Utah Division of Water Resources

Volume I of III
Bear River Development Report

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Prepared by:

BOWEN COLLINS & ASSOCIATES

In Association with:

HDR

BEAR RIVER DEVELOPMENT REPORT

VOLUME I OF III

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LIST OF ACRONYMS

AACE – Association for the Advancement of Cost Engineering—International

BA – Biological assessment
BRAG – Bear River Association of Government
BRD – Bear River Development
BRMBR – Bear River Migratory Bird Refuge
BRWCD – Bear River Water Conservancy District

CAA – Clean Air Act
CFR – Code of Federal Regulations
CMIP5 – Coupled Model Intercomparison Project
CWA – Clean Water Act
CWD – Cache Water District

DA – Department of the Army
DAQ – Division of Air Quality
DEQ – Department of Environmental Quality
DWRe – Division of Water Resource
DWQ – Division of Water Quality

EA – Environmental Assessment
EIS – Environmental Impact Statement
ENR – Engineering News Record
EPA – Environmental Protection Agency
ERI – Ecosystems Research Institute
ESA – Endangered Species Act

FERC – Federal Energy Regulatory Commissions
FFSL – Foresty, Fire, State Lands

GCI – Gerhart Cole, Inc.
GCM – Global climate model
GIS – Geographic Information System
GOMB – Governor's Office of Management and Budget
GSL – Great Salt Lake

IRT – Interagency Review Team
IWRA – International Water Resources Association

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LIST OF ACRONYMS

JMM – James M Montgomery
JVWCD – Jordan Valley Water Conservancy District

MBI – Mitigation-Banking Instrument
MGTA – Migratory Bird Treaty Act
M&I – municipal and industrial
MOA – Memorandum of Agreement
MSL – Mean sea level
MWH – Montgomery Watson Harza

NAAQS – National Ambient Air Quality Standards
NEPA – National Environmental Policy Act
NFMA – National Forest Management Act
NHPA – National Historic Preservation Act
NPDES – National Pollutant Discharge Elimination System
NWI – National Wetlands Inventory

OHWM – Ordinary High Water Mark

PCN – Pre-Construction Notice
PFD – Process Flow Diagrams
PMF – Probable Maximum Flood
PMP – Probable Maximum Precipitation

RCC – roller compacted concrete
ROW – Right-of-Way
RWC – Recycled Water Coalition

SHPO – State Historic Preservation Offices

TBM – Tunnel-boring machine
TES – Threatened endangered species
THD – Total design head

UACD – The Utah Association of Conservation Districts
UCDC – Utah Conservation Data Center
ULS – Utah Lake Systems
UPC – Utah Population Committee

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LIST OF ACRONYMS

UPDES – Utah Pollutant Discharge Elimination System
UPEC – Utah Population Estimates Committee
UPRR – Union Pacific Railroad
USACE – U.S. Army Corps of Engineers
USBR – US Bureau of Reclamation
USFS – U.S. Forest Service
UTA – Utah Transit Authority
UWRL – Utah Water Research Laboratory
VFD – Variable Frequency Drives
VIC – Variable Infiltration Capacity

WBWCD – Weber Basin Water Conservancy District
WHWTP – West Haven Water Treatment Plant
WOUS – Waters of the United States

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

BACKGROUND AND PURPOSE

In 1991, the Utah State Legislature passed the Bear River Development Act (Act), Utah Code 73-26, which directs the Utah Division of Water Resources (DWRe) to develop the surface waters of the Bear River and its tributaries. The Act indicates that DWRe will develop up to 220,000 acre-feet of water. The Act also indicates that the developed water will be distributed by the following four Water Districts (Districts) in the amounts shown:

- Bear River Water Conservancy District (BRWCD): 60,000 acre-feet
- Cache Water District (CWD): 60,000 acre-feet
- Jordan Valley Water Conservancy District (JVWCD): 50,000 acre-feet
- Weber Basin Water Conservancy District (WBWCD): 50,000 acre-feet

DWRe has continued planning and studying aspects associated with future development of the Bear River as authorized in the Act. This current feasibility report provides a conceptual plan for an overall Bear River Development (BRD) system. The overall study area is shown on Figure ES-1. The study area extends over roughly seventy-five miles through Cache, Box Elder, and Weber counties.

As development within Weber and Box Elder counties has increased, DWRe recognizes the need to acquire land and rights-of-way, as authorized in the Act, to reduce future impacts to the surrounding communities. The feasibility study provides updated information about potential reservoir sites and pipeline alignments, as well as updated cost estimates.

PREVIOUS STUDIES

Planning and studies for the development or storage of the Bear River have been ongoing for several decades. Some of the results from these earlier studies may be out-of-date while other studies were preliminary in nature or written to reflect earlier assumptions for operation or construction. The main components of the BRD planning have remained consistent: diversion of the Bear River, use of reservoir(s) to make the supply reliable, and diversion upstream of areas where water quality degradation occurs (Malad River).

WATER DEMAND

The Districts and DWRe are continually updating water demand projections. Water from the BRD is currently projected to be needed by 2045-2050. The projections of the potential "build-out" demand for the four Districts indicate the eventual need for more than 400,000 acre-feet of water beyond existing supplies. This increased demand will have to be met through a combination of agricultural water conversion to municipal and industrial (M&I) use, reductions in per capita water use through water conservation efforts and efficiency projects, and development of new supplies like the BRD.

It is challenging to project future water demands and the needed supplies due to the difficulty in projecting many factors including population growth, water conservation efforts, agricultural to M&I use conversion, and climate change impacts. These factors will all affect the timing and volume of water needed by the Districts to serve future populations within their service areas.

The Division of Water Resources has hired a consultant to develop regional water conservation goals. The current projected need for a Bear River Development project of 2045-2050 does not take into account these new conservation goals. Once the conservation goals have been developed, projections may need to be adjusted reflect the impact of these goals.

RESERVOIR SITE INVESTIGATIONS

As part of this study effort, six potential reservoir sites identified in previous studies were evaluated in more depth. Preliminary subsurface (geology/geotechnical) investigations were performed at each of the sites. Additional analysis of each of the sites also included general site conditions and information, hydrology, and conceptual layouts and sizing of reservoirs, outlet works, spillways, and other facilities.

