5 Ability to use for sediment removal in spring</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>6 Potential for increased usable release (yield) from storage as compared to prior Level II Study (including reduction to either option in yield to address estimated evaporative losses)</td>
<td>100 acre-ft net <em>reduction</em></td>
<td>200-300 acre-ft net <em>increase</em></td>
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<tr>
<td>6 Sediment removal requirements</td>
<td>No change - addressed at WTP</td>
<td>No change - removal not required during life of facility</td>
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<tr>
<td>7 Water Rights issues</td>
<td>No change</td>
<td>Possible minor additional evaporative losses with increased pool level; possible operational constraints due to &quot;one-fill&quot; rule</td>
</tr>
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<td>8 ROW requirements</td>
<td>Reduction from original plan due to relocating pumping station to north end of site</td>
<td>Increased along Swearengin Trust to provide road access and pumping station location at south end of site</td>
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<tr>
<td>9 Operational Flexibility</td>
<td>No change</td>
<td>Increased</td>
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<tr>
<td>10 Power costs for pumping</td>
<td>No change</td>
<td>Slight potential increase if basin is used for sediment removal due to increased head in basin ($100 per year estimated increase - present population)</td>
</tr>
<tr>
<td>11 Project capital cost</td>
<td>No Change</td>
<td>$125,000 estimated increase (2% increase in total project cost)</td>
</tr>
</tbody>
</table>
To: Doug Yadon, SEH

From: Steve Muth, WWDO

Date: February 27, 2008

RE: Bridger Valley Reservoir, Level II – Project Meeting Results and WWDO Direction
SEH Contract No. 05SC0293240

On February 13, 2008, Bill Kelly and I presented and discussed with the Bridger Valley Joint Powers Board (BVJPB) the 4 issues that you discussed in SEH’s email memo dated January 24, 2008. The meeting was held in Mountain View, Wyoming. The above email memo was distributed to each of the BVJPB members for review prior to this meeting. In summary, the BVJPB had only a few questions on each issue and agreed to accept our recommendations on each of the 4 issues.

A summary of their responses and WWDO’s guidance to SEH is as follows:

1) Separate Inlet and Outlet Facilities
The BVJPB agreed to the designs/installation of separate inlet and outlet structures (as opposed to a single structure acting as both an inlet and outlet structure) in the proposed reservoir design.

The WWDO requests that SEH include separate inlet and outlet structures in the design and cost estimate of the proposed reservoir.

2) Multiple Use Benefits
The BVJPB no longer wishes to pursue multiple benefits as part of their proposed reservoir design.

The WWDO requests that SEH not include multiple benefits in the design and cost estimate of the proposed reservoir.

3) Existing On-Site Gravel Resource
The BVJPB agreed that the final design and cost estimate be calculated on the purchase of off-site construction material rather than assuming the use of existing on-site construction material located within the proposed reservoir site. The BVJPB will be responsible for contacting the landowner (Blaine Rees) regarding his plans for the site and establishing a budget for land cost. It would also be helpful to confirm that costs for gravel royalty are included in the land value (as discussed at the meeting). If already included in the land cost then adding an additional royalty for offsite materials may not be appropriate as the land cost would decrease if the gravel from Site A were depleted. Any additional information that the BVJPB can provide regarding land costs should be incorporated by SEH in the plan.

The WWDO requests that SEH include the purchase and use of off-site construction material for the purpose of completing the construction of the reservoir’s embankment in the design and cost estimate of the proposed reservoir.
4) Preservation of the Rinker Property
The BVJPB agreed to modifying the reservoir layout in order to preserve the Rinker property located adjacent to the proposed reservoir site. It was recognized that this action could add several hundred thousand dollars to the project cost, but that the alternative cost to acquire the land could offset the additional construction cost.

The WWDO requests that SEH not include the Rinker property in the design and cost estimate of the proposed reservoir.

Finally, SEH may contact the quarry operator at the proposed reservoir site in order to obtain cost estimates of materials needed for construction.

Feel free to call me if you have any questions with this memo.

Steve Muth
WWDO

cc: BVJPB
    Bill Kelly, Doug Yadon/SEH
Bridger Valley Reservoir Project
Level II Study

Project Presentation

Prepared for
Wyoming Water Development Commission
and
Bridger Valley Joint Powers Board
by
Short Elliott Hendrickson Inc.

August 13, 2008
Presentation Topics

• Overview and Background
• Purpose of Study
• Scope of Study
• Conceptual Design & Cost Estimates
• Permitting and Mitigation
• Economic Evaluation & Project Financing
Overview and Background

• Project Need
  - Fall shortage/dry periods
  - Spring runoff/turbidity
  - Growth

• Stateline Reservoir
  - Mandatory non-irrigation season release (700 acre-feet)
  - Need for downstream storage

• Prior Studies
  - 2004 Level I – Jack Hollow
  - 2006 Level II – Jack Hollow – Basins A & B
Purpose of Study

• Level II Study
• Evaluate Feasibility of 750 acre-feet Reservoir
  - Alternatives sites – Basins A & B
  - Store releases from Stateline Reservoir
  - Supply BVJPB water treatment plant
Scope of Study

Project Tasks:

• Compare/recommend alternative storage sites
• Complete field survey, site mapping and geologic/geotechnical investigations
• Develop water supply and release system
• Prepare conceptual designs
• Prepare capital and OM&R cost estimates
• Complete economic evaluation
• Identify land purchase, easement and ROW requirements
• Evaluate permit and mitigation requirements
Conceptual Design – Reservoir/Embankment

Key Factors Considered:

- Property ownership
- Site topography
- Reservoir capacity requirements
- Materials types and balance
- Subsurface conditions
- Drainage – surface and subsurface
- Inlet and outlet configuration
- Cost
STATIONS 0+00 TO 37+00

STATIONS 37+00 TO 47+00

STATIONS 47+00 TO 60+53

MATERIALS:

- **TYPE A**: Pittum Sand & Gravel Embankment Fill
- **TYPE B**: Select Pittum Processed Permeable Sand/Gravel
- **TYPE C**: Processed Sand Filter/Coarse Liner Cushion
- **TYPE D1**: Fine Liner Cushion
- **TYPE E**: Gravel, Drain
- **TYPE F**: Rippa
- **TYPE G**: Rippa Filter

NOTES:

1. NOT CRITICAL TO EMBANKMENT STABILITY. COLLECTS SEEPAGE FOR PUMPBACK TO RESERVOIR OR FOR GRAVITY DRAINAGE.

2. TYPE G RIPPAA IS PLACED AT 8" THICKNESS WITH NO RIPPAA FILTER FROM STATIONS 7+00 TO 12+50 AND 32+50 TO 42+50.

BRIDGER VALLEY RESERVOIR PROJECT, LEVEL II STUDY EMBANKMENT SECTIONS

PROJECT: 904333.00 DATE: 8/4/19 SHEET: 7.4

SEH
Conceptual Design - Water Delivery System

- **Outlet at North End**
  - Topography/drain reservoir
  - Multi-level draw

- **Inlet at South End**
  - Circulation – avoid stagnation
  - Potential sediment removal during spring runoff
  - Effectively increases useable yield by +/- 100%

- **Pump Station at South End**
  - Upgrade access along water line easement
  - Property ownership - Swearengin Trust
  - Capacity range from 1.0 to 3.0 mgd

- **Use Existing 14-inch A.C. Pipeline as Supply and Release**
NOTE: PUMPS ARE 694 GPM AT 78 TDH, 20 BHP
Cost Estimates

• Capital Cost
  - Onsite & offsite borrow
  - Quantities and unit prices

• Operations, Maintenance and Replacement Costs (OM&R)
  - Embankment monitoring, inspection & maintenance
  - Pump Station, power, labor & replacement
  - Estimated at $30,400 per year
## Table 7.2-1
Final Cost Estimates

<table>
<thead>
<tr>
<th>Description</th>
<th>Onsite Borrow</th>
<th>Offsite Borrow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation of Final Designs and Specifications</td>
<td>$ 630,000.00</td>
<td>$ 710,000.00</td>
</tr>
<tr>
<td>Permitting and Mitigation</td>
<td>$ 65,000.00</td>
<td>$ 115,000.00</td>
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<tr>
<td>Legal Fees</td>
<td>$ 50,000.00</td>
<td>$ 60,000.00</td>
</tr>
<tr>
<td>Acquisition of Access and Rights of Way</td>
<td>$ 609,000.00</td>
<td>$ 704,000.00</td>
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<tr>
<td>Cost of Project Components</td>
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</tr>
<tr>
<td>Access Road Improvements</td>
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<td>$ 70,000.00</td>
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<tr>
<td>Pump Station</td>
<td>$ 378,000.00</td>
<td>$ 378,000.00</td>
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<tr>
<td>Inlet Piping and Inlet Structure</td>
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<tr>
<td>Outlet</td>
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<tr>
<td>Liner</td>
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<td>Embankment</td>
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<td>Erosion Protection</td>
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<td>Miscellaneous</td>
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<td>Construction Cost Subtotal #1</td>
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<td>Engineering Costs = CCS#1 x 10%</td>
<td>$ 506,388.00</td>
<td>$ 569,936.69</td>
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<tr>
<td>Subtotal #2</td>
<td>$ 5,570,268.00</td>
<td>$ 6,269,303.55</td>
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<td>Contingency = Subtotal #2 x 15%</td>
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<tr>
<td>Construction Cost Total</td>
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<td>Project Cost Total (2008 $)</td>
<td>$ 7,760,000.00</td>
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<tr>
<td>Project Cost Total (2011 $)</td>
<td>$ 8,729,000.00</td>
<td>$ 9,898,000.00</td>
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</table>
Permitting and Mitigation

- Identify and characterize known or potential environmental issues
- Potential minor issues identified (wetlands) along access road to and at pump station
- Easily mitigated/Nationwide permit
- Surface water appropriation
  - Storage permit
  - Direct flow permit enlargement
- No major hurdles at Basin A reservoir site
Economic Evaluation and Project Financing

• WWDC Grant/Loan assumed
  - 67% / 33% standard
  - 75% / 25% also illustrated
  - 50-year and 30-year loan illustrated

• Assumed local financing of loan portion through service fee increase
  - Considered increase required at current 1800 system-wide taps and alternative at 1.5 % per year assumed growth
# Table 8.0-2
## Project Financing Summary

<table>
<thead>
<tr>
<th></th>
<th>50-Year Loan</th>
<th>30-Year Loan</th>
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<tr>
<td></td>
<td>Onsite Borrow</td>
<td>Offsite Borrow</td>
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<tr>
<td><strong>Total Project Capital Cost(^1)</strong></td>
<td>$8,729,000</td>
<td>$9,898,000</td>
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<tr>
<td><strong>Sponsor Cost(^1)</strong></td>
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<tr>
<td>33% Cost Share</td>
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<td>$3,266,000</td>
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<td>25% Cost Share</td>
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<tr>
<td><strong>Annualized Debt Share of Project Costs(^2)</strong></td>
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<tr>
<td>33% Cost Share</td>
<td>$134,100</td>
<td>$152,000</td>
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<td>25% Cost Share</td>
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<td><strong>Operations &amp; Maintenance Costs (O$M)</strong></td>
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<td><strong>Total Annual Sponsor Cost - Debt Service &amp; O&amp;M</strong></td>
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<tr>
<td>33% Cost Share</td>
<td>$164,500</td>
<td>$182,400</td>
</tr>
<tr>
<td>25% Cost Share</td>
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</table>

\(^1\) Estimates are rounded to the nearest 1000 dollars

\(^2\) Annualized cost based on 4% interest, estimates are rounded to the nearest 100 dollars
### Table 8.0-3
Estimated Rate Increases per Tap per Month

<table>
<thead>
<tr>
<th></th>
<th>50-Year Loan</th>
<th>30-Year Loan</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Onsite Borrow</td>
<td>Offsite Borrow</td>
</tr>
<tr>
<td><strong>Total Annual Sponsor Cost - Debt Service &amp; O&amp;M</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33% Cost Share</td>
<td>$164,500</td>
<td>$182,400</td>
</tr>
<tr>
<td>25% Cost Share</td>
<td>$132,000</td>
<td>$145,600</td>
</tr>
<tr>
<td><strong>Monthly Rate Increase per Tap - 1800 Taps</strong></td>
<td></td>
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</tr>
<tr>
<td>33% Cost Share</td>
<td>$7.62</td>
<td>$8.44</td>
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<tr>
<td>25% Cost Share</td>
<td>$6.11</td>
<td>$6.74</td>
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<tr>
<td><strong>Monthly Rate Increase per Tap - 1.5 %/yr growth in Taps</strong></td>
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<tr>
<td>33% Cost Share</td>
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<tr>
<td>25% Cost Share</td>
<td>$4.39</td>
<td>$4.85</td>
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</table>

1 Estimates are based on 1800 taps currently on the total system
2 Estimates assume 1.5% per year increase in taps from the 1800 taps currently on the total system
Questions and Answers
NAME

STEVE MUTH
Dave Dasher
Ralph Bradshaw
LaDonna Bugas
Bob Stoddard
Gary Hutchinson
Scott Dellinger
Mick Powers
Jarrod Jeppesen
Rockey Irick
Kenny Fackrell
Dean Redusan
Garrell Powell

ORG

WY WATER DEVELOPMENT

Town of Twin View

Town of Hyrum

Bjspb Office Manager

County Commissioner

Town of Hyrum

Town of Twin View

County Commissioner

Ft. Bridger Sewer

Bjspb System Manager

Bridger Valley Water Conservancy

Unto Engineering
Appendix B
Geologic/Geotechnical Investigations
Technical Memorandum

Date: 5/5/08

To: Doug Yadon and Bill Kelly
Short Elliott Hendrickson Inc.
2637 Midpoint Drive, Suite E
Fort Collins, CO 80525

From: Patrick Plumley, PG, CEG
Consulting Engineering Geologist
Plumley & Associates, Inc.

Project: Wyoming Water Development Commission
Bridger Valley Reservoir Level II Project

Subject: Preliminary Engineering Geologic Investigations
Bridger Valley Reservoir Site,
Uinta County, Wyoming

1.0 Introduction

This memorandum presents the results of Plumley & Associates, Inc.’s (PAI’s) preliminary engineering geologic investigations for the Bridger Valley Reservoir Project, Level II Study. The Bridger Valley Reservoir Project site is located in the western half of Section 34, T.14.N., R.115W approximately 6 miles southwest of Mountain View, Wyoming.

PAI performed the scope of work specified by Short Elliott Hendrickson Inc. (SEH), as part of the Bridger Valley Reservoir Project, Level II Study for the Wyoming Water Development Commission (WWDC). The primary purpose of the scope of work was to conduct preliminary surface and subsurface investigations for a screening level assessment of the foundation conditions and potential on-site borrow materials for preliminary design of the Bridger Valley Reservoir.

The work completed to date includes the following:

(1) Data Collection and Review. Prior to initiating geologic mapping, PAI researched and reviewed available published and unpublished geologic information relevant to the project. Primary sources of information are provided in the list of references at the end of this memorandum.

(2) Photogeologic Interpretation. PAI reviewed stereo-paired aerial photographs for the project area to assist in developing a preliminary engineering geologic map of the project area.

(3) Preliminary Geologic Mapping. PAI performed geologic mapping for the proposed embankment dam and reservoir foundation areas. Mapping for the site was performed using SEH’s topographic map prepared for the site with a scale of 1 inch = 200 feet with 2-foot elevation contour intervals.

(4) Subsurface Investigation. PAI coordinated and directed the test pit excavations and geotechnical exploration borings at the site. This work included recording the results of the exploration in the field on
(5) Analyses and Reporting. PAI evaluated the results of the surface mapping and subsurface investigation to develop a preliminary interpretation of the subsurface conditions at the site; and summarized our current understanding of the engineering geologic site conditions and geotechnical considerations as presented in this technical memorandum.

2.0 Surface and Subsurface Investigations

PAI’s engineering geologist performed preliminary geologic mapping to identify and map surficial materials (such as alluvium and terrace deposits) and bedrock units in the vicinity of the projects. The results of the geologic mapping for the Bridger Valley Reservoir site are provided on Figure B-1 at the end of this memorandum.

Surface and subsurface investigations were conducted between September 25 and 28, 2007. The subsurface investigations consisted of excavating 15 test pits and drilling 4 borings at the site. The exploration locations were accessed off existing dirt roads, two-track roads, and open fields. All subsurface exploration locations were located using a handheld Garmin GPS unit.

The backhoe test pits were excavated to expose, examine, and sample the shallow subsurface materials within the project vicinity. Test pits TP-A1 and TP-A2 were excavated on August 8, 2007 under the direction of Doug Yadon/SEH. The remaining test pits (TP-3 to TP-15) were excavated under the direction of Patrick Plumley on September 26, 2007. This report provides interpretations of the subsurface conditions based on the results of all of the available subsurface data collected for the site.

The test pits were excavated by Kevin Kondus who operates a sand and gravel mining operation that at the time of this investigation was located in the southern portion of the proposed reservoir area. The test pits were excavated using a trackhoe equipped with a 24-inch bucket. The test pits ranged from 6.5 to 13.0 feet deep and approximately 10 to 20 feet in length. After logging and sampling, the test pits were backfilled with the spoil material and covered with the topsoil stockpiled during excavation. The surface was then smoothed by tracking over the area with the trackhoe. The locations of the test pits at the site are shown on Figure B-1. Test pit logs are presented at the end of this memorandum.

LK Drilling of Green River, Wyoming, performed the drilling using a Simeco 2400 SK-1 truck-mounted drilling rig. The borings were advanced through the unconsolidated soil material and deeply weathered bedrock using either 4-inch ID hollow stem auger or 4½ inch OD solid flight augers. The depth of the borings ranged from 15 to 21.5 feet. Samples were collected at regular intervals (typically 5 feet) with a standard split-spoon sampler and using Standard Penetration Test (SPT) protocol (ASTM D1586-08). In brief, the samples were driven using a 140-pound mechanical hammer dropped 30 inches. The number of hammer blows required to drive the sampler was recorded for all of the drive samples to provide an indication of penetration resistance. Each sample was driven 18 inches or until refusal (defined as less than 6 inches of penetration after 50 blows). The number of blows required to drive the sampler for each 6-inch interval (or if the sampler met refusal, the inches of penetration after 50 blows) were recorded on the field logs. When the augers met refusal, or drive sampling became difficult due to the hardness or consolidation of the materials, the drilling was discontinued. The open boreholes were backfilled with bentonite chips. The locations of the borings are shown on Figure B-1. Engineering geologic field logs for these borings are presented at the end of this memorandum.

Falling head tests were attempted in some of the open, uncased borehole intervals to provide some preliminary information on the relative permeability of the formation materials encountered. The tests were
performed by removing the drill stem to expose the open borehole, filling the borehole with water and then monitoring the drop in elevation of the water level with an electric water level meter in the open borehole over time. However, these tests were determined to be unreliable in the field because of the auger drilling technique used and the tendency for the fine-grained materials to smear and seal off the native intrinsic (intact material) and secondary (i.e., fractures/joints) permeability in the borehole wall.

3.0 Regional Geologic Conditions

The Bridger Valley Reservoir site is situated in the southwestern portion of a broad structural depression that is known as the Green River Basin. The Green River Basin is bounded to the south by the east-west trending Uinta Mountains located about 25 miles south of the project. The bedrock within the basin consists of older Precambrian to Late Cretaceous rocks and younger Tertiary sedimentary rocks. The older Precambrian to Late Cretaceous rocks are exposed in uplifted mountainous areas along the margins of the basin covered by younger Tertiary-age rocks in the central portion of the basin. The sequence of Tertiary rocks reaches a thickness of several thousand feet near the center of the Green River Basin and at least 1,850 feet near Lyman (Robinove and Cummings, 1963).

The Tertiary sequence includes (from oldest to youngest) the Green River Formation, Wasatch Formation, Bridger Formation, Bishop Conglomerate and Browns Park Formation. However, in the vicinity of the project, the Bridger Formation is the only formation exposed at or near the surface (Robinove and Cummings, 1963). Erosion of the sediments within the Bridger Formation forms classic badlands topography. According to Bradley (1964) the Bridger Formation consists of predominately sandy tuffaceous mudstone of various colors including gray, dark green and chocolate brown. The mudstone contains local interbeds and lenses of cross-bedded, medium-grained, tuffaceous sandstone. The Bridger Formation is also noted to contain occasional thin limestone, marlstone, shale, clay and tuff beds (Bradley 1964). Observations of exposures located to the northeast and southwest of the project site indicate that the bedding within the Bridger Formation is generally flat lying (<5 degrees); and the overall appearance suggest that these rocks are generally undisturbed structurally (i.e., lack evidence of noticeable folding, faulting, or fracturing resulting from tectonic events).