RESERVOIR STORAGE AND COMBINATIONS OF RESERVOIRS

As part of this study, the hydrologic data for the Bear River was updated for inclusion in operational models. The modeling for this study included a 30-year period of record from 1981 to 2010. This data includes two of the worst droughts of the last 60 years. The modeling data was needed to update potential facility sizing requirements, water supply reliability, and cost estimates. The modeling included instream flow assumptions, revised reservoir capacity assumptions, and climate change-influenced hydrologic datasets. The climate change datasets were developed to estimate future water supply conditions. Thirteen different combinations of potential reservoir sites were evaluated to determine the most effective and the least-costly potential reservoir combinations.

COST ESTIMATES

Cost estimates were produced for the 13 reservoir combinations. The cost estimates range from approximately $1.5 billion to $2.8 billion. The Act currently requires that the State will fund the planning, studies, design and construction and environmental mitigation costs of the BRD System. The Act also requires that the funding will be repaid by the Districts “within a period not to exceed 50 years” at an interest rate set by the Utah Board of Water Resources. For the purposes of this study, an interest rate of 4.0% was assumed. Additional costs will be incurred by the Districts to deliver and treat water from the BRD.

The cost estimates include reservoirs, pipelines, and other facilities to deliver raw water from storage or diversions to delivery points for the four Districts. Treatment, operation, and maintenance costs are not included. Those costs are not part of the overall funding provided by the State and will be paid for by the Districts.

In order to show the potential costs for each District, the breakdown of costs for Scenario J, which provides the entire needed water supply at the lowest cost, are included in Table ES-1. The overall cost estimate for Scenario J is about $1.7 billion. The table includes the potential capital cost, cost per acre-foot, and annual repayments for each District. Scenario J is shown on Figure ES-2.

Table ES-1
Potential Costs by District
Scenario J

District	BRD Allocation (acre-foot)	Capital Cost	Capital Cost per acre-foot	Annual Repayment	Annual Cost per acre-foot
Bear River Water Conservancy District	60,000	$ 470,400,000	$ 7,840	($21,897,214)	$ 365
Cache Water District	60,000	$ 470,400,000	$ 7,840	($21,897,214)	$ 365
Jordan Valley Water Conservancy District	50,000	$ 392,000,000	$ 7,840	($18,247,679)	$ 365
Weber Basin Water Conservancy District	50,000	$ 392,000,000	$ 7,840	($18,247,679)	$ 365
Total	220,000	$ 1,724,800,000	$ 7,840	($80,289,786)	$ 365

Notes:
1. Repayments based on 50-year repayment (see Act) at an assumed interest rate of 4.0%.
2. Annual costs do not include costs for treatment or normal operation and maintenance (O&M) costs.

ENVIRONMENTAL REVIEW

Existing environmental data was collected to identify the major environmental constraints in the study area for potential pipeline routings and reservoir sites. This was supplemented by a preliminary field reconnaissance of the study area. Data included identification of habitat for wildlife and threatened and endangered species, water resources (including wetlands and floodplains), cultural and historic resources, and socioeconomic considerations.

POTENTIAL EFFECTS OF THE BEAR RIVER DEVELOPMENT ON LAKE LEVELS OF GREAT SALT LAKE

The BRD System is expected to deliver 220,000 acre-feet annually. Not all the diverted water is expected to be depleted from the watershed. Much of the BRD water is expected to return to the watershed in the form of “return flows”. A preliminary analysis was completed to estimate the amount of BRD water that could potentially return to the watershed, and not be depleted from the watershed.

While the Bear River Development Act indicates that the BRD water can be used for both M&I and agricultural uses, it is expected that most of the BRD water will be used for M&I use. Thus, the analysis assumed that the water will be used for M&I purposes.

Recent estimates of return flow percentages for municipal systems in northern Utah were used to estimate the potential return flow percentages of BRD water for each District. Using the estimated return flow percentages for each District, it is estimated that, at full development of 220,000 acre-feet, approximately 85,600 acre-feet will be depleted from the watershed. Current modeling efforts indicate that the depletion of about 85,600 acre-feet from the GSL Watershed will reduce the lake level by an average of 8.5 inches and by as much as 14 inches in some years, depending on the level of the lake.

A White Paper titled “Impacts of Water Development on Great Salt Lake and the Wasatch Front” (February 2016) was produced through a collaborative effort between Utah State University, Salt Lake Community College, and the Utah Divisions of Water Resources and Wildlife Resources. The results of the potential depletion and resulting impact to the level of the lake from the BRD are included in the White Paper.

RIGHT-OF-WAY ACQUISTION

One of the primary charges of the Bear River Development Act (Act) is to identify the feasibility of potential corridors for a transmission pipeline for the BRD System. In addition, the Act specifically authorizes DWRe to acquire “land and rights-of-way” for a pipeline corridor. Rapid growth continues in both Weber and Box Elder counties and undeveloped land is quickly increasing in value. Early acquisition of rights-of-way is expected to reduce future impacts to the surrounding communities and reduce costs. A review of potential reservoir sites indicates that there is limited space available that can provide the storage capacity needed.

IMPLEMENTATION

Bear River Development Schedule

The overall development of the Bear River includes facilities as described to develop a water supply of 220,000 acre-feet. Current water demand studies indicate water will be needed by 2045-50. This could change as the Districts and DWRe update use and demand forecasts. Due to the enormity of completing the BRD System, including real estate acquisition, environmental studies, and design and construction, it is essential to continue the planning process to assure completion of the development when it is needed.

Because of the cost and potential impacts of the BRD, the Districts will utilize existing water supplies and increased conservation to stretch the need for the BRD as far into the future as possible. In the meantime, DWRe needs to continue planning for the BRD in two important areas: environmental compliance and right-of-way acquisition.

Environmental Compliance Plan. Bear River Development (BRD), including necessary storage reservoirs, pump stations, and pipelines, will require environmental and other permitting and agency coordination. Both state and federal level permits and approvals are anticipated for the BRD. Along with federal permits and clearances, state environmental permitting requirements are administered under state rules that have generally been developed to comply with federal regulations. Certain regulations would apply depending on the selected reservoir site(s). Federal permitting actions could include compliance with the Clean Water Act and the National Forest Management Act (NFMA).

Compliance with the National Environmental Policy Act (NEPA; 42 U.S.C. §4321 et seq) is also anticipated. The purpose of NEPA is to ensure that environmental factors are weighted equally when compared to other factors in the decision-making process undertaken by federal agencies. Because of the potential for large direct wetland impacts from some of the BRD reservoir sites, and pipeline alignments, and based on the potential for significant cost savings through advanced mitigation activities, early environmental baseline studies and mitigation banking activities are recommended.

Right-of-Way Acquisition. As discussed above and as authorized in the BRD Act, DWRe has begun initial acquisition of real property for corridor preservation through critical areas. While the need for water through BRD is not currently anticipated for a few decades, early acquisition of rights-of-way can preserve corridor options and reduce future impacts to surrounding communities. DWRe has identified a list of priority parcels to acquire and has begun the process of obtaining critical parcels for corridor preservation.

Additional Studies for Next Steps

It is important to continue studying issues that either could affect, or be impacted by, the development of the Bear River as outlined in the Bear River Development Act. Recommendations for some possible next steps for additional studies include the following:

- Additional Climate Change Modeling
- Modeling of Great Salt Lake
- Additional Pipeline Corridor Options

CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION

1.1 BACKGROUND AND PURPOSE

In 1991, the Utah State Legislature passed the Bear River Development Act (Act), Utah Code 73-26, which directs the Utah Division of Water Resources (DWRe) to develop the surface waters of the Bear River and its tributaries. The Act indicates that DWRe will develop up to 220,000 acre-feet of water. The Act also indicates that the developed water will be distributed by the following four Water Districts (Districts) in the amounts shown:

- Bear River Water Conservancy District (BRWCD): 60,000 acre-feet
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- Weber Basin Water Conservancy District (WBWCD): 50,000 acre-feet

A copy of the Bear River Development Act (Utah Code 73-26) is included in the Appendix.

DWRe has continued planning and studying aspects associated with future development of the Bear River as authorized in the Act. This current feasibility report provides a conceptual plan for an overall Bear River Development (BRD) system. Prior to this report, individual reservoir sites and pipeline alignments were studied without a plan of how each of these facilities could function as one system.

The current area of study encompasses the area between the upper reaches of the Logan River and the Bear River where it enters Utah in Cache County to West Haven, Utah. The overall study area is shown on Figure 1-1 (Volume II). The study area extends over roughly seventy-five miles through Cache, Box Elder, and Weber counties.

As the population within Weber and Box Elder Counties has increased over the last decade, the need to preserve a corridor for a future large-diameter pipeline as part of the BRD has also increased. Limited rights-of-way currently exist, particularly through Box Elder County, and it will become more difficult to preserve a corridor as development increases. DWRe recognizes the need to identify potential BRD facilities so that rights-of-way (ROW) for a corridor may be preserved. Early acquisition of a ROW can lessen future impacts to the surrounding communities.

The feasibility study will provide an overall implementation plan, cost estimates, and potential BRD System facilities, such as storage reservoir sites and pipeline alignments.

The planning for the BRD is currently at a conceptual level; the language used in this report may not always infer or convey the conceptual nature of potential reservoir sites and associated facilities. The overall purpose of this study is to provide conceptual BRD System scenarios and cost estimates for planning purposes.

DWRe has been studying and planning for development of the Bear River since the early 1980s. A previous report published in 2014, titled “Bear River Pipeline Concept Report” (Concept Report), examined potential design concepts and potential facilities. This feasibility study develops additional information about potential reservoir sites that were identified in the Concept Report. In addition, facility configurations have been further refined in order to update cost estimates, identify possible fatal flaws, and to further define potential options. DWRe conducted initial communication with regulatory agencies to define the possible impacts of potential BRD features. Preliminary geotechnical, environmental, and engineering analyses were conducted at several potential reservoir sites to determine the site feasibility and to allow future studies to focus on developable sites and configurations. At the end of this study, DWRe and the Districts will have the information needed for potential reservoir sites and facility combinations.

The Division of Water Resources has hired a consultant to develop regional water conservation goals. The current projected need for a Bear River Development project of 2045-2050 does not take into account these new conservation goals. Once the conservation goals have been developed, projections may need to be adjusted reflect the impact of these goals.

This report will provide DWRe with the following:

- Additional information on potential reservoirs sites
- Overall BRD system feasibility
- Preliminary information of potential environmental impacts
- Cost estimates for different scenarios
- Cost estimates and funding requirements for the Districts
- Corridor preservation/ROW acquisition plan
- Overall BRD implementation plan

CHAPTER 2

PREVIOUS BEAR RIVER STUDIES

2.0 PREVIOUS BEAR RIVER STUDIES

Planning and studies for the development or storage of the Bear River has been ongoing for several decades. This has provided a significant amount of investigation and information. Some of the results from these earlier studies may be out of date while other studies were preliminary in nature or written to reflect earlier assumptions for operation or construction. The main components of the BRD planning have remained consistent: diversion of the Bear River, use of reservoir(s), and diversion upstream of areas where water quality degradation occurs.

This chapter summarizes many of the earlier studies and highlights information that seemed most relevant for use in current planning activities

2.1 EARLY RESERVOIR STUDIES (1960s-1970s)

The US Bureau of Reclamation (USBR) completed initial studies of Bear River water development for both municipal and agricultural use in the 1960s. In 1966, the USBR published a geologic analysis of potential sites for the Smithfield Dam with a capacity of 100,000 acre-feet (USBR, 1966, *Bear River Project Feasibility Geologic Report Smithfield Dam and Reservoir Sites*). In 1970, the USBR published a summary of Bear River investigations related to potential reservoir storage projects that included projects from Oneida Narrows in Idaho, and downstream to Honeyville and Corinne (USBR, *Bear River Investigations*, June 1970). A range of reservoir capacities were evaluated from 10,000 acre-feet up to 435,000 acre-feet.

In the 1970s, DWRe evaluated a range of potential storage projects in Cache County, which included storage capacities between 12,000 acre-feet and 75,000 acre-feet. These studies included sites on most of the major Cache Valley tributaries to the Bear River. All these potential projects had benefit/cost ratios over 1.0.

2.2 ADDITIONAL STUDIES (1980s and early 1990s)

A subsequent Cache Valley study by DWRe evaluated four different storage sites (Cutler enlargement, Amalga Barrens, Cub River, and Smithfield), at capacities ranging from 25,000 acre-feet up to 172,000 acre-feet (DWRe, *Cache Valley Study*, December 1982). The most economically favorable project was a 102,000 acre-feet offstream municipal and industrial (M&I) project located at the Amalga Barrens site. DWRe also completed a multiple reservoir study that evaluated three combinations of ten different reservoirs located from Cache Valley down to the West Bay on the Great Salt Lake (DWRe, Summary of Investigations, Lower Bear River Basin, January 1983).