The Bridger Formation is locally covered by Quaternary Terrace Deposits. The terrace deposits occur on benches located tens of feet up to approximately 100 feet above (and generally adjacent to) the active stream floodplains. In the region, these terrace deposits occur on Tipperary Bench, Cottonwood Bench, Nebraska Flats, and Lyman Bench. The terrace deposits are coarse-grained alluvial deposits that were deposited on an erosional surface by ancestral streams flowing from the Uinta Mountains. Stream downcutting left remnants of the former floodplains as terraces bordering new lower active floodplains. These terrace deposits consists of unconsolidated alluvial sand, gravel and silt that do not exceed 40 feet in thickness and are more typically 10-20 feet thick (Robinove and Cummings, 1963).

The proposed reservoir site is situated on Tipperary Bench. Most of the surface of Tipperary Bench was originally covered by terrace deposits. However, sand and gravel mining has removed a large percentage of the sand and gravel from Tipperary Bench within the project area.

4.0 Engineering Geologic Conditions

The interpreted geologic conditions in the vicinity of the reservoir site are illustrated in the geologic map and cross-section presented in Figures B-1to B-5. The following discussion provides a summary of our

---

1 Badlands topography refers to an intricately stream-dissected topography that develops on surfaces with little to no vegetation cover.
2 Containing volcanic ash particles.
3 Referring to the forces or conditions within the earth that cause movements of the crust.
interpretation of the subsurface conditions and geologic units (from oldest to youngest) across the reservoir site.

The entire site and slope bounding the west side of the site, is underlain by the Bridger Formation comprised of interbedded sandstone and fine-grained beds (predominately mudstone and siltstone). It is important to recognize that the subsurface investigation explored the conditions up to a depth of 21.5 feet. Therefore, the interpretive cross-sections provided on Figures B-2 to B-5, and the bedrock conditions described herein, reflect the shallow (<21.5 feet) bedrock conditions observed at the exploration locations across the site. The actual bedrock conditions below this depth may vary considerably from the near surface materials.

The results of the subsurface investigation were used to map the general distribution of two types of materials encountered within the Bridger Formation at the site: sandstone (map unit Tb1) and fine-grained materials (map unit Tb2). The subsurface results suggest that the sandstone unit occurs throughout the reservoir site. The sandstone unit consists of predominately medium- to fine-grained sandstone. The sandstone is dark olive colored, low hardness, weak to friable and weakly cemented with calcium carbonate. The upper few feet of the unit is generally closely fractured and the degree of fracturing appears to decrease with depth suggesting that most observed fractures are related to weathering and stress relief and not tectonically related. As described in Section 2, sampling was conducted at approximately 5-foot intervals using drive sampling techniques. Detailed fracture characterization at the site would require continuous sampling preferably using rotary coring techniques. Based on the observations of the intermittent drive samples it appeared that below a depth of between 5-10 feet (depending on location) from the top of this unit, fractures were observed to be less frequent and appeared to be relatively tight (i.e., hairline to 1/16 inch wide openings).

The fine-grained unit (Tb2) occurs as a bed overlying the sandstone unit (Tb1) in the southwestern portion of the reservoir site. The fine-grained unit also occurs as localized zones or lenses within the sandstone unit as shown on Cross-Sections A-A’, and D-D’. (Figures B-2 and B-5). The fine-grained unit is variable and includes mudstone, siltstone, and silty claystone with thin beds of tuff. The material is low hardness, weak to friable, and deeply weathered near the surface (upper few feet).

These two bedrock units are overlain by residual soil derived from the weathering of these weak bedrock materials. The sandstone unit (Tb1) is typically overlain by olive gray, fine to medium grain, dense sand (shown as unit QTr1 on the interpretive cross-sections). The thickness of this residual sand layer is variable and ranges from 0 to approximately 6 feet. The fine-grained bedrock unit (Tb2) is overlain by silty clay or silt soil (shown as unit QTr2 on the interpretive cross-sections) that ranges from 0 to approximately 5 feet thick.

The bedrock and associated residual soil layers are locally overlain by terrace deposits. As shown on the preliminary geologic map (Figure B-1), the terrace deposits cover the eastern portion of the site and occur in the highwall located along the southern margin of the site. Most of the site was originally covered by these terrace deposits. Sand and gravel mining has removed most of this material from the central and northern portions of the reservoir site. The current thickness of these deposits was highly variable across the site and ranged from 0 up to an estimated 22 feet along the centerline of the proposed reservoir embankment (Figures B-2 to B-5). We understand that active sand and gravel mining operations have continued at the site since the time of this field investigation. Therefore, the thickness and distribution of terrace deposit materials (and fill stockpiles associated with the mining operations) will vary from the conditions described herein as mining proceeds.

The mapping and subsurface investigations indicate that the terrace deposits (QTg) were generally deposited on a relatively flat to gently sloping surface. However, in the northern section of the embankment alignment, the base of the terrace deposit drops about 10 feet (i.e., TP -12, TP-13, and B-1); and then along the northeast segment of the reservoir embankment alignment the base of the terrace deposits drops another 10 feet (at TP-15). The drop in elevation of the base of the terrace alluvial material encountered in TP-15 suggests that there
is a buried channel in this area (as illustrated in Figure B-5). The actual dimensions and orientation of the apparent buried channel could not be determined based on the limited subsurface investigation.

The terrace deposits are characterized by light reddish brown color and mixture of cobbles and sand with lesser amounts of gravel. The estimated relative percentages of these materials by volume based on a visual observation of highwall exposures in the southwest corner of the reservoir area is approximately 40 to 50% cobbles with occasional boulders up to 2 feet in diameter; 30 to 40% fine- to medium-grained sand, and 10 to 20% gravel.

The Smiths Fork Valley located west and downslope of the reservoir site is underlain by alluvium. No exploration was conducted to evaluate the physical characteristics or depth of the alluvium.

Groundwater was encountered in a few of the exploration locations as shown in the test pit and boring logs (included at the end of this memorandum) and on the cross-sections (Figures B-2 to B-5). However, the subsurface investigation did not encounter a consistent water table condition within the depth of the exploration. Water that was encountered in a few isolated locations appears to be controlled by localized perched conditions.

**5.0 Geotechnical Considerations and Recommendation**

The terrace deposits and fill stockpiles derived from the terrace deposits are unconsolidated, coarse-grained materials that are presumed to contain high permeability zones. Appropriate measures to minimize the potential for seepage losses through the terrace and associated fill deposits located in the embankment foundation and reservoir floor area (such as over-excavation and replacement with low permeability fill, or installation of a liner) should be evaluated and incorporated into the embankment and reservoir design.

We understand that active sand and gravel mining operations have continued at the site since the time of this field investigation. Therefore, the thickness and distribution of terrace deposit materials (and fill stockpiles associated with the mining operation) along the embankment and reservoir floor areas within the mining area need to be further investigated and adjusted prior to final design and construction.

There is downward undulation in the top of the bedrock and base of the terrace deposits in the northern portion of the site. In addition, an apparent buried channel was encountered in a single test pit (TP-15) located along the northeast perimeter of the proposed embankment alignment. The extent and orientation of this buried channel in the vicinity of the proposed dam and reservoir is not known. If consideration is given during design to construct the reservoir without a liner, additional test pits and drilling and sampling should be performed to further evaluate this buried channel in the vicinity of the dam and reservoir. Appropriate measures to minimize the potential for seepage losses through the channel deposits should be incorporated into the embankment and reservoir design as described above.

Observations from the test pits and intermittent sampling of the borings indicates that the upper few feet (5-10 feet) of the bedrock material is highly weathered and contains abundant stress relief type fractures or partings. It is likely that this upper weathered material would need to be addressed relative to reservoir seepage if the reservoir is to be constructed without a liner. This would include evaluating the permeability of the weathered zone to determine if the material should be removed or seepage cutoff design features need to be incorporated in final design to minimize seepage. The visual observations of the bedrock materials beneath this weathered zone suggest that the deeper bedrock likely has a low to moderately low permeability. However, the results of this preliminary screening-level investigation are insufficient to provide a reasonable estimate of the bulk permeability of the bedrock beneath the site. Reliable estimates of the bulk permeability of the bedrock are required to evaluate the feasibility of constructing the reservoir without a liner. Additional subsurface exploration combined with in-situ permeability testing would be necessary to evaluate the
permeability of the bedrock materials beneath the site. This additional subsurface exploration would need to include continuous coring combined with single packer-type constant head permeability testing at approximate 10 foot intervals conducted as the borehole is advanced. The depth of these borings should extend at least 60 to 80 feet beneath the site. Large scale trench-type permeability tests designed to characterize the fractures in the bedrock and quantitatively evaluate the permeability of the bedrock should also be performed. It is important to note that even with additional drilling and in-situ permeability testing data there will be uncertainty regarding the actual permeability of the bedrock materials. Considering the size of the reservoir area, length of the embankment, and geologic and topographic setting, a relatively large number of borings and trench permeability test would likely be required to estimate the permeability of the bedrock to an acceptable level of certainty required to evaluate if it would be feasible to construct the reservoir without a liner. This additional exploration and testing would not be necessary if the reservoir is constructed with a liner.

A west facing slope that ranges from approximately 80 to 100 feet in height is located immediately at the west side of the reservoir site (Figure B-1). Bedrock in the slope is largely covered by thin (< 5 feet) residual and colluvial soils. Subsurface investigations were not conducted on this slope due to legal access constraints. However, our site reconnaissance of the slope did not reveal the presence of any significant landslide deposits or other related slope instability features. Therefore, the potential risk of landslide development under current conditions in this slope appears to be low. Subsurface investigation should be performed in the slope to verify the soil and bedrock conditions within this slope. If significant seepage through the embankment or reservoir floor were to occur it would likely emerge in this slope. Seepage in the slope could result in accelerated erosion and weathering (and softening) of the bedrock materials and increase pore pressures, all of which could potentially contribute to local destabilization of the slope. Additional investigation and testing needs to be performed to quantitatively evaluate the potential for seepage losses through the embankment foundation and reservoir floor as discussed previously.

The conditions along the eastern section of the dam embankment have been inferred based on surface reconnaissance and extrapolation of information collected in areas located west of the current embankment alignment. Access constrains and local presence of thick terrace deposits prohibited subsurface investigations in this area. Therefore, the subsurface conditions along the eastern margin of the proposed embankment alignment need to be explored and evaluated. This exploration should include a combination of borings and test pits.

The fine-grained unit (Tb2) (specifically the mudstone and silty claystone) and its overlying residual soil should be evaluated and tested to determine if this material is suitable as a source of low permeability material for use in an internal core of the embankment. The sandstone and terrace deposits should be evaluated for possible use for the outer zones of the embankment, or in a homogenous embankment.

We did not conduct any field investigations or reconnaissance to identify any potential rip rap borrow sources for the project. However, the regional geologic mapping indicates that there are no known sources of suitable rip rap materials located in near proximity (10 mile radius) of the site. One possible area to explore for rip rap materials is the foothills of the Uinta Mountains located approximately 25 miles south of the project.

6.0 References


**LIST OF FIGURES**

Figure B-1 Preliminary Geologic Map
Figures B-2 to B-6 Interpretive Geologic Cross-Sections A-A’ through D-D’

**LIST OF ATTACHMENTS**

Field Test Pit Logs
Field Geologic Boring Logs
TP-3

0-1.4: cobble, gravel and sand, medium dense, moist, light, reddish brown [TERRACE GRAVEL]

1.4-8.0: SAND (SP), olive-gray, medium to fine-grained, med. dense, mod. permeability [WEATHERED BRIDGER FM]

8.0-10: SANDSTONE, dark olive, low Hardness, friable, wet, closely fractured [BEDDING PLANE], 8' in spacing

TP-4

0-1.1: cobble w/ sand & gravel, reddish brown

1.1-2.4: SILTY CLAY (CL), medium gray, stiff w/ pods of CaCO3 to 1/2" diameter

2.4-8.0: SILTSTONE / TUFFACEOUS SILTSTONE, MEO. Gray, low Hardness, weak to friable, closely fractured, fracture hairline to 1/16" wide openings, deeply weathered; Authigenic indurated Tuffaceous

NOTE: W.O. Sample Taken @ 10:30 AM

TP-5

0-0.6: cobble, w/ sand in gravel

0.6-8.2: TUFFACEOUS SILTSTONE, MEO. Gray, low to mod. hardness, weak to friable becomes gradually harder w/ deep closely fractured; Flx on 3T, fracture 4'-8'; upper 2' wet

NO WATER ENCOUNTERED
**TP - 6**

- **0 - 0.5**: Cobbles w/ sand & gravel.
- **0.5 - 5.1**: Sand & silt, olive gray, dense to very dense, moist residual soil, red clay.
- **5.1 - 7.0**: Sandstone, dark olive, low hardness, friable, closely frac, no water.

**TP - 7**

- **0 - 1.8**: Cobbles w/ sand & gravel.
- **1.8 - 4.1**: Silt, brown, stiff, v. moist w/ fine sand, olive gray, dry.
- **4.1 - 6.8**: Silty claystone, medium gray, v. weak, soil like, residual soil.
- **6.8 - 9.0**: Silty claystone/mudstone, medium olive gray, low hardness, weak, same as TP-5.

**TP - 8**

- **0 - 3.2**: Cobbles w/ sand & gravel, reddish brown, dense.
- **3.2 - 8.0**: Silt, olive gray, stiff, moist, minor clay, residual soil, faint relic rock texture w/ occasional gravel, very muddy, few roots.
- **8.0 - 10**: Siltstone, medium olive gray, mod hard, weak.

No water.
TP-9

0 - 0.2: Cobble, Sand & Gravel

1.2 - 5.3: Sand (SP), Dark Olive, Dense, Moist, Residual Soil

5.3 - 7.6: Sandstone, Dark Olive, Medium Grained, Low Hardness, Friable

Same as TP-6

TP-10

0 - 2.5: Cobble, Sand & Gravel, QTS

0.2 - 5.0: Sand (SP), Dark Olive, Medium Grained, Dense, Residual Soil

5.0 - 8.0: Sandstone, Medium Grained, Dark Olive

No Water

TP-11

0 - 2.6: Cobble, Sand & Gravel, QTS

2.6 - 4.7: Sand (SP), Dark Olive, Medium Grained, Dense, Residual Soil

4.7 - 8.0: Sandstone, Dark Olive, Low Hardness, Weakly Fractured, Fine Grained

No Water
TP-12

0.1-0.5  TOO SOIL W/ COBBLES/ SAND  QTg

SANDSTONE; MOD. OLIVE BROWN , FINER GRAINED  MOD. HARD; WEAK/ CLEAVELY FRACTURED  LOCAL CA603 PODE TO 1"; FRACTURES OPEN 1/4-1/8"

3.5-6.5  TUFFACEOUS MUDSTONE, LOU HARDNESS; WEAK  BREAKS DOWN TO CLAY WHEN STRECKED  RELIC FAULT W. FINE TEXTURAL TEXTURE; FRACTURE CLEAVELY FILLED  ROCK TOO WEATHERED FOR ACCURATE STRIKE & DIP  ROCK APPEARS TO BE DIPPING SW E 1-3°

PIT IS DRY

TP-13

0-1.0  COBBLES; SAND & GRAY  QTg

1.0-2.2  SANDST.; OLIVE BROWN; LOW HARDNESS; FRIABLE/ DEEPLY WEATHERED; INTENSIVELY FRACTURED W. CA603 WOULD WEAKEN TO 1/4"

2.2-8.0  SANDST.; OLIVE BROWN; MOD. HARDY WEAK TO FRIABLE; CLEARLY FRACTURED; FINE - MEDIUM GRADE  CA603 CEMENT

DAY PIT

TP-14

0.1-0.5  COBBLES WITH SAND-GRAVEL  QTg

V. DENSE; CA603 CEMENT IN ZONES  BOTTOM 3' APPEARS TO BE A CHANNEL DEPOS  

5-8.0  SAND(STR.) DARK OLIVE/ MEDIUM- GRAINED/ V. DENSE) IS MIST [RESIDUAL SOIL]

SANDSTONE; MOD. HARDNESS; FRIABLE  CLEARLY FRACTURED; OPEN FRACTURE 1/4-1/8"

PIT IS DRY
<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Description</th>
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<tbody>
<tr>
<td>0 - 4.8</td>
<td>Sand at (SM) Dark gray / mid dense / moist</td>
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<tr>
<td>4.8 - 9.0</td>
<td>Silt w/ Fine Sand (ML) Medium dense / moist</td>
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<tr>
<td>9.0 - 12.0</td>
<td>Cobble / sand / gravel / well rounded</td>
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<tr>
<td>12.0 - 13.0</td>
<td>Sand (SP) Dark olive / medium - sand / residual soil</td>
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<td>Depth (Ft)</td>
<td>Samp Blows (6&quot;)</td>
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**Description of Materials**

- **Cobble with sand and gravel**, cobble size to 6" on the right.
- **Diameter: Sono 12/"**, Sono medium-grained sand and gravel.
- **Sandstone: student's idea of Tn.**
- **Granular, very fine-grained, low hardness, friable, closely fractured, strong material.**
- Becomes less fractured, FRAC: SPACING 2"-B".
- **Bedrock: 15°.**
- **Stop Drilling 1" above bedrock.**
- **52 foot section out exposing bottom 2' + "."**
- **Falling Head Test.**
- **Hole Backfilled well.**
- **Restored to hole plus 10.5'**
# Falling Head Test

**Project:** ALTO VALLEY

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<tr>
<th>Open Interval Tested</th>
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<tbody>
<tr>
<td>2.9' - 11.6'</td>
<td>0' - 14.6'</td>
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<th>Open Hole Diameter</th>
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<td>7 3/4&quot;</td>
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<th>Remarks</th>
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Remarks: 2.33' - 11.5' Hour dry prior to test

Remarks: Moved 5' to north of 16' 15' W/ sonic wave; repeat test 1.65' - 11.6' Hour dry prior to test
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<th>Blows</th>
<th>Recovery (Ft)</th>
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## Falling Head Test

### Project: Barrel Valley

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<th>Open Hole Diameter</th>
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### Remarks:

- Hole dry when test started
- Water level 17' G.S.
- Well run may not be reliable
- Water may need to be added for testing

---

**Remarks:**

- Water level 17' G.S.
- Run may not be reliable
- Water may need to be added for testing
- May not be reliable
**Falling Head Test**

**Project:** Bower Valley

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### Falling Head Test

**Project:**

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**Remarks:**

- Hole open to 21'
- No tree
- Well prior to test: dry
## DRILLING LOG

**Project:** Plumley & Associates, Inc.  
**Hole No.:** B-4  
**Sheet:** 1 of 1  
**Line & Station:**

### Date
- **Started:** 9/27/07
- **Finished:** 1/27/07

### Soil Sampling
- **Rock Sampling:**
  - **Total Depth of Hole:** 28 ft
  - **No. of Undist. Samples:** 2
  - **Total Number of Core Boxes:** 12
  - **Bit Size and Type:** CME Sampler
  - **Casing Size:**
  - **Hollow-Stem:**
  - **Spoon Size:** 6 PT
  - **Hammer Wt.:** 140 lb
  - **Ground Elevation:**
  - **Hole Inclination:** 90°

### Drilling Contractor
- **Drilling Contractor:** Plumley & Associates, Inc.

### Drilling Rig
- **Drill Rig:** SImco Truck Mount

### Groundwater
- **At Ft. After Drilling Fluid:**
- **At Ft. After Drill Rig:**

### Eng. Geologist
- **Eng. Geologist:** P.S. Plumley

### depth chart

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<th>Recovery (% of Test)</th>
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**Remarks:**  
- At Ft. After Drilling Fluid:  
- At Ft. After Drill Rig:  
- Hole Backfilled  
- Bentonite Backfill  
- Hole Plug.
## Falling Head Test

**Project:** BRIDGER VALLEY  
**Boring:** B-4

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</tr>
<tr>
<td>7:00</td>
<td>4.93</td>
<td>5.60</td>
</tr>
</tbody>
</table>

**Remarks:**

- **Remarks:** How open to 19.9'  
  Water slowly rising

- **Remarks:** How open to 19.9'  
  Water at 4.50' START OF FILLING
Bridger Valley WWDC Level II Project

Terrace Deposit

Note: Pick handle is 36" long; pick is 18" wide
B-2: View towards southwest
Bridger Valley B-4
10.0 - 11.5

Sample: Chert. Fine grained, low hardness, friable.