Additionally, DWRe completed studies about potential conveyance and treatment options including a study regarding water conveyance from the Bear River to Salt Lake County (James M Montgomery [JMM]), *Municipal Pipeline Project from Bear River/Honeyville to Salt Lake County, 1984*). This study assessed the feasibility of transporting and treating 50,000 to 100,000 acre-feet annually. The recommended pipeline route began in Honeyville, just upstream from where the river crosses I-15, and ran parallel to the Union Pacific railroad south to Salt Lake County. DWRe assessed three additional routes in addition to the railroad pipeline: a route following I-15, a route following the power lines west of I-15, and a route following SR84 and SR89. DWRe examined these based on capacity, cost, environmental considerations, point of intake and delivery, pipe failure impact, and geologic considerations. In addition, DWRe also evaluated design criteria for an optimal water treatment facility, intake method, pipe diameter, pumping stations, and storage mechanisms.

Ultimately, the study concluded that the optimal scenario was the railroad alignment with a bank-type intake, 54-inch to 96-inch diameter pipes (depending on delivery capacity), two pumping stations along the pipeline, intermediate and terminal storage reservoirs, and a conventional water treatment plant.

During this period, the DWRe also began a series of studies to examine potential environmental effects and water quality issues. The Utah Association of Conservation Districts (UACD) conducted a public involvement program concerning development of the Lower Bear River (Utah Association of Conservation Districts 1986, *Public Involvement Program Concerning Water Development in the Lower Bear River Basin*). The objectives of the program were to inform interest groups of the probable future needs for water in the Lower Bear River basin. Additionally, UACD sought to receive feedback from local officials concerning the perceived impacts of the options, and to analyze issues, concerns, opportunities, and problems identified by concerned parties. Moreover, UACD wanted to identify key areas where there was consensus or conflict over water development, to identify areas that needed further study, and to report the findings to the DWRe.

UACD analyzed data collected from an extensive process of interviews, forums, and meetings with local leaders at two levels. The first level identified those areas of most concern to local leaders with respect to water development in the Lower Bear River basin. The second level identified problematic areas related to potential reservoir sites in the basin. UACD combined the results of the analysis and a final forum to provide recommendations for the DWRe to consider during the next phase of water development planning.

In the mid-80s, the Utah Water Research Laboratory (UWRL) completed an investigation of Bear River water quality and reservoir eutrophication potential (UWRL, 1986, *Water Quality Management Studies for Water Resources Development in the Bear River Basin*). The review of previous water quality studies on the Bear River found issues associated with high fecal indicator bacteria, BOD_5, TDS, and phosphorus concentrations. This study, along with a previous similar study, indicated that the Cub River was a significant source of pollutants to the Bear River. UWRL modeled the eutrophication potential of the proposed reservoirs using a water temperature model and a longitudinal finite-difference eutrophication simulation model. UWRL predicted the Amalga, Honeyville, and Avon reservoir sites to have the greatest eutrophication potentials. Additionally, the UWRL also examined potential water treatment costs for the reservoir sites.

Two years later, Palmer-Wilding completed a study to evaluate the feasibility of diverting water by gravity from Cutler Reservoir to Willard Bay (Palmer-Wilding, 1988, *Cutler Diversion to Willard Bay Reservoir*). The objectives of the study included selection of possible canal/pipeline alignments and cost estimates for conveying 50,000 to 100,000 acre-feet annually using existing canals. The study examined the Hammond East Side and West Side/Corinne Canals with possible canal or pipeline extensions. Palmer-Wilding also examined the available capacity in the canals along with environmental considerations including water and fish, wildlife, vegetation, wetlands, air quality, agricultural lands, recreation, and cultural resources.

The Ecosystems Research Institute (ERI) completed water quality investigations of the Lower Bear River (Ecosystems Research Institute, 1991, *Water Quality Investigations: Lower Bear River and Water Quality Investigations: Hyrum Reservoir*). This report summarized available environmental data for the Lower Bear River basin and documented existing water quality conditions. The ERI investigated and modeled water quality at seven potential reservoir sites. They predicted reservoir water quality based on modeled algal biomass, orthophosphorus, nitrate and ammonia, total dissolved solids, total suspended solids, water temperature, and dissolved oxygen. The potential sites included Hyrum Reservoir, Avon Reservoir, Mill Creek Reservoir, Smithfield Reservoir, Willard Bay, Barrens Reservoir, and Honeyville Reservoir. The ERI predicted that the Avon site would have the best water quality, while the Honeyville site was predicted to have the lowest. This report developed a Water Quality Management Plan for the Lower Bear River basin to address specific areas of concern.

DWRe completed a study examining the environmental impacts of the pipeline alternative described in the previous JMM, 1984 study (BioWest, Inc., 1991, *Investigation of Environmental Impacts of the Bear River Water Development Storage Unit*). The primary conclusion was that most impacts were expected to be temporary during the construction phase of the project. The focus areas of the report were vegetation, aquatics/fisheries, and wildlife. DWRe examined each area concerning the existing environment, the environmental consequences of the development, and proposed mitigation measures. Permanent loss of wetland vegetation due to the pipeline ROW was determined to be the area of greatest concern regarding vegetation. Stream water quality and fisheries habitat would only be temporarily impacted during construction of the pipeline, and the greatest concern for wildlife was determined to be temporary and permanent loss of riparian and wetland habitat along the proposed ROW. This study also examined five potential reservoir sites (Mill Creek, Avon, Amalga Barrens, Hyrum, and Honeyville) to determine site feasibility from an environmental perspective.

DWRe also completed a re-evaluation of seven potential reservoir sites for use in preparing a report for the Bear River Task Force Legislative Commission (CH2M Hill, 1991, *The Re-evaluation of Bear River Reservoir Sites*). This study evaluated Honeyville, Washakie, Barrens, Smithfield, Avon, Mill Creek, and Oneida Narrows, with special attention given to foundation, feasibility, and cost. Honeyville, Washakie, and Barrens were found to have soft, compressible foundations, but with potential for large reservoir capacity and relatively low dams. The others had steep abutments, rock foundations, and relatively small reservoir capacity compared to dam height. DWRe determined that the Smithfield site would not meet state dam stability standards, so it was not evaluated for cost. Table 2-1 summarizes the results of the DWRe study.