Terrace Deposits

B-4: View towards northeast
Appendix C

Seismological Characterization – Uinta County
Basic Seismological Characterization
for
Uinta County, Wyoming

by

James C. Case, Rachel N. Toner, and Robert Kirkwood
Wyoming State Geological Survey
September 2002

BACKGROUND

Seismological characterizations of an area can range from an analysis of historic seismicity to a long-term probabilistic seismic hazard assessment. A complete characterization usually includes a summary of historic seismicity, an analysis of the Seismic Zone Map of the Uniform Building Code, deterministic analyses on active faults, "floating earthquake" analyses, and short- or long-term probabilistic seismic hazard analyses.

Presented below, for Uinta County, Wyoming, are an analysis of historic seismicity, an analysis of the Uniform Building Code, deterministic analyses of nearby active faults, an analysis of the maximum credible "floating earthquake," and current short- and long-term probabilistic seismic hazard analyses.

Historic Seismicity in Uinta County

The enclosed map of "Earthquake Epicenters and Suspected Active Faults with Surficial Expression in Wyoming" (Case and others, 1997) shows the historic distribution of earthquakes in Wyoming. Twenty-three magnitude 1.5 and greater earthquakes have been recorded in Uinta County. Most of these were relatively small magnitude events and subsequently, not felt. These earthquakes are discussed below.

The first earthquake that was reported in Uinta County occurred on December 1, 1925. This intensity III earthquake was centered approximately five miles southeast of Evanston. People reported doors swinging and a sound similar to the passing of a fast train. (Neumann, 1927).

Several earthquakes occurred in Uinta County during the 1960s. On June 14, 1966, the U.S.G.S. National Earthquake Information Center reported a magnitude 2.6 earthquake approximately 9 miles west-northwest of Carter. No one reported feeling this event. The University of Utah Seismograph Stations detected a magnitude 2.4 earthquake in Uinta County on June 22, 1966.
This non-damaging earthquake was located on the Uinta County-Lincoln County border approximately 11 miles north-northwest of Carter. On April 24, 1967, a magnitude 3.4 event was recorded approximately 9 miles northwest of Carter (University of Utah Seismograph Stations). An explosion is the probable cause of this event. The final earthquake that occurred in the 1960s was detected by the U.S.G.S. National Earthquake Information Center on January 18, 1968. This magnitude 2.6 earthquake, centered approximately 3.5 miles south-southwest of Robertson, was not felt.

The University of Utah Seismograph Stations recorded seven earthquakes in Uinta County during the 1970s. A magnitude 2.1 earthquake occurred on July 26, 1972, approximately 9 miles southwest of Piedmont. On December 19, 1974, a magnitude 2.0 event was reported approximately 12 miles southeast of Evanston. Three magnitude 2.1 earthquakes occurred on August 2, 1975, June 26, 1976, and August 3, 1976. The August 2, 1975, event was located approximately 17-18 miles south of Evanston; the June 26, 1976 earthquake had an epicenter approximately 6-7 miles south-southeast of Piedmont; the August 3, 1976 earthquake was centered approximately 6 miles south of Piedmont. On September 10, 1977, a 2.2 event was detected on the Uinta County-Sweetwater County border, approximately 7 miles northeast of Lonetree. Finally, a magnitude 2.0 earthquake occurred on October 5, 1979, approximately 11-12 miles south of Piedmont. No damage was reported from any of these earthquakes.

On March 31, 1981, a magnitude 3.1 earthquake occurred near the Uinta County-Lincoln County-Utah border approximately 23 miles northwest of Evanston. A magnitude 2.5 earthquake was detected on August 13, 1985. This earthquake was centered approximately 7 miles southeast of Robertson. According to the U.S.G.S. National Earthquake Information Center, no one reported feeling either event. On December 24, 1989, the University of Utah Seismograph Stations detected a magnitude 2.4 earthquake. Its epicenter was located just to the northeast of Millburne.

Several earthquakes were reported in Uinta County during the 1990s. The first occurred on March 22, 1990 (University of Utah Seismograph Stations). This magnitude 1.7 event was located roughly 3 miles northeast of Millburne. On June 25, 1990, the U.S.G.S. National Earthquake Information Center recorded a magnitude 2.1 event approximately 5 miles south of Robertson. No one reported feeling the earthquake. The University of Utah Seismograph Stations detected the six other earthquakes that occurred in Uinta County in the 1990s. A magnitude 2.25 earthquake occurred on October 15, 1990, approximately 6 miles east-southeast of Piedmont. On December 4, 1990, a magnitude 2.5 event was recorded approximately 3 miles southeast of Robertson. A magnitude 2.2 earthquake occurred on April 16, 1991. Its epicenter was located approximately 14 miles south of Piedmont. On December 18, 1993, a magnitude 2.28 earthquake was recorded approximately 5 miles southwest of Robertson. A few days later, a magnitude 2.77 event occurred on December 27, 1993. This earthquake was centered approximately 5 miles west-northwest of Mountain View. On January 21, 1995, a magnitude 2.0 earthquake was reported near Fort Bridger.
Most recently, on July 5, 2002, the U.S.G.S. National Earthquake Information Center recorded a magnitude 2.8 earthquake 3 miles west of Lyman. No one felt this event and no damage was reported.

**Regional Historic Seismicity**

Several earthquakes have also occurred near Uinta County. The first took place on October 3, 1956, in far western Sweetwater County, approximately 7 miles southwest of Little America. The earthquake was felt as an intensity IV event in Opal, where windows, doors, and dishes rattled and walls creaked. Loud “earth noises” from the west were heard one second before the shock (Brazee and Cloud, 1958).

On September 10, 1977, the University of Utah Seismograph Stations recorded a non-damaging magnitude 2.2 earthquake on the Uinta County-Sweetwater County border. The epicenter was located approximately 18 miles east-southeast of Robertson.

The U.S.G.S. National Earthquake Information Center detected a magnitude 3.5 earthquake in southern Lincoln County, approximately 27 miles north-northwest of Evanston, on February 24, 1979. No one reported feeling the earthquake.

On August 1, 1979, the University of Utah Seismograph Stations recorded a magnitude 2.2 earthquake near the Wyoming-Utah border. This event was centered approximately 17 miles south of Evanston.

On September 23, 1985, a magnitude 2.5 earthquake occurred in Lincoln County, approximately 22 miles northwest of Carter (University of Utah Seismograph Stations). The University of Utah Seismograph Stations also detected a magnitude 2.0 event on February 5, 1988. Its epicenter was located approximately 18 miles south-southwest of Evanston.

On June 22, 1991 (University of Utah Seismograph Stations). This magnitude 2.0 event was centered just over the Wyoming border approximately 15 miles south-southwest of Evanston.

On February 3, 1994, a magnitude 5.9, intensity VII earthquake occurred near Draney Peak, Idaho, west of Auburn, Wyoming. The earthquake was felt in Wyoming, Idaho, Colorado, and Idaho. The earthquake was felt in Evanston.

On February 3, 1995, one of the largest historic earthquakes in southwestern Wyoming occurred near Little America, Wyoming. A magnitude 5.3, intensity V earthquake was associated with the collapse of a 3,000 foot wide by 7,000 foot long portion of a trona mine operated by the Solvay Minerals, Inc. One miner lost his life as a result of the collapse. Minor damage was reported at a school administration building in Green River and at a motel near Little America. The earthquake was felt in Rock Springs and in Salt Lake City. An indisputable triggering mechanism for the collapse has not been determined, although the U.S. Mine Safety and Health Administration (1996) feels that the most likely failure trigger was “the degradation of the strength of the pillar-floor system over a long period of time”.

3
Uniform Building Code

The Uniform Building Code (UBC) is a document prepared by the International Conference of Building Officials. Its stated intent is to “provide minimum standards to safeguard life or limb, health, property, and public welfare by regulating and controlling the design, construction, quality of materials, use and occupancy, location and maintenance of all buildings and structures within this jurisdiction and certain equipment specifically regulated herein.”

The UBC contains information and guidance on designing buildings and structures to withstand seismic events. With safety in mind, the UBC provides Seismic Zone Maps to help identify which design factors are critical to specific areas of the country. In addition, depending upon the type of building, there is also an “importance factor”. The “importance factor” can, in effect, raise the standards that are applied to a building.

The current UBC Seismic Zone Map (Figure 1) (1997) has five seismic zones, ranging from Zone 0 to Zone 4, as can be seen on the enclosed map. The seismic zones are in part defined by the probability of having a certain level of ground shaking (horizontal acceleration) in 50 years. The criteria used for defining boundaries on the Seismic Zone Map were established by the Seismology Committee of the Structural Engineers Association of California (Building Standards, September-October, 1986). The criteria they developed are as follows:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Effective Peak Acceleration, % gravity (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>30% and greater</td>
</tr>
<tr>
<td>3</td>
<td>20% to less than 30%</td>
</tr>
<tr>
<td>2</td>
<td>10% to less than 20%</td>
</tr>
<tr>
<td>1</td>
<td>5% to less than 10%</td>
</tr>
<tr>
<td>0</td>
<td>less than 5%</td>
</tr>
</tbody>
</table>

The committee assumed that there was a 90% probability that the above values would not be exceeded in 50 years, or a 100% probability that the values would be exceeded in 475 to 500 years.

Uinta County is primarily in Seismic Zones 2 and 3 of the UBC. Except for Evanston and Bear River, all towns are in Seismic Zone 2. Since effective peak accelerations (90% chance of non-exceedance in 50 years) can range from 10-20%g in Zone 2, and since there has been historic seismicity and exposed active faults exist in the county, it may be reasonable to assume that a maximum peak acceleration of 15%-20%g could be applied to the design of a non-critical facility located in the county if only the UBC were used. Such acceleration, however, is significantly less than would be suggested through newer building codes.

Evanston and Bear River are in Seismic Zone 3. Since effective peak accelerations (90% chance of non-exceedance in 50 years) can range from 20-30%g, and there are significant active faults nearby, it may be reasonable to assume that a maximum peak acceleration of 25%g could be applied to the design of a non-critical facility located in the county if only the UBC were used.
Figure 1. UBC Seismic Zone Map.
Such acceleration, however, is significantly less than would be suggested through newer building codes.

Recently, the UBC has been replaced by the International Building Code (IBC). The IBC is based upon probabilistic analyses, which are described in a following section. Uinta County still uses the UBC, however, as do most Wyoming counties as of October 2002.

Deterministic Analysis of Regional Active Faults with a Surficial Expression

Uinta County has two exposed active fault systems that should be included in a deterministic analysis. The Bear River fault system is composed of a series of short, north-trending faults and associated scarps in southwestern Uinta County. West (1989) found evidence of Quaternary-age movement on this fault system. A minimum recurrence interval of 1800 years can be inferred for the Bear River fault system. Over 2320 years have elapsed since the last event. West (1994) estimates that the Bear River fault could generate a maximum magnitude 7.5 earthquake. A magnitude 7.5 event could generate peak horizontal accelerations of approximately 79\%g at Sulphur Creek Reservoir Dam, approximately 27 \%g at Evanston, approximately 26\%g at Meeks Cabin Dam, approximately 13\%g at Mountain View, approximately 11\%g at Lyman, and approximately 9\%g at Bear River (Campbell, 1987). These accelerations are roughly equivalent to an intensity IX earthquake at Sulphur Creek Reservoir Dam, an intensity VII earthquake at Evanston and the Meeks Cabin Dam, and intensity VI earthquakes in Lyman, Mountain View, and Bear River. Heavy damage could occur to the Sulphur Creek Reservoir Dam, while Evanston and the Meeks Cabin Dam may sustain moderate damage. Light damage may occur at Lyman, Mountain View, and Bear River.

In addition to the ground shaking hazards associated with the Bear River fault system, numerous pipelines cross the fault traces. If an earthquake occurred on this fault system, the pipelines could potentially rupture. Shut-off valves can minimize the effect of pipeline rupture.

The second exposed active fault system in Uinta County is the Northern Bear River fault system. It is located north of Evanston along the margins of the Bear River Valley. Evidence of recent, late-Quaternary movement has been identified on several north-trending faults (Gibbons and Dickey, 1983). Previous investigations on the Northern Bear River fault system have not determined a maximum possible magnitude that would be produced by this system. Because a magnitude 6.5 event is usually required to expose faults at the surface, however, it may be reasonable to assume that the Northern Bear River fault system could generate at least a magnitude 6.5 earthquake. A magnitude 6.5 earthquake could in turn generate peak horizontal accelerations of 70\%g at Bear River, up to 28\%g at Evanston, approximately 10\%g at the Sulphur Creek Reservoir Dam, approximately 4.3\%g at the Meeks Cabin Dam, approximately 3.5\%g at Mountain View, and approximately 3.3\%g at Lyman (Campbell, 1987). These accelerations are roughly equivalent to an intensity IX earthquake at Bear River, an intensity VII earthquake at Evanston, an intensity VI earthquake at the Sulphur Creek Reservoir Dam, an intensity V earthquake at Meeks Cabin Dam, and intensity III earthquakes in Lyman and Mountain View. Bear River could sustain heavy damage, while moderate damage could occur at
Evanston. Some light damage could occur at the Sulphur Creek Reservoir Dam and the Meeks Cabin Dam, but no significant damage should occur at Lyman and Mountain View.

Pipelines also cross the Northern Bear River fault traces. If an earthquake occurred on this fault system, the pipelines could potentially rupture. Again, shut-off valves can minimize the effect of pipeline rupture.

An active fault system is also present near Uinta County in western Lincoln County. The Rock Creek fault system is a north-south-trending normal fault located approximately 15 miles west of Kemmerer, Wyoming, near Fossil Butte National Monument. McCalpin and Warren (1992) found evidence of late-Quaternary movement on this system. Based upon a surface rupture length of 24 miles (38 km) and Quaternary displacement amounts, Chambers (1988) estimates that the Rock Creek fault is capable of generating a magnitude 6.9 to 7.2 earthquake. A maximum magnitude 7.2 earthquake could generate peak horizontal accelerations of approximately 5.8%g at Evanston, approximately 4.9%g at Lyman, and approximately 4.5%g at Mountain View (Campbell, 1987). This acceleration is roughly equivalent to an intensity V earthquake, which may cause some light damage.

Floating or Random Earthquake Sources

Many federal regulations require an analysis of the earthquake potential in areas where active faults are not exposed, and where earthquakes are tied to buried faults with no surface expression. Regions with a uniform potential for the occurrence of such earthquakes are called tectonic provinces. Within a tectonic province, earthquakes associated with buried faults are assumed to occur randomly, and as a result can theoretically occur anywhere within that area of uniform earthquake potential. In reality, that random distribution may not be the case, as all earthquakes are associated with specific faults. If all buried faults have not been identified, however, the distribution has to be considered random. “Floating earthquakes” are earthquakes that are considered to occur randomly in a tectonic province.

It is difficult to accurately define tectonic provinces when there is a limited historic earthquake record. When there are no nearby seismic stations that can detect small-magnitude earthquakes, which occur more frequently than larger events, the problem is compounded. Under these conditions, it is common to delineate larger, rather than smaller, tectonic provinces.

The U.S. Geological Survey identified tectonic provinces in a report titled “Probabilistic Estimates of Maximum Acceleration and Velocity in Rock in the Contiguous United States” (Algermissen and others, 1982). In that report, Uinta County was classified as being in a tectonic province with a “floating earthquake” maximum magnitude of 6.1. Geomatrix (1988b) suggested using a more extensive regional tectonic province, called the “Wyoming Foreland Structural Province”, which is approximately defined by the Idaho-Wyoming Thrust Belt on the west, 104° West longitude on the east, 40° North latitude on the south, and 45° North latitude on the north. Geomatrix (1988b) estimated that the largest “floating” earthquake in the “Wyoming Foreland Structural Province” would have a magnitude in the 6.0 – 6.5 range, with an average value of magnitude 6.25.
Federal or state regulations usually specify if a “floating earthquake” or tectonic province analysis is required for a facility. Usually, those regulations also specify at what distance a floating earthquake is to be placed from a facility. For example, for uranium mill tailings sites, the Nuclear Regulatory Commission requires that a floating earthquake be placed 15 kilometers from the site. That earthquake is then used to determine what horizontal accelerations may occur at the site. A magnitude 6.25 “floating” earthquake, placed 15 kilometers from any structure in Uinta County, would generate horizontal accelerations of approximately 15%g at the site. That acceleration would be adequate for designing a uranium mill tailings site, but may be too large for less critical sites, such as a landfill. Critical facilities, such as dams, usually require a more detailed probabilistic analysis of random earthquakes. Based upon probabilistic analyses of random earthquakes in an area distant from exposed active faults (Geomatrix, 1988b), however, placing a magnitude 6.25 earthquake at 15 kilometers from a site will provide a fairly conservative estimate of design ground accelerations.

**Probabilistic Seismic Hazard Analyses**

The U.S. Geological Survey (USGS) publishes probabilistic acceleration maps for 500-, 1000-, and 2,500-year time frames. The maps show what accelerations may be met or exceeded in those time frames by expressing the probability that the accelerations will be met or exceeded in a shorter time frame. For example, a 10% probability that acceleration may be met or exceeded in 50 years is roughly equivalent to a 100% probability of exceedance in 500 years.

The USGS has recently generated new probabilistic acceleration maps for Wyoming (Case, 2000). Copies of the 500-year (10% probability of exceedance in 50 years), 1000-year (5% probability of exceedance in 50 years), and 2,500-year (2% probability of exceedance in 50 years) maps are attached. Until recently, the 500-year map was often used for planning purposes for average structures, and was the basis of the most current Uniform Building Code. The new International Building Code, however, uses a 2,500-year map as the basis for building design. The maps reflect current perceptions on seismicity in Wyoming. In many areas of Wyoming, ground accelerations shown on the USGS maps can be increased due to local soil conditions. For example, if fairly soft, saturated sediments are present at the surface, and seismic waves are passed through them, surface ground accelerations will usually be greater than would be experienced if only bedrock was present. In this case, the ground accelerations shown on the USGS maps would underestimate the local hazard, as they are based upon accelerations that would be expected if firm soil or rock were present at the surface. Intensity values can be found in Table 1.

Based upon the 500-year map (10% probability of exceedance in 50 years) (Figure 2), the estimated peak horizontal acceleration in Uinta County ranges from approximately 8%g in the eastern portion of the county to over 20%g in the southwestern corner of the county. These accelerations are roughly comparable to intensity V earthquakes (3.9%g – 9.2%g), intensity VI earthquakes (9.2%g – 18%g), and intensity VII earthquakes (18%g – 34%g). Intensity V earthquakes can result in cracked plaster and broken dishes. Intensity VI earthquakes can result in fallen plaster and damaged chimneys. Intensity VII earthquakes can result in slight to moderate damage in well-built ordinary structures, and considerable damage in poorly built or
badly designed structures, such as unreinforced masonry. Chimneys may be broken. Evanston would be subjected to an acceleration of approximately 16%g or intensity VI.

Based upon the 1000-year map (5% probability of exceedance in 50 years) (Figure 3), the estimated peak horizontal acceleration in Uinta County ranges from over 10%g in the eastern third of the county to over 40%g in the southwestern corner of the county. These accelerations are roughly comparable to intensity VI earthquakes (9.2%g – 18%g), intensity VII earthquakes (18%g – 34%g), and intensity VIII earthquakes (34%g – 65%g). Intensity VI earthquakes can result in fallen plaster and damaged chimneys. Intensity VII earthquakes can result in slight to moderate damage in well-built ordinary structures, and considerable damage in poorly built or badly designed structures, such as unreinforced masonry. Chimneys may be broken. Intensity VIII earthquakes can result in considerable damage in ordinary buildings and great damage in poorly built structures. Panel walls may be thrown out of frames. Chimneys, walls, columns, factory stacks may fall. Heavy furniture may be overturned. Evanston would be subjected to an acceleration of approximately 25%g or intensity VII.