Table 2-1
Summarized Results of 1991 Re-Evaluation of Bear River Reservoir Sites

Reservoir Site	Storage Capacity (acre-feet)	Dam Height (feet)	Outlet Capacity (cfs)	Cost (M)	Cost/acre-foot of Storage
Honeyville, Box Elder County, UT (Earth-fill)	117,000	90	2,000	$43	$367
Barrens, Cache County, UT (Earth-fill)	35,000-100,000	25 - 40	500	$23 - $64.5	$645-$657
Washakie, Box Elder County, UT (Earth-fill)	160,000 - 185,000	66 - 71	500	$103.5 - $116.5	$629-$647 (need range)
Avon, Cache County, UT (Earth-fill)	33,000	207	460	$36	$1,090
Mill Creek, Summit County, UT (Earth-fill)	27,000	210	460	$19	$704
Oneida Narrows, Franklin County, ID (Roller-Compacted Concrete)	103,000	240	2,500	$66.5	$645
Smithfield, Cache County, UT (Earth-fill)	80,000	35	2,500	Not evaluated	Not evaluated

DWRe completed an evaluation of Lower Bear River water treatment needs and started a long-term water-quality monitoring program on the Bear River (Montgomery Watson Americas, Inc., 1994, *Update to the Preliminary Engineering Evaluation of Bear River Water Treatment*). Updating the 1991 report titled *Preliminary Engineering Evaluation of Bear River Water Treatment*, the report considered new Federal Safe Drinking Water regulations and assessed whether there was a substantial difference in the water quality of samples upstream and downstream of the Cutler Reservoir. The report included three tasks: 1) updating the raw water quality data, 2) reviewing existing and anticipated safe drinking water regulations, and 3) developing revised water treatment requirements, cost estimates, and implementation schedules. The results of the raw water quality analysis indicated no significant difference in the levels of TDS or chlorides downstream and upstream of the Cutler Reservoir, indicating no inflow of saline streams to the site. DWRe assessed and updated impacts of the new regulations on treatment recommendations from the 1991 report and made new recommendations in anticipation of future regulations. DWRe also updated total annual costs and the implementation schedule for the overall Bear River water treatment.

A follow-up study to the 1991 BioWest study served as an environmental evaluation for the potential construction of the Honeyville Reservoir (BioWest, Inc., 1995, *Honeyville Dam and Reservoir Environmental Evaluation Report*). The 117,000 acre-foot reservoir was to serve as a storage site for water needed in the Bear River Migratory Bird Refuge (Refuge), and also as an additional water supply for Wasatch Front M&I users only (exclusive of Cache County and Box Elder County). The reservoir would have supplied 50,000 acre-feet per year for M&I demands and 50,000 acre-feet to the Refuge. BioWest divided the study area into four management areas: 1) the dam and reservoir footprint, 2) the Bear River corridor between the dam and the Bear River Migratory Bird Refuge, 3) the Bear River Migratory Bird Refuge, and 4) the Bear River Bay. The report evaluated each management area based on its existing environmental conditions, water resources, wetland and aquatic habitats, wildlife, fish, and threatened and endangered species. In addition, the report also presented mitigation methods for establishing new wetland areas to compensate for those likely to be impacted during construction and operation of a potential reservoir.

In the mid-1990s, the DWRe also completed specific studies of the Beeton and Barrens reservoir locations. The Beeton site was an alternative to the Honeyville site. A 1993 report provided a cost estimate for the Beeton site comparable to that of the Honeyville site (DWRe, 1993, *Beeton Dam and Reservoir Preliminary Design*). The proposed site was located approximately one mile upstream of where State Highway 102 crosses the Bear River, and DWRe estimated the reservoir capacity to be 50,000 acre-feet. Evaluation of the location included hydrology, capacity, slope stability analyses, and possible seismic activity in the area. DWRe assumed that geology, subsurface conditions, and liquefaction potential were similar to those at the Honeyville site. A final cost estimate was completed based on the previously mentioned evaluations.

2.3 MORE RECENT STUDIES

In recent years, MWH has presented a series of annual and semi-annual reports that document the results of regular water quality monitoring efforts (MWH; 1996, 1997, 1998, 1999, 2000, 2002, 2005, 2007, 2010, 2014, 2015, 2016; *Bear River Water Quality Monitoring Report*). These reports include monitoring results at several sampling sites located on the Bear River from downstream of the Idaho border to near the Great Salt Lake, and on the Malad River (a tributary to the Bear River). The reports also include recommendations on potential water treatment issues and the results of special studies related to Bear River water quality. In addition, the reports make recommendations regarding changes to the monitoring program. Currently, water quality monitoring is ongoing at four sites on the Bear River and one site on the Malad River.

Bear River Development, produced by the DWRe in August 2000, summarizes the history of the Bear River development and the planning and schedule status at that time. The high runoff years of the 1980s, followed by the low water years of the late 1980s and early 1990s, lead the Utah Legislature to pass the Bear River Development Act to "plan, construct, own, and operate reservoirs and facilities on the river." The report summarized the four-part development plan as follows: 1) enlarge Hyrum Reservoir, 2) connect the Bear River to Willard Bay Reservoir, 3) provide conveyance and treatment to deliver water to the Wasatch Front, and 4) build Honeyville Reservoir. In the 2000 DWRe report, the development plan was changed to: 1) modify the existing operation of Willard Bay by agreement with WBWCD, 2) connect the Bear River with a pipeline to Willard Bay; 3) construct conveyance and treatment to deliver water from Willard Bay to the Wasatch Front, and 4) build a dam in the Bear River Basin.

Scenarios evaluated for water supply benefits in the 2000 DWRe report include Willard Bay separately as well as Willard Bay combined with the conceptual Honeyville, Barrens, and Beeton reservoirs. The report highlights that water shortage could be mitigated using groundwater pumping, improving irrigation efficiency or fallowing of irrigated agricultural lands, or by leasing or purchasing of water rights. For all options, DWRe concluded the connection from the Bear River be via pipeline from Honeyville, or from the Bear River/I-15 crossing to Willard Bay. The report also notes WBWCD's reluctance to store Bear River water in Willard Bay due to a perception that Willard Bay has much higher water quality.