Based upon the 2500-year map (2% probability of exceedance in 50 years) (Figure 4), the estimated peak horizontal acceleration in Uinta County ranges from approximately 17%g in the northeastern corner of the county to over 80%g in the southwestern corner of the county. These accelerations are roughly comparable to intensity VI earthquakes (9.2%g – 18%g), intensity VII earthquakes (18%g – 34%g), intensity VIII earthquakes (34%g – 65%g), and intensity IX earthquakes (65%g-124%g). Intensity VI earthquakes can result in fallen plaster and damaged chimneys. Intensity VII earthquakes can result in slight to moderate damage in well-built ordinary structures, and considerable damage in poorly built or badly designed structures, such as unreinforced masonry. Chimneys may be broken. Intensity VIII earthquakes can result in considerable damage in ordinary buildings and great damage in poorly built structures. Panel walls may be thrown out of frames. Chimneys, walls, columns, factory stacks may fall. Heavy furniture may be overturned. Intensity IX earthquakes can cause considerable damage in specially designed structures and great damage and partial collapse in substantial buildings. Well-designed frame structures could be thrown out of plumb. Buildings can be shifted off their foundations. The ground can crack and underground pipes could be broken. Evanston would be subjected to an acceleration of approximately 35%g, or intensity VII.

As the historic record is limited, it is nearly impossible to determine when a 2,500-year event last occurred in the county. Because of the uncertainty involved, and based upon the fact that the new International Building Code utilizes 2,500-year events for building design, it is suggested that the 2,500-year probabilistic maps be used for Uinta County analyses. This conservative approach is in the interest of public safety.
Table 1:

<table>
<thead>
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<th>Modified Mercalli Intensity</th>
<th>Acceleration (%g) (PGA)</th>
<th>Perceived Shaking</th>
<th>Potential Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>&lt;0.17</td>
<td>Not felt</td>
<td>None</td>
</tr>
<tr>
<td>II</td>
<td>0.17 – 1.4</td>
<td>Weak</td>
<td>None</td>
</tr>
<tr>
<td>III</td>
<td>0.17 – 1.4</td>
<td>Weak</td>
<td>None</td>
</tr>
<tr>
<td>IV</td>
<td>1.4 – 3.9</td>
<td>Light</td>
<td>None</td>
</tr>
<tr>
<td>V</td>
<td>3.9 – 9.2</td>
<td>Moderate</td>
<td>Very Light</td>
</tr>
<tr>
<td>VI</td>
<td>9.2 – 18</td>
<td>Strong</td>
<td>Light</td>
</tr>
<tr>
<td>VII</td>
<td>18 – 34</td>
<td>Very Strong</td>
<td>Moderate</td>
</tr>
<tr>
<td>VIII</td>
<td>34 – 65</td>
<td>Severe</td>
<td>Moderate to Heavy</td>
</tr>
<tr>
<td>IX</td>
<td>65 – 124</td>
<td>Violent</td>
<td>Heavy</td>
</tr>
<tr>
<td>X</td>
<td>&gt;124</td>
<td>Extreme</td>
<td>Very Heavy</td>
</tr>
<tr>
<td>XI</td>
<td>&gt;124</td>
<td>Extreme</td>
<td>Very Heavy</td>
</tr>
<tr>
<td>XII</td>
<td>&gt;124</td>
<td>Extreme</td>
<td>Very Heavy</td>
</tr>
</tbody>
</table>

Modified Mercalli Intensity and peak ground acceleration (PGA) (Wald, et al 1999).
Abridged Modified Mercalli Intensity Scale

Intensity value and description:

I  Not felt except by a very few under especially favorable circumstances.

II  Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.

III  Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing automobiles may rock slightly. Vibration like passing of truck. Duration estimated.

IV  During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing automobiles rocked noticeably.

V  Felt by nearly everyone, many awakened. Some dishes, windows, and so on broken; cracked plaster in a few places; unstable objects overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop.

VI  Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster and damaged chimneys. Damage slight.

VII  Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving cars.

VIII  Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving cars disturbed.


X  Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed, slopped over banks.


XII Damage total. Waves seen on ground surface. Lines of sight and level distorted. Objects thrown into the air.
Figure 2. 500-year probabilistic acceleration map (10% probability of exceedance in 50 years).
Figure 3. 1000-year probabilistic acceleration map (5% probability of exceedance in 50 years).
Peak Acceleration (%g)
with 2% Probability
of Exceedance in 50 Years
site: NEHRP B-C boundary

U.S. Geological Survey
National Seismic Hazard Mapping Project
Albers Conic Equal-Area
Projection
Standard Parallels: 29.5

Figure 4. 2500-year probabilistic acceleration map (2% probability of exceedance in 50 years).
Summary

There have been thirty-one historic earthquakes with a magnitude greater than 1.5 recorded in and near Uinta County. Because of the limited historic record, it is possible to underestimate the seismic hazard in Uinta County if historic earthquakes are used as the sole basis for analysis. Earthquake and ground motion probability maps and specific fault analyses give a more reasonable estimate of damage potential.

Current earthquake probability maps that are used in the newest building codes suggest a scenario that would result in moderate to heavy damage to buildings and their contents, with damage increasing from the northeast to the southwest. More specifically, the probability-based or fault activation-based worst-case scenario could result in the following damage at points throughout the county:

**Intensity IX Earthquake Areas**

Bear River
Sulphur Creek Dam

Intensity IX earthquakes can cause considerable damage in specially designed structures and great damage and partial collapse in substantial buildings. Well-designed frame structures could be thrown out of plumb. Buildings can be shifted off their foundations. The ground can crack and underground pipes could be broken.

**Intensity VIII Earthquake Areas**

Evanston
Piedmont

Intensity VIII earthquakes can result in considerable damage in ordinary buildings and great damage in poorly built structures. Panel walls may be thrown out of frames. Chimneys, walls, columns, factory stacks may fall. Heavy furniture may be overturned.

**Intensity VII Earthquake Areas**

Carter    Millburne
Fort Bridger Mountain View
Lonetree Robertson
Lyman    Urie
Meeks Cabin Dam

In intensity VII earthquakes, damage is negligible in buildings of good design and construction, slight-to-moderate in well-built ordinary structures, considerable in poorly built or badly designed structures such as unreinforced masonry buildings. Some chimneys will be broken.
References


U.S.G.S. National Earthquake Information Center: http://wwwneic.cr.usgs.gov/
University of Utah Seismograph Station Epicenter Listings:
http://www.seis.utah.edu/HTML/EarthquakeCatalogAndInfo.html


Appendix D

Existing Groundwater Quality
**LAB #** W163

**DOMESTIC WATER ANALYSIS**

**SOURCE:** ground water trench basin ATP-A2

**"Routine Package"**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Recommended</th>
<th>Results</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductivity</td>
<td></td>
<td>693</td>
<td>&lt;693 µhos/cm</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>8.2</td>
<td>6.5 to 8.5</td>
</tr>
<tr>
<td>Calcium</td>
<td>mg/L</td>
<td>25.8</td>
<td>N/A</td>
</tr>
<tr>
<td>Magnesium</td>
<td>mg/L</td>
<td>13.1</td>
<td>N/A</td>
</tr>
<tr>
<td>Sodium</td>
<td>mg/L</td>
<td>178</td>
<td>20</td>
</tr>
<tr>
<td>Potassium</td>
<td>mg/L</td>
<td>1.1</td>
<td>N/A</td>
</tr>
<tr>
<td>Carbonate</td>
<td>mg/L</td>
<td>&lt;0.1</td>
<td>N/A</td>
</tr>
<tr>
<td>Bicarbonate</td>
<td>mg/L</td>
<td>450</td>
<td>N/A</td>
</tr>
<tr>
<td>Chloride</td>
<td>mg/L</td>
<td>35.2</td>
<td>250</td>
</tr>
<tr>
<td>Sulfate</td>
<td>mg/L</td>
<td>72.3</td>
<td>250</td>
</tr>
<tr>
<td>Nitrate</td>
<td>mg/L</td>
<td>16.5</td>
<td>45</td>
</tr>
<tr>
<td>Nitrate-Nitrogen</td>
<td>mg/L</td>
<td>3.7</td>
<td>10</td>
</tr>
<tr>
<td>Total Alkalinity</td>
<td>as CaCO₃</td>
<td>369</td>
<td>400</td>
</tr>
<tr>
<td>Total Hardness</td>
<td>as CaCO₃</td>
<td>118</td>
<td>300 6.9</td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td></td>
<td>796</td>
<td>500</td>
</tr>
</tbody>
</table>

**"Metals" and "Individual Element" Analysis**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Results</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boron</td>
<td>0.55</td>
<td>N/A</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>*</td>
<td>N/A</td>
</tr>
<tr>
<td>Aluminum</td>
<td>*</td>
<td>0.05-0.2</td>
</tr>
<tr>
<td>Iron</td>
<td>*</td>
<td>0.3</td>
</tr>
<tr>
<td>Manganese</td>
<td>*</td>
<td>0.05</td>
</tr>
<tr>
<td>Copper</td>
<td>*</td>
<td>1.3</td>
</tr>
<tr>
<td>Zinc</td>
<td>*</td>
<td>5.0</td>
</tr>
<tr>
<td>Nickel</td>
<td>*</td>
<td>0.1</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>*</td>
<td>N/A</td>
</tr>
<tr>
<td>Cadmium</td>
<td>*</td>
<td>0.005</td>
</tr>
<tr>
<td>Chromium</td>
<td>*</td>
<td>0.10</td>
</tr>
<tr>
<td>Barium</td>
<td>*</td>
<td>2.0</td>
</tr>
<tr>
<td>Lead</td>
<td>*</td>
<td>0.015</td>
</tr>
<tr>
<td>Ammonium</td>
<td>*</td>
<td>N/A</td>
</tr>
<tr>
<td>Fluoride</td>
<td>*</td>
<td>4.0</td>
</tr>
<tr>
<td>Arsenic</td>
<td>0.022</td>
<td>0.05</td>
</tr>
<tr>
<td>TSS</td>
<td>46</td>
<td>N/A</td>
</tr>
<tr>
<td>SAR</td>
<td>7.1</td>
<td>N/A</td>
</tr>
</tbody>
</table>

* Not requested

**COMMENTS:** Sodium and total dissolved solids exceed the EPA suggested limits for domestic use.
**DOMESTIC WATER ANALYSIS**

**LAB #** W164  

<table>
<thead>
<tr>
<th>&quot;Routine Package&quot;</th>
<th>Recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Results</strong></td>
<td><strong>Limit</strong></td>
</tr>
<tr>
<td>Conductivity</td>
<td>3970 μmhos/cm</td>
</tr>
<tr>
<td>pH</td>
<td>8.7</td>
</tr>
<tr>
<td>Calcium</td>
<td>93.3</td>
</tr>
<tr>
<td>Magnesium</td>
<td>33.8</td>
</tr>
<tr>
<td>Sodium</td>
<td>894</td>
</tr>
<tr>
<td>Potassium</td>
<td>3.0</td>
</tr>
<tr>
<td>Carbonate</td>
<td>15.2</td>
</tr>
<tr>
<td>Bicarbonate</td>
<td>561</td>
</tr>
<tr>
<td>Chloride</td>
<td>337</td>
</tr>
<tr>
<td>Sulfate</td>
<td>1296</td>
</tr>
<tr>
<td>Nitrate</td>
<td>4.2</td>
</tr>
<tr>
<td>Nitrate-Nitrogen</td>
<td>0.9</td>
</tr>
<tr>
<td><strong>Total Alkalinity</strong></td>
<td><strong>485</strong></td>
</tr>
<tr>
<td>as CaCO₃</td>
<td></td>
</tr>
<tr>
<td><strong>Total Hardness</strong></td>
<td><strong>372</strong></td>
</tr>
<tr>
<td>as CaCO₃</td>
<td></td>
</tr>
<tr>
<td><strong>Total Dissolved Solids</strong></td>
<td><strong>3,238</strong></td>
</tr>
</tbody>
</table>

**SOURCE:** surface water basin B mouth of valley  

"Metals" and "Individual Element" Analysis

<table>
<thead>
<tr>
<th><strong>Results</strong></th>
<th><strong>Limit</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Boron</td>
<td>3.9</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>*</td>
</tr>
<tr>
<td>Aluminum</td>
<td>*</td>
</tr>
<tr>
<td>Iron</td>
<td>*</td>
</tr>
<tr>
<td>Manganese</td>
<td>*</td>
</tr>
<tr>
<td>Copper</td>
<td>*</td>
</tr>
<tr>
<td>Zinc</td>
<td>*</td>
</tr>
<tr>
<td>Nickel</td>
<td>*</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>*</td>
</tr>
<tr>
<td>Cadmium</td>
<td>*</td>
</tr>
<tr>
<td>Chromium</td>
<td>*</td>
</tr>
<tr>
<td>Barium</td>
<td>*</td>
</tr>
<tr>
<td>Lead</td>
<td>*</td>
</tr>
<tr>
<td>Ammonium</td>
<td>*</td>
</tr>
<tr>
<td>Fluoride</td>
<td>*</td>
</tr>
<tr>
<td>Arsenic</td>
<td>0.065</td>
</tr>
<tr>
<td>Selenium</td>
<td>*</td>
</tr>
<tr>
<td>Mercury</td>
<td>*</td>
</tr>
</tbody>
</table>

* Not requested

**COMMENTS:** Sodium, chloride, sulfate, alkalinity, hardness, total dissolved solids and arsenic exceed the EPA suggested limits for domestic use.
Quick Facts...

Two types of tests – bacteriological and chemical – are used to assess domestic water quality.

The Colorado State University Soil, Water and Plant Testing Laboratory is equipped to determine the chemical constituents of water.

Local county health departments or the Colorado Department of Health will perform bacteriological tests.

Chemical tests are needed to detect water contaminants such as nitrates, sodium, chlorides and the hardness capacity of water.

Introduction

The appearance, taste or odor of water from a well or other source offers some information on obvious contamination but chemical analysis is needed to detect most contamination in water. Obvious contaminants include silt (turbidity) and hydrogen sulfide, which can be detected by smell. As a rule, the senses will not detect impurities that cause hard water, corrode pipe and stain sinks. Two types of tests – bacteriological and chemical – are used to assess water quality. The two tests are separate and distinct, and normally are not made in the same laboratory at the same time. The Colorado State University Soil, Water and Plant Testing Laboratory is equipped to analyze chemical tests. The analysis determines chemical constituents of water as they relate to drinking or irrigation purposes. Direct questions about testing water for bacterial or microbial contamination, including Giardia, to the local health department.

Bacteriological Test

Bacteriological tests are used to determine if water is bacteriologically safe for human consumption. There are tests based on detection of coliform bacteria, a group of microorganisms that are recognized as indicators of pollution from human or animal wastes. Coliform bacteria are found in the intestinal tracts and fecal discharges of humans and all warm-blooded animals. Anyone who wants a bacteriological test performed on their drinking water should contact the local county health department to obtain the specially prepared bottles and instructions for taking a water sample. It is important to note that special techniques are required to collect samples because the samples can be contaminated if procedures are improper. If the county does not offer a bacteriological test for water, contact the Colorado Department of Health, 4210 E. 11th Avenue, Denver CO 80220, (303) 691-4700.

Chemical Tests

Chemical tests identify impurities and other dissolved substances that affect water used for domestic purposes. Water begins to decrease in palatability when the amount of minerals, i.e., dissolved salts, exceeds 500 to 1,000 ppm, but this depends on the nature of the minerals. Note that sea water contains 30,000 ppm of dissolved salt. Beyond these limits, the water becomes increasingly unpalatable. Table 1 lists the constituents and parameters that are routinely determined on a water sample by the Colorado State Soil, Water and Plant Testing Laboratory. Table 2 lists additional constituents in water that can be determined on request by the Colorado State Soil, Water and Plant Testing Laboratory.
In Colorado, the pH of well water normally is between 6.5 and 8.5.

The Laboratory Report – What Do The Numbers Mean?

Most testing laboratories report quantities of chemical substances by weight in volumetric units such as milligrams per liter (mg/L). For all practical purposes, 1 ppm = 1 mg/L. The factors reported on a water analysis report are discussed below and represent the parameters that are considered in the evaluation of domestic water quality.

pH is a measure of intensity of alkali or acid contained in the water. Absolutely pure water has a pH value of 7.0. In Colorado, the pH of well water normally is between 6.5 and 8.5. Water with pH less than 5 may cause problems due to corrosion because many metals become more soluble in low pH waters. Water with pH values higher than 8.5 indicates that a significant amount of sodium bicarbonate may be present.

Calcium and Magnesium cause water hardness and result from limestone-type materials in underground soil layers. Separate values are of minor concern but they are combined for calculating hardness.

Hardness is the soap-consuming capacity of water; that is, the more soap required to produce lather, the harder the water. Hard water also causes greasy rings on bathtubs, films on dishes or hair after washing, and poor laundry results. Problems caused by hard water in bathing or washing can be overcome by the use of synthetic detergents or packaged softening compounds. The hardness of water may be removed by a water softening unit containing exchange resins. This will result in the exchange of calcium and magnesium (Ca and Mg) by sodium so it may be a concern to people on a low-sodium diet for medical reasons. Do not use softened water for gardens, lawns or plants. Hardness is reported as calcium carbonate in milligrams per liter (mg/L). A commonly used classification for hardness is given in Table 3.

Sodium may be of health significance to people on a low-sodium diet. Sodium can be reduced or removed by expensive treatment systems, but when Ca and Mg are removed from water by passing through a water softener, sodium replaces it.

Potassium is an essential nutritional element, but its concentration in most drinking water is trivial and quantities seldom reach 10 mg/L.

Carbonates and bicarbonates are the major contributors to the "total alkalinity" that may be determined in a routine water test. The alkalinity of a

---

### Table 1: The parameters determined for the routine domestic water analysis test

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Recommended Limits (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductivity (Microsiemens/cm)</td>
<td></td>
</tr>
<tr>
<td>pH (pH units)</td>
<td>6.5-8.5</td>
</tr>
<tr>
<td>Calcium</td>
<td></td>
</tr>
<tr>
<td>Magnesium</td>
<td></td>
</tr>
<tr>
<td>Sodium</td>
<td>20</td>
</tr>
<tr>
<td>Potassium</td>
<td></td>
</tr>
<tr>
<td>Carbonate</td>
<td></td>
</tr>
<tr>
<td>Bicarbonate</td>
<td></td>
</tr>
<tr>
<td>Chloride</td>
<td>250</td>
</tr>
<tr>
<td>Sulfate</td>
<td>250</td>
</tr>
<tr>
<td>Nitrate</td>
<td>45</td>
</tr>
<tr>
<td>Total Alkalinity as CaCO₃</td>
<td>400</td>
</tr>
<tr>
<td>Hardness as CaCO₃</td>
<td></td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>500</td>
</tr>
<tr>
<td>Boron</td>
<td></td>
</tr>
</tbody>
</table>


| * Mandatory upper limit for nitrate (NO₃⁻). |

---

* Limits not established.
Table 2: Additional tests that can be determined in water on request

<table>
<thead>
<tr>
<th>Constituent</th>
<th>MCL (mg/l)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>0.05</td>
</tr>
<tr>
<td>Selenium</td>
<td>0.05</td>
</tr>
<tr>
<td>Chromium (total)</td>
<td>0.10</td>
</tr>
<tr>
<td>Fluoride</td>
<td>4.0</td>
</tr>
<tr>
<td>Barium</td>
<td>2.0</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.005</td>
</tr>
<tr>
<td>Lead</td>
<td>0.015</td>
</tr>
<tr>
<td>Mercury</td>
<td>0.002</td>
</tr>
<tr>
<td>Copper</td>
<td>1.3</td>
</tr>
<tr>
<td>Nickel</td>
<td>0.1</td>
</tr>
<tr>
<td>Nitrate (as N)</td>
<td>10</td>
</tr>
<tr>
<td>Beryllium</td>
<td>0.004</td>
</tr>
</tbody>
</table>

SMCL (Mg/l)b

<table>
<thead>
<tr>
<th>Constituent</th>
<th>SMCL (Mg/l)b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>0.05-0.2</td>
</tr>
<tr>
<td>Copper</td>
<td>1.0</td>
</tr>
<tr>
<td>Fluoride</td>
<td>2.0</td>
</tr>
<tr>
<td>Iron</td>
<td>0.3</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.05</td>
</tr>
<tr>
<td>Silver</td>
<td>0.1</td>
</tr>
<tr>
<td>Zinc</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Limits not established

<table>
<thead>
<tr>
<th>Constituent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonium</td>
</tr>
<tr>
<td>Phosphorus</td>
</tr>
<tr>
<td>Molybdenum</td>
</tr>
</tbody>
</table>

Maximum contaminant level
Secondary maximum contaminant level

Table 3. Hardness expressed as mg/l of CaCO₃

<table>
<thead>
<tr>
<th>mg/l or ppm*</th>
<th>Water hardness</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-75</td>
<td>Soft</td>
</tr>
<tr>
<td>75-150</td>
<td>Moderately hard</td>
</tr>
<tr>
<td>150-300</td>
<td>Hard</td>
</tr>
<tr>
<td>Over 300</td>
<td>Very Hard</td>
</tr>
</tbody>
</table>

*When expressed as grains of hardness, 1 grain = 17.1 mg/l (ppm).

water sample is a measure of its ability to neutralize acids. Naturally-occurring levels of total alkalinity up to 400 mg/l as CaCO₃ are not a health hazard. Low alkalinity is associated with low pH values and may indicate potential for problems due to corrosion of metal in plumbing systems.

Chloride concentrations in drinking water may be important to people on low-salt diets. Most people will detect a salty taste in water containing more than 250 mg/l of chloride. Expensive treatment methods are needed to remove chloride from water.

Sulfate content in excess of 250 to 500 ppm (mg/l) may give water a bitter taste and have a laxative effect on people not adapted to the water. Expensive treatment methods are necessary to remove or reduce sulfate in a private water system.

Nitrate in excess of 45 mg/l (or in excess of 10 mg/l if reported as nitrate-nitrogen) is of health significance to pregnant women and infants under 6 months. Do not use high nitrate water in infant formulas or other infant foods. Considerably higher nitrate content apparently is tolerated by most adults. Nitrate can be removed from private water supplies, but the equipment is expensive and not commonly used.

Total dissolved solids, also called "total mineral content" or "total residue," is the total amount of material remaining after evaporation of the water. Values of less than 300 ppm (mg/l) are satisfactory and up to 1,000 ppm (mg/l) can be tolerated with little effect.

Fluoride is important in the development of teeth in infants and youth. The optimum fluoride content to assist in the control of tooth decay is 0.9 to 1.5 ppm (mg/l). Excessive amounts are rarely found in Colorado waters, but a concentration over 3.0 ppm (mg/l) may cause darkening of the tooth enamel and other undesirable effects.

Iron and manganese are nuisance chemicals that cause troublesome stains and deposits on light-colored clothes and plumbing fixtures. Iron causes yellow, red or reddish-brown stains and deposits, while manganese stains and deposits are gray or black. Excessive amounts also may cause dark discoloration in some food and beverages and cause an unpleasant taste. Iron and manganese can be removed or reduced in a softener equipped with special resins or by small treatment systems involving aeration, filtration and chlorination.

Copper and zinc will cause an undesirable taste if concentrations are above the recommended limits. A water softening system should significantly lower the levels of these elements.

Arsenic, selenium, barium, cadmium, lead and mercury are potentially toxic elements. Fortunately, these elements rarely exceed the mandatory limits in most Colorado well water. If high concentrations are found, it is necessary to remove these elements using expensive treatment methods, such as distillation or reverse-osmosis. Lead contamination in drinking water can come from lead pipes and lead-based solder pipe joints.

Aluminum, ammonium, phosphorus, nickel and molybdenum are additional constituents that can be determined by the laboratory. Although no limits are established for these parameters, pollution of some sort is indicated if significant concentrations are detected in a water sample.

Taste and odor problems are difficult to solve. Some inorganic compounds may impart detectable tastes without odor. Hydrogen sulfide (rotten egg smell), when present, will impart an undesirable odor and taste. Generally, undesirable tastes may be caused by any of numerous organic compounds. These may be present naturally in the water or due to sewage or other surface contamination sources. They can impart disagreeable taste and odor in minute concentrations (a few parts per billion or a few milligrams per kiloliter) and specialized chemical tests are needed to detect such small levels. Turbidity in
drinking water is caused by suspended sediments from erosion and runoff discharges. The maximum contaminant level in drinking is 1 to 5 turbidity units.

Water Treatment Systems

Some water constituents can be removed or reduced by ion-exchange resins, distillation, reverse osmosis or a combination of these methods. Other treatment processes might involve aeration or chemical oxidation followed by filtration. Organics can be removed by filtration through charcoal, but this may not be an effective method for removing inorganic contaminants. Treatment methods are specific to the type of chemical problems and generally are quite costly. For additional information on water quality or treatment systems, refer to the fact sheets listed below or call the EPA Safe Drinking Water Hotline, 1-800-426-4791.

References


Appendix E

Certificates of Appropriation of Water
THE STATE OF WYOMING  
Certificate of Appropriation of Water  

WHEREAS, Bridger Valley Joint Powers Board has presented to the Board of Control of the State of Wyoming proof of the appropriation of water from Water Stored in Stateline Dam (under Utah Permit), Supplied by East Fork Smith's Fork Creek, tributary Black's Fork River, tributary River through the Bridger Valley Water Project Pipeline - Stateline Dam under Permit No. 26356... municipal purposes and miscellaneous purposes... herein described, lying and being in

Twp.  Range Sec. NE1/4 NW1/4 SW1/4 SE1/4 NE1/4 NW1/4 SW1/4 SE1/4 NE1/4 NW1/4 SW1/4 SE1/4 TOTAL

SEE ATTACHED TABULATION SHEET

IN TESTIMONY WHEREOF, I, Gordon W. Fassett, President of the State Board of Control, have hereunto set my hand this 9th day of April, A.D. 1990, and caused the seal of said Board to be hereto affixed.

Attest:    Ex-officio Secretary  

Certificate Record No. 77, Page 206  
Water Division No. 5, District No. 3  
Proof No. 35341
THE STATE OF WYOMING  
Certificate of Appropriation of Water

WHENAS, Bridger Valley Joint Powers Board has presented to the Board of Control of the State of Wyoming proof of the appropriation of water from Smith's Fork Creek, tributary Black's Fork River, tributary Green River through the Bridger Valley Water Project Pipeline - Smith's Fork Creek under Permit No. 26355, for municipal purposes and miscellaneous purposes herein described, lying and being in Uinta County, Wyoming.

NOW KNOW YE, That the State Board of Control, under the provisions of the Statutes of Wyoming, has, by an order duly made on February 15, 1990, and entered on April 9, 1990, in Order Record 36, Page 117, determined and established the priority and amount of such appropriation as follows:

<table>
<thead>
<tr>
<th>Name and Address of Appropriator(s)</th>
<th>Bridger Valley Joint Powers Board, P. O. Box 295, Lyman, Wyoming 82937</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priority</td>
<td>June 29, 1978</td>
</tr>
<tr>
<td>Amount of Appropriation</td>
<td>4,378 ft. per sec.</td>
</tr>
</tbody>
</table>

None of the land to be irrigated and for which this appropriation is determined and established.

The right to water hereby confirmed and established is limited to municipal purposes and miscellaneous purposes and the use is restricted to the place where acquired and to the purpose for which acquired.

IN TESTIMONY WHEREOF, I, Gordon W. Fassett, President of the State Board of Control, have hereunto set my hand this 9th day of April, A.D. 1990, and caused the seal of said Board to be hereunto affixed.

Gordon W. Fassett
President

Revised 2-87
THE STATE OF WYOMING  
CERTIFICATE OF APPROPRIATION OF WATER  
CERTIFICATE RECORD NO. 40

WHEREAS, John L. Johnson has presented to the Board of Control of the State of Wyoming proof of the appropriation of water from the Red Rock Creek, tributary of the Green River, through the Johnson Ditch under Permit No. 13412, for irrigation of the lands herein described, lying and being in [illegible] County, Wyoming.

Now know Ye, That the Board of Control, under the provisions of Chapter 61, Compiled Statutes of Wyoming, 1910, has, by an order duly made and entered on the [illegible] day of November, A. D. 19[illegible], in Order Record No. [illegible], determined and established the priority and amount of such appropriation as follows:

Name of Appropriator: John L. Johnson; Postoffice Address: [illegible], Wyoming;
Amount of Appropriation: 90.78 cu. ft. per sec.; Date of Appropriation: Nov. 3, 19[illegible]; Description of land to be irrigated and for which this appropriation is determined and established; Total Acreage: [illegible].

For change of use & change of pt. of diversion & means of conveyance, see Ch. 37, p. 39; C. 78, p. 43.

The right to water hereby confirmed and established is limited to irrigation and the use is restricted to the place where acquired and to the purpose for which acquired; rights for irrigation not to exceed one cubic foot per second for each seventy acres of land for which appropriation is herein determined and established.

IN TESTIMONY WHEREOF, I, [illegible], President of the State Board of Control, have hereunto set my hand this 31st day of January, A. D. 19[illegible], and caused the seal of said Board to be hereunto affixed.

ATTEST: [illegible], Secretary. [illegible], President.
**THE STATE OF WYOMING**

Certificate of Appropriation of Water

WHEREAS, (successor to John E. Johnson, orig. appropriator) has presented to the Board of Control of the State of Wyoming proof of the appropriation of water from Black’s Fork River, tributary Green River, under Permit No. 12810, for municipal purposes, and the State Board of Control, under the provisions of the Statutes of Wyoming, has, by an order duly made on February 15, 1990, determined and established the priority and amount of such appropriation as follows: Name and Address of Appropriator(s) Bridger Valley Joint Powers Board, P. O. Box 295, Lyman, Wyoming 82937.

NOW KNOW YE, That the State of Board of Control, under the provisions of the Statutes of Wyoming, has, by an order duly made on January 15, 1991, determined and established the priority and amount of such appropriation as follows:

**DESCRIPTION OF LAND TO WHICH APPROPRIATION IS DETERMINED AND ESTABLISHED**

<table>
<thead>
<tr>
<th>TWP.</th>
<th>RANGE</th>
<th>SEC</th>
<th>NE¼</th>
<th>NW¼</th>
<th>SW¼</th>
<th>SE¼</th>
<th>NE¼</th>
<th>NW¼</th>
<th>SW¼</th>
<th>SE¼</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(see attached sheets)</td>
</tr>
</tbody>
</table>

This appropriation is limited to a maximum diversion period of 105 days beginning May 15 of each year, at a rate of 4,047 c.f.s., when in priority not to exceed 20.82 acre-feet in any one year.

The right to water hereby confirmed and established is limited to municipal purposes and the use is restricted to the place where acquired and to the purpose for which acquired.

IN TESTIMONY WHEREOF, Gordon W. Fassett, President of the State Board of Control, have hereunto set my hand this 14th day of January, A.D. 1991, and caused the seal of said Board to be hereunto affixed.

Ex-officio Secretary

President

**Proof No. 15881**

Certificate Record No. 78, Page 43

Water Division No. 4, District No. 13

Certificate Record 48, Page 37, Page 30

Amends the Order of Adjudication of Record 5, Page 498; Proof No. 15881.
THE STATE OF WYOMING
CERTIFICATE OF APPROPRIATION OF WATER

WHEREAS, \textit{John A. Johnson} has presented to the Board of Control of the State of Wyoming proof of the appropriation of water from \textit{E. Branch of Bunkle's Fork} tributary of \textit{Green River} through the \textit{Johnson No. 2} Ditch under Permit No. 13311 for irrigation of the lands herein described, lying and being in \textit{Uinta} County, Wyoming.

Now Know Ye, That the Board of Control, under the provisions of Chapter 61, Compiled Statutes of Wyoming, 1910, has, by an order duly made and entered on the 23rd day of November, A.D. 1949, in Order Record No. 5, Page 455, determined and established the priority and amount of such appropriation as follows:

- **Name of Appropriator:** \textit{John A. Johnson}  
- **Postoffice Address:** \textit{Fort Bridger}, Wyoming
- **Amount of Appropriation:** \textit{0.09} cu. ft. per sec.; **Date of Appropriation:** Nov. 13, 1949
- **Description of land to be irrigated and for which this appropriation is determined and established:** Total Acreage \textit{2,106} Acres  
- **Description:** \textit{Sec. 32, T. 16 N., R. 115 W.}

For change of use, change of point of diversion and means of conveyance see G.R. 32, p. 30; G.R. 78, p. 40.

The right to water hereby confirmed and established is limited to irrigation and the use is restricted to the place where acquired and to the purpose for which acquired; rights for irrigation not to exceed one cubic foot per second for each seventy acres of land for which appropriation is herein determined and established.

In Testimony Whereof, \textit{John A. Rhine}, President of the State Board of Control, have hereunto set my hand this 31st day of January, A.D. 1949, and caused the seal of said Board to be hereunto affixed.

\textit{Attest:} \textit{Secretary.}\textit{ President.}
THE STATE OF WYOMING
Certificate of Appropriation of Water

WHEREAS, (successor to John E. Johnson, orig. appropriator) has presented to the Board of Control of the State of Wyoming proof of the appropriation of water from Black's Fork River, tributary Green River, through the Johnson No. 2 Ditch (as changed to Bridger Valley Joint Powers Board Robertson Pipe-line) under Permit No. 12811 for municipal purposes as herein described, lying and being in Uinta County, Wyoming.

NOW KNOW YE, That the State of Board of Control, under the provisions of the Statutes of Wyoming, has, by an order duly made on February 15, 1990 and entered on January 14, 1991 in Order Record 37 Page 30 determined and established the priority and amount of such appropriation as follows: Name and Address of Appropriator(s) Bridger Valley Joint Powers Board, P. O. Box 293, Lyman, Wyoming 82937

| Description of Land and For Which This Appropriation is Determined and Established |
|------------------------------------------|-------------|
| TWP. RANGE SEC. | NE1/4 | NW1/4 | SW1/4 | SE1/4 | TOTAL |
|                | NEW NW1/4 SW1/4 SE1/4 | NEW NW1/4 SW1/4 SE1/4 | NEW NW1/4 SW1/4 SE1/4 | NEW NW1/4 SW1/4 SE1/4 |      |
|                | (see attached sheets) |                        |                        |                        |      |

This appropriation is limited to a maximum diversion period of 105 days beginning May 15 of each year, at a rate of 4,400 c.f.s., then in priority not to exceed 42,800 acre-feet in any one year.

IN TESTIMONY WHEREOF, I, GORDON W. FASSELT, President of the State Board of Control, have hereunto set my hand this 14th day of January, 1991, and caused the seal of said Board to be hereunto affixed.

Attck: \[Signature\] Ex-officio Secretary

\[Signature\] President

Revised 2-87
THE STATE OF WYOMING

CERTIFICATE OF APPROPRIATION OF WATER

Whereas, ... Charles A. Dwyer ... has presented to the Board of Control of the State of Wyoming proof of the appropriation of water from ... Smith's Fork ... through the ... Enl. Prairie ... Ditch under Permit No. 3573 ... for irrigation of the lands herein described, lying and being in ... Uinta County, Wyoming, ... for domestic purposes.

Now Know Ye. That the Board of Control, under the provisions of Chapter 61, Compiled Statutes of Wyoming, 1910, has, by an order duly made and entered on the ... day of November ... A. D. 19... in Order Record No. ... Page ... determined and established the priority and amount of such appropriation as follows:

Name of Appropriator: Charles A. Dwyer ... Postoffice Address: ... Wyoming; Amount of Appropriation: ... cu. ft. per sec.; Date of Appropriation: ... Oct. 29 ... ; Description of land to be irrigated and for which this appropriation is determined and established; Total Acreage: ...; Description: 37 Acres SE1/4 Sec. 27, T. 15 N. R. 115 W.; 41 Acres, total.

For change of use & change of point of diversion & means of conveyance see 0.R. 37, p. 39; 0.R. 78, p. 84.

The right to water hereby confirmed and established is limited to irrigation and the use is restricted to the place where acquired and to the purpose for which acquired; rights for irrigation not to exceed one cubic foot per second for each seventy acres of land for which appropriation is herein determined and established.

In Testimony Whereof, I, ... Charles A. Dwyer ... President of the State Board of Control, have hereunto set my hand this ... day of ... January ... A. D. 19... , and caused the seal of said Board to be hereunto affixed.

Attest: ... Secretary ... President.
THE STATE OF WYOMING
CERTIFICATE OF APPROPRIATION OF WATER Certificate Record No. Page.

WHEREAS, ____________________________ has presented to the Board of Control of the State of Wyoming proof of the appropriation of water from ____________________________ tributary of ____________ for irrigation of the lands herein described, lying and being in ____________ County, Wyoming, for domestic use.

Now Know Ye, That the Board of Control, under the provisions of Chapter 61, Compiled Statutes of Wyoming, 1910, has, by an order duly made and entered on the _ ___ th day of ____________, A. D. 19__ , in Order Record No. ____, determined and established the priority and amount of such appropriation as follows:

Name of Appropmtor ____________________________; Postoffice Address ____________________________, Wyoming;
Amount of Appropriation __________ cu. ft. per sec.; Date of Appropriation ____________; Description of land to be irrigated and for which this appropriation is determined and established; Total Acreage ________________

For change of point of diversion and means of conveyance of this appropriation, see P.O. No. __________.

The right to water hereby confirmed and established is limited to irrigation ____________________________ and the use is restricted to the place where acquired and to the purpose for which acquired; rights for irrigation not to exceed one cubic foot per second for each seventy acres of land for which appropriation is herein determined and established.

IN TESTIMONY WHEREOF, I, ____________________________, President of the State Board of Control, have hereunto set my hand this ___ th day of ____________, A. D. 19__, and caused the seal of said Board to be hereunto affixed.

ATTEST: ____________________________, Secretary. ____________________________, President.
THE STATE OF WYOMING

CERTIFICATE OF APPROPRIATION OF WATER

WHEREAS, W. H. Thomas has presented to the Board of Control of the State of Wyoming proof of the appropriation of water from Smith's Fork Creek, tributary of Blacks Fork tributary of Green River through the Em. Prairie Chief Ditch under Permit No. 3573 Enl. for irrigation and domestic purposes.

of the lands herein described, lying and being in Uinta County, Wyoming.

Now Know Ye, That the State Board of Control, under the provisions of Chapters 65 and 68, Wyoming Compiled Statutes, 1930, has, by an order duly made and entered on the 26th day of April, A. D. 1929, in Order Record No. 7, Page 187, determined and established the priority and amount of such appropriation as follows:

<table>
<thead>
<tr>
<th>Name of Appropriator</th>
<th>W. H. Thomas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postoffice Address</td>
<td>Mt. View</td>
</tr>
</tbody>
</table>

Date of Appropriation: October 23, 1915; Total Acreage Seventeen and five-tenths (17.5) acres

Amount of Appropriation: 0.25 cu. ft. per sec.; Description of land to be irrigated for which this appropriation is determined and established:

<table>
<thead>
<tr>
<th>TWN</th>
<th>RANGE</th>
<th>SEC.</th>
<th>NE 1/4</th>
<th>NW 1/4</th>
<th>SW 1/4</th>
<th>SE 1/4</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15N</td>
<td>116E</td>
<td>27</td>
<td></td>
<td></td>
<td></td>
<td>17.5</td>
</tr>
</tbody>
</table>

The right to water hereby confirmed and established is limited to irrigation and domestic purposes and the use is restricted to the place where acquired and to the purpose for which acquired; rights for irrigation not to exceed one cubic foot of water per second for each seventy acres of land for which the appropriation is herein determined and established.

In Testimony Whereof, I, JOHN A. WHITING, President of the State Board of Control, have hereunto set my hand this 25th day of June, A. D. 1929, and caused the seal of said Board to be hereunto affixed.

John A. Whitling, President.
THE STATE OF WYOMING
Certificate of Appropriation of Water

WHEREAS, (successor to Charles A. Davis, orig. appropriator) has presented to the Board of Control of the State of Wyoming proof of the appropriation

of water from Smith's Fork Creek, tributary Black's Fork River, tributary Green River

through the Enl. Prairie Chief Ditch (as changed to Bridger Valley Joint Powers Board Intake)

under Permit No. 3573 Enl.: for municipal purposes

NOW KNOW YE, That the State of Board of Control, under the provisions of the Statutes of Wyoming, has, by an order duly made on February 15, 1990

and entered on January 14, 1991, in Order Record 10, Page 30, determined and established the priority and amount of such appropriation

as follows: Name and Address of Appropriator(s) Bridger Valley Joint Powers Board, P. O. Box 295, Lyman, Wyoming 82937

Priority: October 29, 1915

Amount of Appropriation: 0.22 acre-feet per sec.