The DWRe Plan for the Bear River (DWRe, 2004, *Bear River Basin, Planning)* described the then current (2004) and projected water use and water supply within the Bear River Basin. The study projected a need to import Bear River water to the Wasatch Front within the about 2025, and to provide additional industrial, commercial and agricultural water supply to Box Elder County and Cache County water users within the same period. The report indicated that the Bear River had a remaining, developable supply of about 250,000 acre-feet annually, but that full development of this water would require the construction of reservoir storage. The 2004 Plan outlined four stated objectives:

- Modify the existing operation of Willard Bay by agreement with Weber Basin Water Conservancy District.
- Connect the Bear River with a pipeline and/or canal to Willard Bay from a point near the I-15 crossing of the Bear River near Elwood in Box Elder County.
- Construct conveyance and treatment facilities to deliver water from Willard Bay to the Wasatch Front.
- Build a dam in the Bear River Basin as the demand for additional water continues to increase.

The 2004 Plan also indicated that the Honeyville and Barrens reservoir sites were removed from consideration by the 2002 Legislature due to "growing concern with the possible environmental and social impacts of those two reservoir sites." Additionally, the Washakie reservoir site was added to the list of reservoirs to be studied.

The Water Delivery Financing Task Force (Task Force) completed a report, *Financing the Lake Powell Pipeline and Bear River Projects* (September 2005), that evaluated the funding needs associated with both projects. The report noted that proceeding with development evaluation studies should begin immediately, as deferring further state involvement would greatly increase the ultimate cost of the development and compress the planning and engineering of development into a few years. The Task Force recommended the State's then-current formulation, outlined in the 2004 Plan, as shown above. The report also noted that studies concerning environmental impacts, water quality, and hydrology would be required before federal involvement would be considered.

In 2010, DWRe completed a preliminary design for the Washakie off-stream reservoir site (CH2M Hill, 2010*, Washakie Reservoir Project Preliminary Engineering and Design Report*). The report focused on the geologic and geotechnical setting of the potential reservoir, but also included a description of the major facilities (including a dam and reservoir, Malad River bypass channel, and inflow and outflow piping and pump stations), as well as the hydrology, water quality, and environmental considerations associated with the potential reservoir. The geotechnical analyses concluded that the embankments would perform adequately during the design seismic event. The hydrologic and water quality review included the assumed use of Willard Bay as a second storage site. The report includes a cost estimate for a 160,000 acre-foot capacity reservoir, Malad River bypass facilities, and conveyance facilities ranging from $876M to $1,022M.

2.4 BEAR RIVER PIPELINE CONCEPT REPORT

In 2014, DWRe completed the Bear River Pipeline Concept Report *(Bowen Collins, Bear River Pipeline Concept Report, 2014).* The report identified a potential alignment corridor for a large-diameter pipeline from its source on the Bear River to the potential Washakie Reservoir site, and from the Washakie Reservoir site to the proposed West Haven Water Treatment Plant (WHWTP) in Weber County. An additional goal was to develop a conceptual design for the overall BRD system, including analyzing additional potential reservoir sites. The alignment of the pipeline from Washakie Reservoir to WHWTP is about fifty miles long through Box Elder and Weber counties. The review of the pipeline alignment allowed DWRe to prioritize and implement ROW acquisition activities.

In addition, the study re-examined more than 40 reservoir sites. Six of these sites were recommended for further study: Temple Fork, Cub River, Above Cutler, Whites Valley, Fielding, and Weber Bay. The study included updated hydrological information and determined that a reservoir volume of between 250,000 and 300,000 acre-feet would be required to develop a reliable water supply of 220,000 acre-feet annually. This was more storage than was estimated in past studies. Information generated by the report provided DWRe with updated BRD design criteria, pipeline design assumptions, and a comprehensive pipeline routing analysis. The study also developed a pipeline/pumping facilities design, a reservoir siting analysis, recommendations for further study of some of the potential reservoir sites, and an updated overall cost estimate.

2.5 SUMMARY OF PREVIOUS STUDIES

After more than four decades of evaluations and studies of potential plans for future development of the Bear River for M&I use, DWRe is still developing an overall plan for development. Early studies included diversion of water only to the Wasatch Front, examined only a single aspect of the development, such as a reservoir site, or focused on water quality and/or environmental analysis. Planning in the 1990s and early 2000s included a refined “big-picture” understanding of the phasing of the project, but lacked detailed review of facility requirements, institutional restrictions, or updated hydrology. The study of the Washakie site provided adequate detail about the suitability of the site for a reservoir but did not consider how to deliver water from the site to the water users. The Washakie site study also incorporated the use of Willard Bay Reservoir, which may not be possible given that use of Willard Bay for storage of Bear River water would require Federal authorization to allow non-Weber Basin Water Project water to be stored.

The Bear River Pipeline Concept Report outlined reservoir sites and facility combinations needed to develop an overall design and developed an overall development plan for the BRD System. The report also includes updated hydrologic data to determine the amount of storage necessary to develop the needed water supply.

Considering the evaluations above, the following conclusions can be made:

- Bear River water, above the confluence of the Malad River, is treatable to meet drinking water quality standards with conventional treatment processes.
- Bear River development will require a significant amount of reservoir storage to deliver 220,000 acre-feet annually to the water users.
- The 2014 Concept Report was the first time a comprehensive plan was completed for the BRD System.
- Concerns exist among stakeholder groups regarding certain reservoir sites.

Many of the previous studies and reports referenced herein include the use of Willard Bay. USBR constructed the Willard Bay Reservoir as part of the Weber Basin Project in the 1960s. The current authorized use of Willard Bay is for collection and storage of Weber River and Ogden River water for Weber Basin Project purposes only. Use of Willard Bay for storage of Bear River water would require Federal authorization to allow non-Project water to be stored in project facilities, and agreement with WBWCD as the project sponsor. Any discussion of the use of Willard Bay in this document is conceptual in nature as no formal discussions between DWRe, USBR, and WBWCD have been initiated. USBR and WBWCD recently engaged in a Safety of Dams improvement project, which included raising the dam structure slightly to optimize the storage of Weber and Ogden river water rights. These projects were constructed solely for the storage of Weber Basin Project water rights from the Weber and Ogden rivers, and were not intended for the storage of Bear River water.

CHAPTER 3

GOVERNING AGREEMENTS

3.0 GOVERNING AGREEMENTS

3.1 BEAR RIVER COMPACT

The Bear River has the unique distinction of being the longest river in North America does not reach an ocean. The headwaters are in Utah, and the river flows through Wyoming, Utah, and Idaho for more than 500 miles from Utah's Uinta Mountains to the Great Salt Lake (see Figure 3-1). The river flows over state lines several times, initially traveling in a northerly direction, turning west, then to the south, eventually terminating in Great Salt Lake.