Total Acreage: None

DESCRIPTION OF LAND FOR WHICH THIS APPROPRIATION IS DETERMINED AND ESTABLISHED

<table>
<thead>
<tr>
<th>TWP.</th>
<th>RANGE</th>
<th>SEC.</th>
<th>NE 1/4</th>
<th>NW 1/4</th>
<th>SW 1/4</th>
<th>SE 1/4</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This appropriation is limited to a maximum diversion period of 105 days beginning May 15 of each year, at a rate of 0.02 c.f.s. when in priority, not to exceed 2.1 acre-feet in any one year.

IN TESTIMONY WHEREOF, I, GORDON W. FASSETT, President of the State Board of Control, have hereunto set my hand this 14th day of January, A.D. 1921, and caused the seal of said Board to be hereunto affixed.

Attest: Thomas O. Calwell, Ex-officio Secretary

Revised 2-87
WHEREAS, Town of Lyman, Wyoming has presented to the Board of Control of the State of Wyoming proof of the appropriation of water from Bradshaw Spring, Tributary of a Draw, Tributary Black's Fork River, Tributary Green River through the Lyman Pipe Line under Permit No. 17993 for municipal use in Uinta County, Wyoming.

NOW KNOW YE, That the State Board of Control, under the provisions of the Statutes of Wyoming, has, by an order duly made and entered on the 17th day of August, A. D. 1967, in Order Record No. 17, Page 140, determined and established the priority and amount of such appropriation as follows:

Name of Appropriator: Town of Lyman, Wyoming; Postoffice Address: Lyman, Wyoming;
Date of Appropriation: October 23, 1921; Total Acreage: None;
Amount of Appropriation: 0.127 cu. ft. per sec.; Description of land for which this appropriation is determined and established:

<table>
<thead>
<tr>
<th>TWP</th>
<th>RANGE</th>
<th>SEC</th>
<th>NE¼</th>
<th>NW¼</th>
<th>SW¼</th>
<th>SE¼</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>NE¼</td>
<td>NW¼</td>
<td>SW¼</td>
<td>SE¼</td>
<td>NE¼</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>NE¼</td>
<td>NW¼</td>
<td>SW¼</td>
<td>SE¼</td>
<td>NE¼</td>
</tr>
</tbody>
</table>

LOCATION OF THE TOWN OF LYMAN:
NW₁/₄, SW₁/₄, SW₁/₄, NW₁/₄, SECTION 38, TOWNSHIP 16 NORTH, RANGE 114 WEST

THIS APPROPRIATION IS LIMITED TO THE AMOUNT BENEFICIALLY USED FOR MUNICIPAL PURPOSES WITHIN THE TOWN OF LYMAN, WYOMING AT THE ABOVE LOCATION, NOT TO EXCEED 0.127 C.F.S.

The right to water hereby confirmed and established is limited to municipal use and the use is restricted to the place where acquired and to the purpose for which acquired.

IN TESTIMONY WHEREOF, I, FLOYD A. BISHOP, President of the State Board of Control, have hereunto set my hand this 17th day of August, A. D. 1967, and caused the seal of said Board to be hereunto affixed.

Att. Ex-officio Secretary.
WHEREAS, Town of Lyman has presented to the Board of Control of the State of Wyoming proof of the appropriation of water from Forman Spring, Tributary Watson Spring Creek, Tributary Black's Fork River, Tributary Green River through the Forman Spring Pipeline for municipal purposes under Permit No. 26193.

NOW KNOW YE, That the State Board of Control, under the provisions of the Statutes of Wyoming, has, by an order duly made and entered on the 28th day of December, A. D. 1972, in Order Record No. 21, determined and established the priority and amount of such appropriation as follows:

<table>
<thead>
<tr>
<th>TWP.</th>
<th>RANGE</th>
<th>SEC.</th>
<th>NE1/4</th>
<th>NW1/4</th>
<th>SW1/4</th>
<th>SE1/4</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>NE1/4</td>
<td>NW1/4</td>
<td>SW1/4</td>
<td>SE1/4</td>
<td></td>
</tr>
<tr>
<td>16N</td>
<td>11W</td>
<td>31</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>16N</td>
<td>11W</td>
<td>32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This appropriation is limited to 0.22 cubic feet per second for municipal purposes at the following points of use within the corporate boundaries of the town of Lyman:

Head Gate: SWNE1/4 Section 20-15-115

The right to water hereby confirmed and established is limited to municipal purposes of the town of Lyman and the use is restricted to the place where acquired and to the purpose for which acquired.

IN TESTIMONY WHEREOF, I, GEORGE L. CHRISTOPULOS, President of the State Board of Control, have hereunto set my hand this 28th day of December, A. D. 1972, and caused the seal of said Board to be hereunto affixed.

Attest: William Long, Ex-officio Secretary.
BENTOMAT® CL CERTIFIED PROPERTIES

<table>
<thead>
<tr>
<th>MATERIAL PROPERTY</th>
<th>TEST METHOD</th>
<th>TEST FREQUENCY</th>
<th>REQUIRED VALUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bentonite Swell Index</td>
<td>ASTM D 5890</td>
<td>1 per 50 tonnes</td>
<td>24 mL/2g min.</td>
</tr>
<tr>
<td>Bentonite Fluid Loss</td>
<td>ASTM D 5891</td>
<td>1 per 50 tonnes</td>
<td>18 mL max.</td>
</tr>
<tr>
<td>Bentonite Mass/Area</td>
<td>ASTM D 5993</td>
<td>40,000 ft² (4,000 m²)</td>
<td>0.75 lb/ft² (3.6 kg/m²) min</td>
</tr>
<tr>
<td>GCL Grab Strength</td>
<td>ASTM D 4632</td>
<td>200,000 ft² (20,000 m²)</td>
<td>120 lbs (530 N)</td>
</tr>
<tr>
<td></td>
<td>ASTM D 6768</td>
<td></td>
<td>30 lbs/in (53 N/cm)</td>
</tr>
<tr>
<td>GCL Peel Strength</td>
<td>ASTM D 4632</td>
<td>40,000 ft² (4,000 m²)</td>
<td>15 lbs (65 N)</td>
</tr>
<tr>
<td></td>
<td>ASTM D 6496</td>
<td></td>
<td>2.5 lbs/in (4.4 N/cm)</td>
</tr>
<tr>
<td>GCL Index Flux</td>
<td>ASTM D 5887</td>
<td>Periodic</td>
<td>1 x 10⁻⁹ m³/m²/sec max</td>
</tr>
<tr>
<td>GCL Hydraulic Conductivity</td>
<td>ASTM D 5887</td>
<td>Periodic</td>
<td>5 x 10⁻¹⁰ cm/sec max</td>
</tr>
<tr>
<td>GCL Hydrated Internal Shear Strength</td>
<td>ASTM D 5321</td>
<td>Periodic</td>
<td>500 psf (24 kPa) typical</td>
</tr>
<tr>
<td></td>
<td>ASTM D 6243</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Bentomat CL is a reinforced GCL consisting of a layer of sodium bentonite between two geotextiles, which are needlepunched together and laminated to a thin flexible membrane liner.

Notes:
1. Bentonite property tests performed at a bentonite processing facility before shipment to CETCO's GCL production facilities.
2. Bentonite mass/area reported at 0 percent moisture content.
3. All tensile strength and peel strength testing is performed in the machine direction using 4 inch grips per modified ASTM D 4632. Results are reported as minimum average roll values unless otherwise indicated. Upon request, tensile strength can be reported per ASTM D 6768 and peel strength can be reported per ASTM D 6496.
4. ASTM D5887 Index flux and hydraulic conductivity testing with deaired distilled/deionized water at 80 psi (551 kPa) cell pressure, 77 psi (531 kPa) headwater pressure and 75 psi (517 kPa) tailwater pressure. Reported value is equivalent to 92 gal/acre/day. This flux value is equivalent to a permeability of 5x10⁻¹⁰ cm/sec for typical GCL thickness. ASTM D 5887 testing is performed only on a periodic basis because the membrane is essentially impermeable.
5. Peak value measured at 200 psf (10 kPa) normal stress for a specimen hydrated for 48 hours. Site-specific materials, GCL products, and test conditions must be used to verify internal and interface strength of the proposed design.
# BENTOMAT® CLT CERTIFIED PROPERTIES

<table>
<thead>
<tr>
<th>MATERIAL PROPERTY</th>
<th>TEST METHOD</th>
<th>TEST FREQUENCY</th>
<th>REQUIRED VALUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bentonite Swell Index&quot;</td>
<td>ASTM D 5890</td>
<td>1 per 50 tonnes</td>
<td>24 mL/2g min.</td>
</tr>
<tr>
<td>Bentonite Fluid Loss&quot;</td>
<td>ASTM D 5891</td>
<td>1 per 50 tonnes</td>
<td>18 mL max.</td>
</tr>
<tr>
<td>Bentonite Mass/Area&quot;</td>
<td>ASTM D 5993</td>
<td>40,000 ft² (4,000 m²)</td>
<td>0.75 lb/ft² (3.6 kg/m²) min</td>
</tr>
<tr>
<td>GCL Grab Strength&quot;</td>
<td>ASTM D 4632</td>
<td>200,000 ft² (20,000 m²)</td>
<td>120 lbs (530 N)</td>
</tr>
<tr>
<td>GCL Peel Strength&quot;</td>
<td>ASTM D 4632</td>
<td>40,000 ft² (4,000 m²)</td>
<td>15 lbs (65 N)</td>
</tr>
<tr>
<td>GCL Index Flux&quot;</td>
<td>ASTM D 5887</td>
<td>Periodic</td>
<td>1 x 10⁻⁹ m³/m²/sec max</td>
</tr>
<tr>
<td>GCL Hydraulic Conductivity&quot;</td>
<td>ASTM D 5887</td>
<td>Periodic</td>
<td>5 x 10⁻¹⁰ cm/sec max</td>
</tr>
<tr>
<td>GCL Hydrated Internal Shear Strength&quot;</td>
<td>ASTM D 5321</td>
<td>Periodic</td>
<td>500 psf (24 kPa) typical</td>
</tr>
</tbody>
</table>

Bentomat CLT is a reinforced GCL consisting of a layer of sodium bentonite between two geotextiles, which are needlepunched together and laminated to a 20-mil (0.5mm) textured HDPE geomembrane.

**Notes**

1. Bentonite property tests performed at a bentonite processing facility before shipment to CETCO's GCL production facilities.
2. Bentonite mass/area reported at 0 percent moisture content.
3. All tensile strength and peel strength testing is performed in the machine direction using 4 inch grips per modified ASTM D 4632. Results are reported as minimum average roll values unless otherwise indicated. Upon request, tensile strength can be reported per ASTM D 6768 and peel strength can be reported per ASTM D 6496.
4. ASTM D5887 Index flux and hydraulic conductivity testing with deaired distilled/deionized water at 80 psi (551 kPa) cell pressure, 77 psi (531 kPa) headwater pressure and 75 psi (517 kPa) tailwater pressure. Reported value is equivalent to 92 gal/acre/day. This flux value is equivalent to a permeability of 5x10⁻¹⁰ cm/sec for typical GCL thickness. ASTM D 5887 testing is performed only on a periodic basis because the membrane is essentially impermeable.
5. Peak value measured at 200 psf (10 kPa) normal stress for a specimen hydrated for 48 hours. Site-specific materials, GCL products, and test conditions must be used to verify internal and interface strength of the proposed design.
# Bentomat® & Claymax® Panel & Roll Specifications

## Panel Specifications

<table>
<thead>
<tr>
<th>PRODUCTS</th>
<th>DIMENSIONS Width x Length</th>
<th>AREA</th>
<th>EFFECTIVE AREA</th>
</tr>
</thead>
<tbody>
<tr>
<td>BENTOMAT® ST</td>
<td>15 ft x 150 ft (4.6 m x 45.7 m)</td>
<td>2,250 ft² (209 m²)</td>
<td>2,145 ft² (200 m²)</td>
</tr>
<tr>
<td>BENTOMAT SDN</td>
<td>14.5 ft x 150 ft (4.4 m x 45.7 m)</td>
<td>2,175 ft² (202 m²)</td>
<td>2,071 ft² (193 m²)</td>
</tr>
<tr>
<td>BENTOMAT DN</td>
<td>14.5 ft x 150 ft (4.4 m x 45.7 m)</td>
<td>2,175 ft² (202 m²)</td>
<td>2,071 ft² (193 m²)</td>
</tr>
<tr>
<td>BENTOMAT YSDN</td>
<td>14.5 ft x 200 ft (4.4 m x 60.9 m)</td>
<td>2,900 ft² (270 m²)</td>
<td>2,771 ft² (258 m²)</td>
</tr>
<tr>
<td>BENTOMAT CL</td>
<td>15 ft x 150 ft (4.6 m x 45.7 m)</td>
<td>2,250 ft² (209 m²)</td>
<td>2,145 ft² (200 m²)</td>
</tr>
<tr>
<td>Lovell, WY Plant</td>
<td>14.5 ft x 150 ft (4.4 m x 45.7 m)</td>
<td>2,175 ft² (202 m²)</td>
<td>2,071 ft² (193 m²)</td>
</tr>
<tr>
<td>BENTOMAT CLT</td>
<td>15 ft x 150 ft (4.6 m x 45.7 m)</td>
<td>2,250 ft² (209 m²)</td>
<td>2,145 ft² (200 m²)</td>
</tr>
<tr>
<td>CLAYMAX 200R</td>
<td>15 ft x 150 ft (4.6 m x 45.7 m)</td>
<td>2,250 ft² (209 m²)</td>
<td>2,145 ft² (200 m²)</td>
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<tr>
<td>600CL</td>
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<td>2,250 ft² (209 m²)</td>
<td>2,145 ft² (200 m²)</td>
</tr>
<tr>
<td>Lovell, WY Plant</td>
<td>14.5 ft x 150 ft (4.4 m x 45.7 m)</td>
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<td>2,071 ft² (193 m²)</td>
</tr>
<tr>
<td>CLAYMAX 600CL</td>
<td>15 ft x 150 ft (4.6 m x 45.7 m)</td>
<td>2,250 ft² (209 m²)</td>
<td>2,145 ft² (200 m²)</td>
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<td>Fairmount, GA Plant</td>
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<td>2,175 ft² (202 m²)</td>
<td>2,071 ft² (193 m²)</td>
</tr>
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## Roll Specifications

<table>
<thead>
<tr>
<th>PRODUCTS</th>
<th>DIMENSIONS Length x Diameter (Avg.)</th>
<th>NOMINAL WEIGHT</th>
<th>ROLLS / TRUCKLOAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>BENTOMAT ST</td>
<td>16 ft x 24 in (4.9 m x 610 mm)</td>
<td>2,600 lbs (1180 kg)</td>
<td>16 rolls per truckload</td>
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<tr>
<td>BENTOMAT SDN</td>
<td>16 ft x 24 in (4.9 m x 610 mm)</td>
<td>2,650 lbs (1200 kg)</td>
<td>15 rolls per truckload</td>
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<tr>
<td>BENTOMAT DN</td>
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<td>2,850 lbs (1200 kg)</td>
<td>15 rolls per truckload</td>
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<tr>
<td>BENTOMAT YSDN</td>
<td>15 ft x 24 in (4.6 m x 600 mm)</td>
<td>2,500 lbs (1133 kg)</td>
<td>17 rolls per truckload</td>
</tr>
<tr>
<td>BENTOMAT CL</td>
<td>16 ft x 24 in (4.9 m x 610 mm)</td>
<td>2,650 lbs (1200 kg)</td>
<td>15 rolls per truckload</td>
</tr>
<tr>
<td>BENTOMAT CLT</td>
<td>16 ft x 26 in (4.9 m x 660 mm)</td>
<td>2,950 lbs (1340 kg)</td>
<td>15 rolls per truckload</td>
</tr>
<tr>
<td>CLAYMAX 200R</td>
<td>16 ft x 20 in (4.9 m x 510 mm)</td>
<td>2,750 lbs (1250 kg)</td>
<td>15 rolls per truckload</td>
</tr>
<tr>
<td>CLAYMAX 600CL</td>
<td>16 ft x 20 in (4.9 m x 510 mm)</td>
<td>2,825 lbs (1250 kg)</td>
<td>15 rolls per truckload</td>
</tr>
</tbody>
</table>

Unloading and handling equipment for all GCL products:
- Spread bar and core pipe: Spread bar 17 ft (5.2 m) long; core pipe 20 ft (6.1 m) long, nominal pipe size, XXH.
- Core Pipe for Bentomat YSDN: 16 ft (4.9 m); O.D. = 3.5 in (90 mm)
- A solid 3.5 in. (90 mm) O.D. x 14.5 ft (4.4 m) solid steel pipe stinger attachment for a forklift.
- Slings: 2 Polyester slings are required, approximately 12 ft (3.7 m) long x 2 in (50 mm) wide each.
- Vehicle needed: Front end loader or forklift (are typical).

**Standard Roll Specifications:**
- Packaging: U.V. resistant polyethylene sleeve.

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The information and data contained herein are believed to be accurate and reliable. CETCO makes no warranty of any kind and accepts no responsibility for the results obtained through application of this information.
GEOMEMBRANE/GCL COMPOSITE FINAL COVER FOR A HAZARDOUS WASTE LANDFILL

MARK SWYKA, P.E., IT CORPORATION
UNITED STATES OF AMERICA
JIM OLSTA, CETCO
UNITED STATES OF AMERICA
RON COTTON, G.E. CORPORATION
UNITED STATES OF AMERICA

ABSTRACT

The incorporation of a geosynthetic clay liner (GCL) in the closure of a permitted hazardous waste landfill resulted in both an increase in waste disposal capacity and a reduction in final cover construction costs. The state regulatory authority required a composite final cover. The cross section originally designed for the site consisted of a 60 cm (24-inch) compacted clay layer overlain by a 40-mil textured geomembrane overlain by 1.1 m (42 inches) of protection soil, and 15 cm (6 inches) of topsoil.

The final cover cross-section was revised to a total of 0.8 m (30 inches) consisting of a needlepunched nonwoven GCL, overlain by a 40-mil textured geomembrane overlain by a 30 cm (12 inch) drainage layer, 30 cm (12 inches) of protection soil, and 15 cm (6 inches) of topsoil. The equivalency issues evaluated included hydraulic issues, physical/mechanical issues, construction issues, and economic issues. An evaluation determined the GCL provided superior performance to a compacted clay liner while accelerating construction and reducing overall costs.

INTRODUCTION

As a component of its materials management system, a major New York industrial manufacturer maintains an active Hazardous Waste Disposal Unit at its facility. This Disposal Unit is necessary to accept hazardous by-products of its manufacturing and on-site waste water treatment processes. As the permitted air-space of this facility was depleted, IT reviewed opportunities to modify the landfill design to extend site life and defer the expense associated with the construction of a new landfill facility.
In 1995, a permit modification application was prepared for the vertical expansion of the facility. The permit modification application had three fundamental components and included the following changes to the permitted design: An increase in the facility sideslopes from the currently permitted slopes of 4H:1V and 5H:1V (the maximum allowed by regulation) and a 3 meter (10-foot) increase in the top elevation of the landfill. These changes increased facility capacity by 30,000 m³ (39,000 cubic yards).

- Replacement of the 60 cm (24-inch) low permeability soil layer with an equivalent geosynthetic clay liner (GCL). This change increased facility capacity by 14,000 m³ (19,000 cubic yards).
- Reduction in the total thickness of cover soils above the liner from 1.2 m (4 feet) to 0.8 m (2.5 feet). This change increased facility capacity by 11,000 m³ (14,000 cubic yards).

These modifications, shown in Figure 1, resulted in a total landfill capacity increase of 55,000 m³ (72,000 cubic yards). While not a huge increase for typical landfills, the hazardous waste capacity is at a premium and the above modifications effectively extended hazardous waste disposal capacity within this landfill for an additional five years. The key to the modification was the use of a GCL in place of compacted clay in the cover design. This paper will focus on the considerations addressed in evaluating the use of a GCL in place of compacted clay.

Figure 1. Original and Revised Final Cover Designs
GEOSYNTHETIC CLAY LINERS

A GCL is a factory manufactured hydraulic barrier that consists of a layer of sodium bentonite bonded to one or more geosynthetics. There are several different types of GCLs currently produced in the United States, 1) bentonite adhesive-bonded to two geotextiles, 2) bentonite needlepunch-bonded between two geotextiles, 3) a membrane laminated to one of the above, and 4) bentonite adhesive-bonded to a geomembrane.

Bentonite is primarily composed of montmorillonite, a high swelling clay. Under a confining pressure of 35 kPa (5 psi) GCLs have a hydraulic conductivity of < 5 x 10^-9 cm/s. Since their introduction in the 1980s, GCLs have become a common material in the design of landfill liners as an alternative to compacted clay liners. Due to final cover stability concerns, a double-nonwoven needlepunched GCL was chosen for evaluation as the alternative in this project.

DESIGN CONSIDERATIONS

The design considerations for the modifications described above, included global landfill stability, final cover stability, protection of final cover barrier layers from freeze/thaw damage and equivalency of cover barriers.

A cross-section was developed using the information from the site topographic mapping, as-built baseline topography for the landfill, the hydrogeologic investigation, the existing grade of waste, and the proposed final grade of the landfill. The slope stability analyses were primarily based on this cross-section.

Because of the relatively low strength of the silty clay layer and the low interface strengths of the baseliner system, the global stability analysis focused on the following:

- The stability of the base soil underlying the baseliner of the landfill
- The stability of the side slopes
- The stability of the baseliner system

The global stability analyses of the landfill were performed using the computer program, PCSTABL5M, developed by Purdue University. This program is capable of conducting two-dimensional slope stability analysis under various circumstances. Seismic stability analyses were also conducted on the long-term global stability of the landfill.

The final cover stability calculations were performed using the infinite slope stability approach. Based upon the proposed final cover profile, stability of the proposed cap is controlled by three primary factors:
• The shear strength of the various interfaces and the internal shear strength of the GCL,
• The shear strength of the soils used above the geomembrane,
• The development of seepage forces or pore pressures above the geomembrane associated with infiltration from rainfall.

The behavior of the geomembrane soil interface is well understood and has been documented many times since the use of geomembrane caps first began. Of greater interest in the design was the interface between the GCL and the geomembrane and the shear forces that may pass directly through the GCL.

GCL DIRECT SHEAR TESTING

Based upon previous discussions and submissions to the NYDEC, the minimum factor of safety against sliding that would be acceptable was 1.25. This factor of safety was based upon the engineered nature of all the products used, the repairable nature of any damage that may occur in the cap and the limited consequences of any failure in the cap with respect to potential loss of life or irreversible damage to the environment.

The stability of the proposed composite cap containing the GCL was evaluated. Two interface direct shear tests were performed at normal loads of 7.5, 15 and 25 kPa (150, 300 and 500 psf) between the 40-mil textured geomembrane and a double-nonwoven needlepunched GCL with no fiber melting process. The design analyses incorporated data from recent laboratory test results of the materials proposed for construction. The results of these analyses supported factors of safety in excess of 1.25 based upon the residual interface shear strengths. Conformance testing of materials supplied for construction exceeded minimum strength requirements. Conformance testing yielded peak friction angles of 37.5 and 32 degrees with respective cohesion values of 118 psf and 111psf. Residual friction angles of 27.1 and 18.5 degrees were measured with cohesion intercepts of 51 psf and 80 psf, respectively.

Internal shear was not considered to be the critical factor for needlepunched GCLs placed against geomembranes at low normal stresses. An EPA sponsored large-scale field study that was in progress at the time of design did not show any internal shear failures for needlepunched GCLs on 2H:1V slopes (Koerner et al., 1996). When loaded in the shear testing apparatus, the GCL/other interface can be constructed to have a multi interface sandwich consisting of the two layers of geotextile, the bentonite, and the other material being tested. In all cases, the GCL/other interface failed before failing the GCL internally. As a result, the internal strength of the GCL is considered greater than the interface strength at relatively low (15 kPa) loads. Also, historical internal direct shear data from an independent laboratory for the double-nonwoven needlepunched GCL under low normal loads had yielded a 44 degree friction angle.
FREEZE/THAW

Based upon the molecular composition of bentonite as well as the results of laboratory and field testing, no impact to the GCL's hydraulic properties due to freeze/thaw is expected. This is due to the weak interbonding in montmorillonite clays that results in interlayer expansion whenever polar molecules, such as water, are available. This is quite in contrast to most naturally occurring clays in the Northeast U.S., which do not expand or swell in the presence of free water. This results in the development in compacted clay of increased permeability upon successive freeze/thaw cycles due to flow channels created by the formation of micro lenses during the freezing process. The moisture that forms the micro lens is drawn from the surrounding clay peds, desiccating the clay. For non-montmorillonite clays, these desiccated zones do not significantly swell upon release of the moisture during thawing. This results in an increase in permeability. Comparatively, bentonite, a montmorillonitic clay, does swell upon thawing and therefore would not be expected to exhibit an increase in permeability associated with freeze-thaw cycles.

Several laboratory and field tests have been performed on geosynthetic clay liners and compacted clay liners, to specifically analyze the affects of freeze/thaw cycles on them. Reports and papers have been written based upon these results. Specifically, Nelson (1993) demonstrated by laboratory testing that the permeability characteristics of a GCL product do not appear to be affected by exposure to multiple freeze/thaw cycles. Kraus et al. (1997) demonstrated by laboratory and field testing that the hydraulic conductivity of needlepunched GCLs did not change significantly after freezing and thawing through one winter. However, Benson et al. (1995) and Chamberlain et al. (1995) have shown through field and laboratory studies that compacted clay does form micro cracks that do not heal upon thawing resulting in increased permeability.

It is evident from this literature that GCLs outperform compacted clay liners with respect to freeze-thaw. Therefore, the thickness of the cover soil of the final cover could be reduced.

EQUIVALENCY

The NYDEC prescriptive cover is a composite cover consisting of 60 cm (24 inches) of compacted clay, with a permeability of no greater than \(1 \times 10^{-7}\) cm/s, overlain by a geomembrane. The idea of using a geomembrane over a clay liner to form a composite liner takes advantage of the beneficial properties of each of the materials in a synergistic manner. The geomembrane provides the primary impermeability of the lining system. Small defects in the geomembrane can be backed up and blinded off by the clay, greatly reducing the leakage potential. In effect, the geomembrane limits flow through the clay liner to relatively small areas.
The specific issues for a technical comparison of GCLs to compacted clay liners have been well documented and presented in literature by Koerner and Daniel (1993). The issues can be divided into two categories: hydraulic and physical/mechanical.

Empirical modeling and field monitoring (Giroud, et al., 1997) have demonstrated that leakage through a circular hole in a geomembrane is a function of the underlying clay permeability, liquid head above the hole, hole size, and degree of intimate contact between the geomembrane and the soil. Leakage rates can be theoretically predicted according to the following equation:

\[ Q = C \left[ 1 + 0.1 \left( \frac{h_w}{t_s} \right)^{0.85} \right] a^{0.1} h_w^{0.9} k_s^{0.74} \]  

Where \( Q \) = rate of leakage through a hole; \( C \) = a constant related to the quality of the intimate contact between the geomembrane and the underlying clay liner; \( a \) = area of hole in geomembrane; \( h_w \) = head of liquid on top of the geomembrane; \( t_s \) = clay liner thickness and \( k_s \) = permeability of the underlying clay liner.

By inspection of the parameters involved in equation (1), it can be deduced that the possibilities of reducing potential liner leakage in terms of the soil component of a composite liner are related to the quality of its surface for creating an intimate interface with the overlying geomembrane and its permeability.

A paper by Harpur, et al. (1993) describes experiments that were performed on five different GCLs to evaluate the quality of their intimate contact with geomembranes in terms of hydraulic transmissivity along the contact. They present a very revealing graph that demonstrates the effectiveness of a GCL in limiting the horizontal flow of liquid coming through a defect in a geomembrane. The graph indicates that GCLs would be 2 to 3 orders of magnitude more effective in reducing horizontal transmissivity than theoretically excellent field conditions with a compacted clay liner. This would have a direct impact on the amount of leakage that would occur through a geomembrane defect.

The permeability of needlepunched GCL, even at low normal loads, has been shown to be on the order of \( 5 \times 10^{-9} \) cm/s (Estornell and Daniel, 1992). This compares favorably to the prescriptive compacted clay liner permeability of \( 1 \times 10^{-7} \) cm/s.

Thus, regarding liner leakage through geomembrane defects, the above analysis indicates that GCLs are at least technically equivalent, and most likely superior, to compacted clay liners. This is supported by an EPA funded study of actual leakage through double-lined composite liner systems in municipal solid waste landfills. Data (Bonaparte et al., 1999) indicates that geomembrane/GCL composite liner systems yielded the lowest flow in leachate detection systems in both active and post-closure cells.
From a physical/mechanical perspective, the most important factor for the final cover is differential settlement. Differential settlement could result in separation, cracking or tearing of various elements of the final cover system. In a related sense, deformation from a seismic event, could cause defects or failures in liner elements in a similar manner to differential settlement.

Koerner and Daniel (1993) describe reports and tests that document needlepunched GCL’s ability to withstand relatively high levels of tensile strain (on the order of 10 to 15 percent) without undergoing significant increases in permeability. Standard compacted clay liners, on the other hand, generally cannot tolerate strains approaching one percent without cracking. GCLs are generally considered superior to compacted clay liners in terms of their ability to resist damage from deformation. Slope stability and freeze/thaw behavior are other key elements in the equivalency demonstration. These elements, discussed previously, also indicated that the GCL is equivalent, or superior, to compacted clay.

CONSTRUCTION ISSUES

The final cover was constructed in several phases. Phase I was completed in July 1997, Phase II was constructed in July of 1998, and Phase III was constructed in May of 1999. Construction issues, when comparing GCLs to compacted clay liners, include subgrade preparation, material availability, speed and ease of installation, and construction quality assurance.

A GCL’s relative thinness requires that more attention be given to subgrade preparation than for a compacted clay liner. The subgrade for the GCL was the in-place soil-like hazardous waste material. This material is a fine-grained soil-like material that when delivered for disposal contained no sharp stones or other objects that could damage the liner. This material was graded to a 3H:1V (33%) slope and covered with a temporary tarp to shed rainwater until the final cover construction was initiated. Prior to GCL placement, the deployment area was inspected and hand picked for large or sharp objects which may have been included with the waste during the process of landfilling and that might damage the liner. After grading and inspection of the subgrade, the GCL could be safely pulled over the waste surface without damage.

Although the additional attention to subgrade preparation may appear at first to be a disadvantage for a GCL compared to a compacted clay liner; it is actually an advantage. The reason for this is that the most critical subgrade preparation is for the geomembrane. In the case of a compacted clay liner, this means the top surface of the clay liner requires very careful finishing. This is often difficult, requires special equipment, and is often at odds with the aim of covering up the clay as soon as possible to reduce desiccation.

In the case of GCLs, the subgrade can be smoothed out to fit the convenience of the construction schedule without worrying about moisture loss. Even though the same subgrade preparation specifications would be used for the GCL as would be used for a geomembrane, it is
actually slightly less critical because of the cushioning effect of the GCL. The surface of the GCL will be much more ideal for a composite liner than the finished compacted clay surface.

Regarding material availability, needlepunched GCLs are readily available from two suppliers.

A GCL can be installed much quicker and easier than a compacted clay liner. Once the GCL material is approved through manufacturers' certifications, conformance testing and on site inspection, its installation is very quick and straightforward. As shown in Figure 2, a backhoe with spreader bar attachment and a four-wheel all-terrain vehicle were used to initially deploy the GCL. A work crew then moved the GCL into final position and placed bentonite between the overlapping seams. In good weather, a crew can typically install one and one-half acres a day with production often limited by the geomembrane installation.

![Figure 2. Geosynthetic Clay Liner Deployment](image)

The most critical item during installation is to prevent excessive hydration of the GCL prior to loading. Hydration sources come from precipitation before the GCL is covered with the geomembrane and moisture absorbed from the subgrade waste. Hydration from precipitation was controlled by covering all in-place GCL with geomembrane on the same day that it was deployed (Figure 3).

Hydration from moisture in the subgrade materials is somewhat less defined. If the GCL hydrates before the soil cover is placed, adequate strength can not be guaranteed to support the soils and the placement equipment. Therefore it is necessary to place the soil cover in a timely fashion. In general, a window of 10 to 20 days is available between the time of GCL placement
and the need to have cover soils in place. All placement of soils in the final cover was performed within this window with no stability issues.

Comparatively, a compacted clay liner must be moisture conditioned, compacted in lifts at controlled moistures and densities, inspected for good lift bonding and breakdown of clods, and finished smooth enough for overlaying of a geomembrane.

In general, both a GCL and compacted clay liner can be satisfactorily constructed during moderate weather. However, during wet, rainy weather neither a GCL nor a compacted clay liner can be installed. During hot, dry weather a GCL would be superior to a compacted clay liner. While this type of weather is actually advantageous to a GCL, it would tend to desiccate a compacted clay liner.

COST ANALYSIS

The GCL barrier layer was overall less costly to construct than the compacted clay barrier. The actual construction cost paid to the contractor to construct the GCL final cover was $112,000 per acre. This cost includes all of the soil and geosynthetic components of the final cover but is exclusive of other ancillary activities associated with the construction. By comparison, using the same unit rates, the cost to construct the final cover with the recompacted clay barrier would have been $154,000 per acre. The direct savings in construction cost were determined to be $42,000 per acre. This cost difference is specific to construction and does not
include the value of the additional waste disposal capacity created through the implementation of this modification.

There are five aspects of cost to consider when comparing the overall costs of the original compacted clay liner/geomembrane composite final cover to the revised GCL/geomembrane composite final cover:

- Material Quantities
- Material Cost (Material, Transportation, Installation)
- Construction Time
- Construction Quality Control (CQC) and Construction Quality Assurance (CQA) Cost
- Airspace

The revised final cover design reduced the overall quantity of material that was incorporated into the closure. In total, the cover soil thickness was reduced from 1.2 m (48 inches) to 0.8 m (30 inches). Therefore a total of 1,850 cubic meters (2,420 cubic yards) of material per acre were saved.

The comparison of the cost of the materials suggests that due to the reasonable availability of naturally occurring clay in the area of the project site, the unit cost per square foot of barrier layer were essentially equivalent. If clay soils had to be purchased from off-site, the GCL would have been less expensive. All other material prices were equivalent between the two final cover cross-sections.

The time required to construct the GCL barrier layer is significantly less than the time required to construct a recompacted clay barrier layer. This reduction in contract time is reflected in the contractor's unit prices for various activities. Savings in "G&A", General and Administrative costs throughout the period of construction were not accounted for in this assessment.

The differential in construction quality control costs were minimal compared to the other parameters. However it is necessary to note that as a reduction in construction time, CQA costs would also be lower for the revised final cover cross-section.

The airspace savings were a key element. Air space for the disposal of Hazardous Waste is at a premium. At the time of this evaluation, the cost for trucking and off-site disposal at a commercial facility is on the order of $105 to $130 per cubic meter ($80 to $100 per cubic yard). Therefore the commercial value of the air space generated by this design change is in the range of $5.7 million to $7.2 million. Without the airspace savings, waste would need to be sent to an off-site disposal facility or another cell would have to be constructed. Both options represent a significant increase in cost over the option selected.
PERFORMANCE

Performance of the composite landfill final cover has been excellent. The measured quantities of leachate collected at the facility have decreased dramatically with the introduction of the final cover. Leachate generation is monitored very closely at this facility. Daily leachate generation data is monitored and reported to NYSDEC on a monthly basis. The first phase of construction was performed in the Spring of 1997. Prior to final cover construction, an average of 867,000 liters (229,000 gallons) of leachate were collected each month (approximately 13,000 lphd or 1,400 gpd). Upon the completion of the Phase I final cover construction, leachate generation dropped to an average of approximately 352,000 liters (93,000 gallons) per month (5,200 lphd or 560 gpd). With the completion of the Phase III final cover construction in May of 1999, leachate generation was reduced to approximately 250,000 liters (66,000 gallons) per month (3,700 lphd or 400 gpd).

It is interesting to note that the reduction in leachate generation observed with this waste material appeared to correspond directly with the placement of the final cover. At the point of completion of the Phase III final cover, approximately 78% of the landfill had received final cover and leachate generation had been reduced by approximately 71% indicating a very close correlation.

CONCLUSION

The use of a GCL in place of a compacted clay liner in a hazardous waste landfill cover design resulted in significant cost savings, accelerated construction time, and improved performance over compacted clay liners.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the firms and individuals without whose efforts the project could have never been completed. Rasheed Ahmed of the EMCON/IT Geosynthetics Laboratory for his dogged persistence and excruciating detail with the interface strength testing; R.J. Kennedy & Sons, Inc.; William J. Keller & Sons Construction Corp.; GSE Lining Technology, Inc.; Solmax Geosynthetics; New England Liner Systems; geotechnical wizards Peter Carey and Nagesh Koragappa; Don Hullings for his critical review and being a-buddy; and most of all Casey Cowan, Matt Hamilton, and Ken Kerr for their copious field notes and proactive approach to construction problem avoidance.
REFERENCES


ENGINEERS designing ponds or canal liners must determine the expected change in water level resulting from two phenomena:

- the amount of water that passes through the liner; and
- the amount of water lost due to evaporation.

Each of the traditional methods of reducing the water flow through these structures, compacted clay liners (CCLs) and geomembranes, has serious drawbacks. CCLs are difficult, expensive and time consuming to build. Even when properly constructed, most CCLs will not perform as designed due to damage from environmental factors such as freeze-thaw and desiccation. While geomembranes can be installed faster than CCLs, they require specially trained personnel and seaming equipment. Additionally, geomembranes are susceptible to small punctures that can dramatically reduce their effectiveness.

**Bentomat® CL, Bentomat CLT and Claymax® 600CL**

Bentomat CL and Claymax 600CL Geosynthetic Clay Liners (GCL) are reinforced and unreinforced GCLs, respectively, consisting of a layer of sodium bentonite between two geotextiles, one of which is laminated with a thin membrane. Bentomat CLT is a reinforced GCL consisting of a standard needlepunched GCL laminated to a 20-mil HDPE geomembrane. These composite laminated (CL) GCLs combine the best features of a GCL and a geomembrane,
making it an excellent choice for lining ponds and other water containment structures. CL series GCLs are very low permeability will significantly reduce the flow rate from a pond more economically than a thick compacted clay liner. CL series GCLs also has several advantages over pure plastic liners including:

- Simpler installation;
- No special seaming equipment required; and
- Self-healing of small punctures.

* If the GCL is to be placed on a non-soil subbase such as gravel, the test should be conducted on that subbase.

**Flow Rate through CL Series GCLs**

The flow rate through CL series GCLs has been determined in the laboratory to be 95 gallons per acre per day (gpad) or $5 \times 10^{-10}$ cm/sec. This value was determined by measuring the flux (flow) across the sample when a head differential equivalent to 4.6-ft (2 psi) of water was applied to the sample. The flow rate through the liner will be greater when the liner is used in ponds with depths exceeding 4.6 ft (2 psi). The CL series GCLs low flux makes them suitable for most wastewater treatment ponds.

Bentomat ST may be used in pond applications where relatively high flow rates are allowable, such as stormwater detention ponds. Also, Bentomat ST may be used in ponds where makeup water is provided to replace evaporation and leakage.

Expected leakage rates for CL series GCLs and Bentomat ST for various pond depths are shown in Figure 2.

![Figure 2](LINER_Flux_Comparison.png)

**Flow Rate through the Seams**

Flow through the seams of a GCL may be an important factor in determining the effectiveness of a GCL. Claymax 600CL seams are formed by a simple overlap of the two adjacent sheets. Bentomat CL and CLT seam overlaps are augmented with 0.25 lbs./lineal foot of granular bentonite between the seams.

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Recent testing has shown that these seams are highly effective. The graph below quantifies the expected flow through the GCL seams.

As this figure indicates, the long-term flow through the GCL seams was approximately 2 gallons per day per mile of seam (gpd/mi) or 4.7 l/km/day. This testing was performed with a 15-inch (45-cm) head of water and a 12-inch (30-cm) thick layer of sand cover soil. The seam flow rate can be estimated for other water depths by applying the following formula (assuming the same cover soil thickness): 

\[
q_{pond} = q_{test} \times \left[ \frac{h_{pond}}{h_{test}} \right]
\]

where

- \( q_{pond} \) = the flow rate through the actual pond;
- \( q_{test} \) = the flow rate measured in the GCL overlap seam flow rate test;
- \( h_{pond} \) = the height of water in the actual pond;
- \( h_{test} \) = the height of water in the GCL overlap seam flow rate test;

The extra flow rate through the overlapped GCL seams may impact the total flow rate through the liner. Designers should account for this additional flow rate when determining which type of liner will work best for their application.