Because of the river's path across state lines (Idaho, Utah, Wyoming), interstate agreements were necessary. In the early 1900s, as the states began to develop the Bear River, there were conflicts over the distribution and use of the river, as well as future development of the water. Utah, Idaho, and Wyoming recognized the need for an agreement concerning the shared use of the Bear River. In the early 1940s with assistance from the federal government, the states began negotiations regarding an agreement. The result was the original Bear River Compact (Compact) signed in 1958. The framework of the Compact regulates how Bear River water is distributed to Wyoming, Idaho, and Utah. The Compact, amended in 1980, defines three divisions along the river (Upper, Central, and Lower divisions), and allocates water from the river to the states in each of those divisions. The Compact limits the amount of water that may be depleted in each Division. As such, Utah may only develop additional supplies by diverting water from the Lower Division downstream of Bear Lake.

The Amendment in 1980 outlined the allocation of future water developed on the river. All surface and ground water applied to beneficial use in the Lower Division after January 1, 1976 was divided on a depletion basis, with Idaho being granted the first right to develop and deplete 125,000 acre-feet. Utah was granted the second right to 275,000 acre-feet, and the next 150,000 acre-feet was divided equally between Utah and Idaho. It also outlined the division of water in excess of the above allocations. The allocations set in the Bear River Compact provide the basis for the water rights to be developed as outlined in the Bear River Development Act.

3.2 BEAR RIVER DEVELOPMENT ACT

Because there is a projected need for future water supplies in northern Utah, and the State of Utah has allocated water rights on the Bear River, the Utah Legislature passed the Bear River Development Act (Act) in 1991. The Act states:

> “The Division (of Water Resources) shall develop the surface waters of the Bear River and its tributaries through the planning and construction of reservoirs and associated facilities as authorized and funded by the Legislature; own and operate the facilities constructed; and market the developed waters.”

The Act was amended in 2006. Changes to the Act through the amendment included defining authorized pre-construction costs, adding potential reservoir sites, authorizing the expenditure of funds on pre-construction activities, and the allocation of water among the Districts.

3.3 OTHER AGREEMENTS RELATED TO THE BEAR RIVER

Under the Bear River Compact, roughly the top 21 feet of Bear Lake is used for storage for agricultural purposes. PacifiCorp uses the water to produce electricity at its hydropower plants along the Bear River. PacifiCorp's use of the water is incidental to the agricultural use. PacifiCorp cannot release water for hydropower purposes only. The operation of Bear Lake and the river system is outlined in following three agreements:

- Operations Agreement for PacifiCorp's Bear River System, April 18, 2000
- Agreement Regarding the Bear River System, October 5, 1999
- Amended and Restated Bear Lake Settlement Agreement, July 2, 2004

Each of these agreements are included in the Appendix (Volume III).

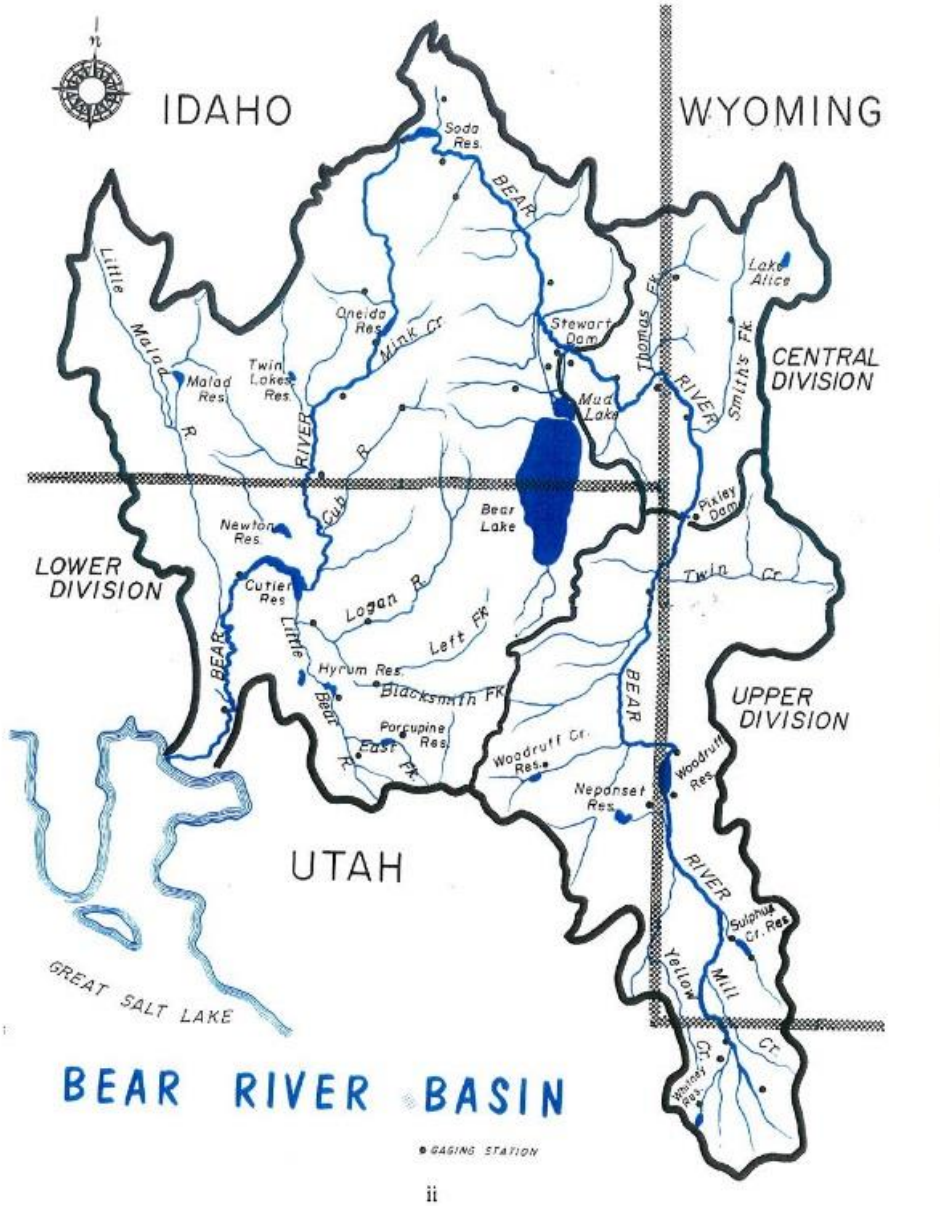


Figure 3-1: Bear River Watershed

CHAPTER 4

BEAR RIVER DEVELOPMENT DESCRIPTION

4.0 BEAR RIVER DEVELOPMENT DESCRIPTION

4.1 DESCRIPTION

The Bear River Development Act (discussed in Chapter 3) authorizes the Division of Water Resources (DWRe) to plan, study and develop 220,000 acre-feet from the Bear River. The development of the Bear River water supply is based on diverting water from the Bear River in the winter and during high spring runoff when it is available. Reservoir storage would be needed to provide a reliable supply. Water would be stored during the winter and spring months for later use, particularly during the peak summer demands for municipal and industrial use.