**Evaporation**

The evaporation at a given location can be estimated by referring to regional evaporation charts or by measuring the water loss in an evaporation pan and correcting for other additions and losses. Evaporation losses can range from 1/4 to 3/4 inches (6 to 18 mm) per day, depending on the specific site conditions.
**Slope Stability**

Another issue facing designers is slope stability. There are several main aspects of slope stability that should be analyzed: stability of the cover material, stability of the lining system and global stability of the embankment. All aspects of stability are important and should be checked for each project.

In any pond-lining project, there will be both sloping areas and flat areas. CETCO typically recommends that Claymax 600CL be used on flat areas (less than 6 degrees steepness), and Bentomat CL and CLT for sloping areas (greater than 6 degrees as described below). The stability of the cover material may necessitate placing the Bentomat CL membrane side down or the Bentomat CL textured geomembrane side up on slopes.

With respect to the liner system, the stability of the GCL itself, the GCL/cover soil interface and the GCL/subgrade soil interface must be evaluated. The stability of each component of the liner system can be evaluated by the following equation:

$$ FS = \frac{[(T/L) + S]}{[(z) (\gamma) (\sin \beta) \cos /3]} $$

where

- $FS$ = the factor of safety;
- $T$ = the allowable long-term tensile strength in the layer above the critical surface being analyzed;
- $T = 390 \text{ lb/ft (6 kN/m)}$ for Bentomat CL;
- $L$ = the slope length;
- $S$ = the shear strength along the surface being analyzed (psf);
- $S = \gamma z \cos \beta \tan \phi + c$
  - $\gamma$ = unit weight of the cover soil (pcf);
  - $z$ = thickness of the cover soil layer;
  - $\beta$ = slope angle (degrees);
  - $\phi$ = internal or interface friction angle along the surface being analyzed (degrees); and
  - $c$ = the apparent cohesion along the surface being analyzed (psf);

The following table lists the typical allowable slope lengths for Bentomat CL (membrane side down) when used in a pond application. Please note that this table lists only typical values that are based on the following assumptions:

- subbase is smooth and well compacted (90% to 95% of Standard Proctor Density);
- liner cross-section is (top to bottom):
I ft. cover soil (Density = 95pcf or 1500 kg/m³);
Bentomat CL (plastic down);
silty sand (SM) subbase.

- the Bentomat CL is properly anchored at the top of the slope;
- the interface friction angle between the Bentomat CL (woven side) and the gravelly sand cover soil is 33°;
- the interface friction angle between the Bentomat CL (membrane) and the subbase soil (SM) is 17°;
- the pond will be filled shortly after placement of the cover material.

Any changes in the above conditions may reduce the allowable slope length for Bentomat CL indicated in the table below:

<table>
<thead>
<tr>
<th>Side Slope</th>
<th>Cover Soil Depth, in (cm)</th>
<th>Factor of Safety</th>
<th>*Max. Allowable Length, ft (m)</th>
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<tbody>
<tr>
<td>4H:1V</td>
<td>12 (30)</td>
<td>1.2</td>
<td>&gt;150 (45)</td>
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<tr>
<td>3H:1V</td>
<td>12 (30)</td>
<td>1.2</td>
<td>45 (14)</td>
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<tr>
<td>3H:1V</td>
<td>24 (60)</td>
<td>1.2</td>
<td>28 (8.5)</td>
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<td>2H:1V</td>
<td>12 (30)</td>
<td>1.2</td>
<td>18 (5.5)</td>
</tr>
</tbody>
</table>

* Longer slopes may be possible using Bentomat CLT (membrane side up) or a wedged slope or reinforcement. To help analyze other cases, CETCO can provide a GRI cover slope stability program upon request. Please contact your CETCO representative for a copy.

CONSTRUCTION

Subbase Preparation
The construction requirements for CL series GCLs are simple. The subbase on which the liner is placed should be smooth and well compacted. An uncompacted subbase might settle out from underneath the liner. This would place the liner in tension and increase the flow rate through this section of the liner. Also, the subbase should be free of any protrusions larger than 1/2 in (12 mm) in diameter.

GCL Storage and Handling
When GCL arrives on site, it should be stored off the ground in a clean dry location on a flat surface such as pallets. Each roll comes in a plastic wrapper to keep the liner dry. An additional plastic tarp should be placed over all the rolls of GCL to ensure that they are not prematurely hydrated.

Construction Sequence
With the exception of a ramp to allow access to the base, the GCL should be installed on the side slopes first. GCL should be overlapped in corner areas and at all joints to ensure that area is completely covered. Once the slopes are completed, the liner can be placed on the base.

Always remember to install only as much GCL as can be covered the same day. DO NOT LEAVE ANY GCL EXPOSED OVER NIGHT. A minimum of 12 in (30 cm) of soil should be placed on the liner (see section on Cover Soil below). The leading edge of the GCL should be wrapped in plastic and covered with sandbags or soil to prevent accidental hydration.
Anchoring on Slopes
The GCL must be secured whenever it is placed on a slope. The most common method of securing the liner is an anchor trench. The anchor trench should be at least 1.5 ft (45 cm) wide, 2 ft (60 cm) deep and it should start at least 3 ft (60 cm) back from the edge of the slope. The GCL should be extended down into the trench and along the trench bottom.

Cover Soil
The performance of the GCL is affected by both the amount and type of cover soil placed on the liner. The cover soil should be a minimum 12 inches thick layer of aggregate or sand with a maximum particle size of 1 in (25 mm).

SOILS THAT CONTAIN HIGH LEVELS OF SOLUBLE CALCIUM AND MAGNESIUM OR OTHER DIVALENT CATIONS (e.g. limestone) SHOULD NOT BE USED AS COVER SOIL.

If the leachate generated from this type of cover soil contains a high total dissolved solid concentration of calcium and magnesium, these cations may chemically react with sodium bentonite, breaking down its structure. The result may be a substantially higher flow rate through the liner.

Similarly, the liquid stored in the pond should not contain a total dissolved concentration of calcium and magnesium.

Compatibility Test
ASTM D6141 has been developed as an initial compatibility test of soils and liquids with GCLs. The testing involves a swell index and fluid loss test. The designer or owner is responsible for determining the chemical compatibility of GCL with the proposed cover soil and the liquid to be contained within the pond. (Please contact your CETCO representative for information on laboratories that are experienced and qualified to perform GCL compatibility tests).

CETCO’s GCLs have been tested and shown to be compatible with MSW leachate, livestock waste and dilute sodium cyanide solution.

SUMMARY
CL series GCLs are excellent choices for a pond liner because of their low permeability, simple installation requirements and self-healing capabilities. Unlike geomembranes, CL series GCLs do not need any special equipment or skilled labor for installation. The panels can be simply unrolled into place and covered with backfill. Also, GCLs ability to seal punctures means that the small holes that are unavoidable during installation will not permanently affect the performance of a CL series GCL liner.

REFERENCES

IMPORTANT
As each application is project specific, this Technical Reference is provided solely as an aid in determining the compatibility of CLAYMAX® and BENTOMAT® products for design consideration. This Technical Reference is not intended nor should it be used to establish product recommendations for any given installation. To the best of our knowledge, the technical data contained herein is true and accurate at the date of issuance, but subject to change without prior notice.
**Enclosure** - 12' x 30' x 9', Dupont Modular Building

**Baseplate** - 12' x 30' Structural Steel Base

**Piping & Valves** -
- 12" Suction and Discharge Headers
- 10" Pump Branch Piping
  - Two ValMatic 15A Air Release Valves
  - Keystone 789 Butterfly Valves w/ Gear Ops
  - Metraflex 700 Silent Check Valves
  - Metraflex Metrasheres
  - Dresser Couplings
  - 10" Magnetic Flow Meter
  - Clow RW Gate Valve
  - Dresser Flanged Coupling Adapters

**Pumps** - Three Aurora 4x5x9.5, 20 HP, 1800 RPM, Prem Eff

**Controls** - Triplex 20 HP Pump Control Panel
- Three Variable Frequency Drives
- PLC and Programming

**Sensor** - Two Pressure Transducers (Suction and Discharge)

**Telemetry** - Provisions only - Telemetry is by others

**Environmentals** -
- Eight 40W Fluorescent Light
- 50 P/D Dehumidifier
- Bard HVAC Unit
- Emergency Light
- Exterior Light

**Conduits** - PVC - As Required

**Motor Wire** - Three Sets #4 in 1" Conduits

**Paint** - Sherwin-Williams

**Options** - Two 4.5" Pressure Gauges

Total budget price for the above pump station is $197,000.00
The above budget price does not includes freight to the job-site or nearest passable road.
Company: Dakota Pump Inc.
Name: James A. Sebert, PE
Date: 5/16/2008

Pump:
- Size: 4 x 5 x 9.5
- Type: 3340 END SUCTION
- Speed: 1770 rpm
- Impeller: 444A445
- Specific Speeds:
  - Ns: ---
  - Nss: ---
- Dimensions:
  - Suction: 5 in
  - Discharge: 4 in

Pump Limits:
- Temperature: 225 °F
- Pressure: 175 psi
- Sphere size: 0.85 in

Search Criteria:
- Flow: 694 US gpm
- Head: 74 ft
- Fluid:
  - Water
  - Temperature: 60 °F
  - Vapor pressure: 0.2563 psi
  - Atm pressure: 14.7 psi

Motor:
- Standard: NEMA
- Size: 20 hp
- Speed: 1800
- Enclosure: ODP
- Frame: 256T

Sizing criteria: Max Power on Design Curve

Selected from catalog: Aurora Pumps.60 Vers: 3.6
The Water-Shed®
Excellence by Design

The Logical Choice In Water Distribution
MODULAR BUILDINGS

- Factory assembled, tested, shipped complete
- Meets BOCA Code for loadings
- Built on a welded, heavy structural steel base
- Walls and ceilings are metal-clad, foam-filled panels
- Glued and flashed 10 year EPDM membrane roof
- Standard single and double entry doors
- Special purpose compartments available
- Crane and hoist systems available
- Safe lighting and environmental control systems
- Various exterior finishes and treatments available

MECHANICAL AND ELECTRICAL EQUIPMENT

Mechanical
- Pumps
- Flow meters
- Control valves
- Hydropneumatic tanks and controls
- Backflow preventors
- Equipment easily removable for scheduled service
- Vibration and isolation dampening as standard
- Full maintenance access space allowed throughout

Electrical
- Integrated control systems based on PLC or relay logic
- Device protection and alarm systems as standard
- Meets all aspects of National Electrical Code
- UL Listed under QCZJ, UL508 and UL508SE
- Motor starters are Across-line, Part-winding or Solid State
  Reduced Voltage
- Adjustable Frequency Drives and Controls available
- Telemetry as telephone/data link or radio link for single or
  multiple points
I apologize that I did not get this information to you when promised. The first sheet is our rate structure and the second sheet has the number of connections at each fee. A new connection fee is $1200 and we average about 5 a year.

If you need any additional information, please call.
## BVJPB WATER RATE CHART FY08

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- Fort Bridger Extension: add $11.00 monthly loan payment
- Big Hill Water Group: add $77.47 monthly loan payment
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- Wholesale Water Usage: add $.75 per 1000 gallons
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Grand Totals: 522 523,000 38,558.95 19,166.70 92.05 57,433.80 10,788,741
Appendix H
Permits
Mr. Bilodeau,

I appreciate your time and information you provided. You are correct that it may be sometime before this project proceeds.

We will keep in touch and notify you (your office) when the project moves forward.

Thanks again,

Chris Wichmann
Senior Scientist
Short Elliott Hendrickson Inc. (SEH)
7000 Yellowtail Road, Suite 230
Cheyenne, WY 82009
Ph#307-633-6450
Fax#307.633.6441
cwichmann@sehinc.com
www.sehinc.com
"Bilodeau, Matthew A NWO" <Matthew.A.Bilodeau@usace.army.mil>

Chris Wichmann:

Just a quick note and follow up to let you know that I discussed the subject project that we went over in my office yesterday afternoon with Thomas Johnson today.

Tom concurred with me that, as you've described it, it would qualify for NWP 12 authorization. As I noted, he also mentioned the need to mitigate impacts over 0.1 acre to wetlands.

We will assign a file number to the project and call your visit yesterday an early pre-application meeting.

I understand it could be quite awhile before we receive any kind of formal
notification on the project given the status of the current study and review.

Sincerely,

Matt Bilodeau

Matthew A. Bilodeau
State Program Manager
Wyoming Regulatory Office
U.S. Army Corps of Engineers
2232 Dell Range, Suite 210
Cheyenne, Wyoming 82009
307-772-2300
Fax: 307-772-2920
STATE OF WYOMING  
OFFICE OF THE STATE ENGINEER  
APPLICATION FOR PERMIT TO APPROPRIATE SURFACE WATER

**NAME OF FACILITY**

1. Name(s), mailing address and phone no. of applicant(s) is/are _____________________________________________________  
   _________________________________________________________________________________________  
   _______________________________________________ E-mail address:  _____________________________________________  
   (If more than one applicant, designate one to act as Agent for the others)

2. Name & address of agent to receive correspondence and notices ___________________________________________________  
   _________________________________________________________________________________________  
   _______________________________________________ E-mail address:  _____________________________________________

3. The use to which the water is to be applied is __________________________________________________________________  
   (a) If more than one beneficial use of water is applied for, the reservoir capacity must be allocated in acre-feet to the various uses:  
       Active Capacity  
       ________________________________________________________________________________  
       Inactive Capacity  
       ________________________________________________________________________________  
   (b) The area of the high water line of the reservoir is ____________ acres.  
   (c) The total available capacity of the reservoir is ____________________ acre-feet.  
   (d) If enlargement, the capacity of this enlargement is ____________________ acre-feet.

4. The source of the proposed appropriation is ____________________________________________________________________  
   _________________________________________________________________________________________  
   _________________________________________________________________________________________

5. The outlet of the proposed reservoir is located _______________ feet distant from the _______________________ corner  
   of Section _____T. _____ N., R. _______ W., and is in the ___________________ of Section ______ T.______ N., R. _______ W.  
   Lot______ Block _____ Subdivision Name ______________________________________________________________________  
   Latitude (Decimal Degrees) ______________________________ Longitude (Decimal Degrees) _____________________________

6. Are any of the lands covered by the proposed reservoir owned by the State or Federal government?  If so, describe lands and  
   designate whether State or Federally owned.  _____________________________________________________________________  
   _________________________________________________________________________________________  
   _________________________________________________________________________________________

7. Fill out for either (a) or (b):  
   (a) The reservoir is located in the channel of _____________________________________________________________________  
   (b) The reservoir is to be filled through the _____________________________ Canal which has a carrying capacity of  
       _______ __________ cubic feet per second (c.f.s.)

8. (a) The dam is to be constructed as follows:  
   ________________________________________________________________________________ contents = ____________________ cubic yards.  
   (b) The water face of the dam is to be protected from wave action in the following manner:  
   (c) The dam height, as measured by the dam crest elevation minus the lowest downstream toe elevation is ______________ feet.
9. The estimated time required for completion of construction is ___________________________.

10. The accompanying map is prepared in accordance with the State Engineer’s Rules and Regulations for filing applications and is hereby declared a part of this application. The State Engineer may require the filing of detailed construction plans.

REMARKS

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NOTE: If construction under this application is for enlargement of an existing reservoir, the following consent to this enlargement must be completed.

CONSENT TO ENLARGE

________________________________________  _________________________________ __________ _______________
________________________________________  _________________________________ __________ _______________
________________________________________  _________________________________ __________ _______________
________________________________________  _________________________________ __________ _______________

my/our free and voluntary consent to the enlargement of said reservoir of this application for enlargement.

Signature                                Printed Name                                Date                                Acre/Feet Owned

___________________________________________________________________________________________
___________________________________________________________________________________________
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___________________________________________________________________________________________

Under penalties of perjury, I declare that I have examined this application and to the best of my knowledge and belief it is true, correct and complete.

________________________________________  _________________________________ __________ _______________
Signature of Applicant or Agent                                Date
STATE OF WYOMING
OFFICE OF THE STATE ENGINEER
APPLICATION FOR PERMIT TO APPROPRIATE SURFACE WATER

THE STATE OF WYOMING STATE ENGINEER’S OFFICE

SS.

This instrument was received and filed for record on the ______ day of ____________, 20______, at ______ o’clock ______ M.

_________________________________________________________ State Engineer

Recorded in Book _______________ of Enlargement Permits, on Page ______

Fee Paid $ _________ Map Filed ________________

WATER DIVISION NO. ______ DISTRICT NO. ______ TEMPORARY FILING NO. __________

PERMIT NO. _______________ ENLARGEMENT

NAME OF FACILITY TO BE ENLARGED

ENLARGEMENT OF THE ____________________________________________________________

1. Name(s), mailing address and phone no. of applicant(s) is/are _____________________________________________________
   ______________________________________________________________________________
   ______________________________________________________________________________
   ______________________ E-mail address: ____________________________________________

   (if more than one applicant, designate one to act as Agent for the others)

2. Name & address of agent to receive correspondence and notices ___________________________________________________
   ______________________________________________________________________________
   ______________________________________________________________________________
   ______________________ E-mail address: ____________________________________________

3. (a) The use to which the water is to be applied is _________________________________________________________________
   (b) If more than one beneficial use of water is applied for, the location and ownership of the point of use must be shown in item 10 of the application and the details of the facilities used to divert and convey the appropriation must be shown on the map in sufficient detail to allow the State Engineer to establish the amount of appropriation. In multiple use applications, stock and domestic purposes are limited to 0.056 cubic feet per second.

4. The source of the proposed appropriation is ________________________________________________________________
   ______________________________________________________________________________
   ______________________________________________________________________________
   ______________________________________________________________________________

5. (a) The headgate of the facility to be enlarged is located __________________ feet distant from the __________________ corner of Section ________________ T. ____________ N., R. _______________ W., and is in the ______________________________________ of Section ________________ T. ____________ N., R. _______________ W. Lot______ Block _____ Subdivision Name ___________________________________________________________________
   Latitude (Decimal Degrees) _____________________________ Longitude (Decimal Degrees) ______________________________
   (b) The said facility has a record carrying capacity of __________________ cubic feet per second (c.f.s.)
   (c) The said facility as enlarged will have a carrying capacity of __________________ cubic feet per second (c.f.s.)
   (d) Permitted uses under said facility are described in Permit Nos. ___________________________________________________

6. If the enlarged or extended portion of the proposed facility is located on lands owned by the State or Federal government, describe lands and indicate whether State or Federally owned. ________________________________________________________________

7. If the proposed application will require a physical enlargement or extension of the facility being enlarged, complete the following:
   (a) The head of extension is located __________________ feet distant from the __________________ corner of Section ________________ T. ____________ N., R. _______________ W., and is in the ______________________________________ of Section ________________ T. ____________ N., R. _______________ W. Lot______ Block _____ Subdivision Name ___________________________________________________________________
   Latitude (Decimal Degrees) _____________________________ Longitude (Decimal Degrees) ______________________________
   (b) The said facility as physically enlarged will have a carrying capacity at the head of extension of __________ c.f.s.

8. The estimated time required for the completion of construction is ________________, and to complete the application of water to the beneficial uses stated in this application is _____________________.

Permit No. _______________ Enl. _______________ Page No. _______________ (Leave Blank)
9. The accompanying map is prepared in accordance with the State Engineer’s Manual of Regulations and Instructions for filing applications and is hereby declared a part of this application. The State Engineer may require the filing of detailed construction plans.

10. The land to be irrigated under this permit is described in the following tabulation. (Give irrigable acreage in each 40-acre subdivision. Designate ownership of land, Federal, State or private. If private, list names of owners and land owned separately.) If application is for stock, domestic, or for purposes other than irrigation, indicate point of use by 40-acre subdivision and owner.

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Number of acres to receive original supply
Number of acres to receive supplemental supply
Total acreage under this enlargement

REMARKS
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CONSENT TO ENLARGE

the sole owner of the ___________________________ Ditch, taking water from ___________________________ under Permit No. ___________________________, for and in consideration of ___________________________, free and voluntary consent to the enlargement or extension of, and to the use of water through the said ditch, for the irrigation of ___________________________ acres, by ___________________________, according to the terms of their application for enlargement.

Dated ___________________________, 20________.

Under penalties of perjury, I declare that I have examined this application and to the best of my knowledge and belief it is true, correct and complete.

Signature of Applicant or Agent ___________________________ Date ___________________________