A pipeline from a diversion site(s) or reservoir(s) downstream of Cutler Reservoir would deliver water through Box Elder and Weber counties to the proposed West Haven Water Treatment Plant (WHWTP). Water could be delivered to BRWCD via turnouts along the pipeline alignment through Box Elder County. CWD could divert water from a tributary of the Bear River, a reservoir located in Cache County, a diversion site on Cutler Reservoir, or from a pipeline from the diversion/storage reservoir downstream of Cutler Reservoir. WBWCD and JVWCD have already initiated ROW acquisition for facilities consisting of the WHWTP, conveyance pipelines, treated water storage reservoirs, and pump stations to deliver the treated water from the WHWTP to Weber, Davis, and Salt Lake counties.

4.2 APPROACH

The purpose of this study is threefold: 1) to further refine and develop overall features that will develop the needed water supply for the Districts, 2) to begin preserving a pipeline corridor, and 3) to update overall costs, including costs to the Districts. The "Study Team" included Bowen Collins and Associates, HDR Engineers, and Gerhart Cole Engineers.

The following tasks were performed to complete the feasibility study objectives:

- **SURVEY/PRE-DELINEATION REVIEW OF RESERVOIR SITE WETLANDS.** Development of the Bear River could impact wetlands and other sensitive environmental areas. Six reservoir sites were recommended in the Concept Report for additional study. This task provided estimates of wetland areas and characteristics for each reservoir site and updated estimates of potential wetland mitigation costs for each site.
- **DEVELOPMENT OF MULTI-PURPOSE BENEFITS.** An initial summary was developed of potential multi-purpose benefits associated with the BRD System. These were evaluated to estimate their potential for impacts upon facilities, water supply reliability, and capital and operation and maintenance costs.
- **RESERVOIR CONCEPTUAL DESIGN AND FEASIBILITY REFINEMENT.** The conceptual design for each of the reservoir sites was refined, with a focus on developing a better understanding of constructability and feasibility. Assessments used existing, available information and geologic mapping, plus results from additional field studies including exploratory borings, trenching, geophysical exploration, and laboratory testing at each site.

- **UPDATED CONCEPTUAL DESIGN AND COST ESTIMATES.** Conceptual designs for potential BRD facilities was developed, including reservoirs, transmission piping, pump stations, and diversions, Using these conceptual designs, cost estimates were developed. In addition, a conceptual financial analysis for the BRD System and costs for each of the Districts was updated.
- **UTILITY CORRIDOR PRESERVATION ACTIVITIES.** DWRe identified parcels where early acquisition of a ROW could reduce future impacts to surrounding communities.
- **OUTSIDE AGENCY COORDINATION.** DWRe developed summary materials for public presentations. Agency coordination informed agencies about the feasibility study. The coordination also identified key issues of various stakeholders and agencies with interest in the feasibility study and the BRD. A list of presentations, meetings, and communications is included in the Appendix.

4.3 STUDY AREA LIMITATIONS

For the purposes of the study of potential reservoir sites, DWRe set two primary limitations. First, potential reservoir sites to be studied should be located within the State of Utah. Second, potential reservoir sites to be studied should be downstream of Bear Lake.

The study area encompasses the area along the Bear River near the Idaho border and along the I-15 corridor to West Haven City. The process of developing the study area for the Bear River included determining the extent of potential facilities, connecting the potential reservoirs to delivery points for the Districts, and determining potential pipeline alignments considered for evaluation.

Generally, the study area encompasses the following area, as illustrated in Figure 1-1 (Volume II):

- South Boundary — West Haven Water Treatment Plant
- North Boundary — Washakie Reservoir Site
- East Boundary — East Bench of the Wasatch Mountains, Logan River Watershed
- West Boundary — Great Salt Lake or West Railroad/I-15 Corridor

More detailed descriptions and maps of the study area are provided in Chapter 11.

CHAPTER 5

WATER DEMAND STUDIES

5.0 WATER DEMAND STUDIES

5.1. BACKGROUND

Projections of future water demand for the Districts were used to develop an estimate for when BRD facilities would need to be constructed. Projected estimates of water supply need from the development of the Bear River are continually updated by the Districts and DWRe. These projections assist DWRe and the Districts in developing an overall schedule for implementation of the BRD and to determine when, how much, and where water will need to be delivered.

5.2. WATER USE PROJECTIONS

Basis for 2020-2060 Projections of Water Use

DWRe has developed future projections for water use for the river basins within Utah. To estimate future water use, DWRe previously used population projections developed by the Governor's Office of Management and Budget (GOMB). Recently, the Utah Population Committee (UPC), convened by the Kem C. Gardner Policy Institute (Institute), has provided population projections. The Institute released population projections in 2017 providing a range of population estimates through 2065. These estimates ranged from 4.6 million to 6.2 million. The baseline scenario projected a population for the state of 5.8 million by 2065. This projection is lower than the 6.0 million by 2060 previously estimated by the GOMB.

In addition to future projections for water use, DWRe and the Districts have developed estimates of existing and future water supplies in the District service areas. The resulting analysis estimates water needs for all areas served by the BRD through 2060.

District Water Use Projections

When water providers plan for their future water use, they must determine what the ultimate (build-out) demand on their systems will be and how to meet that demand. Each of the four Districts (CWD, BRWCD, WBWCD, and JVWCD) have made projections for their ultimate water use. The basis for each of the Districts' ultimate water use estimates is described in the following paragraphs.

5.2.1. Cache Water District (formerly Cache County)

CWD developed a water master plan (*Cache County Master Plan, JUB Engineers, 2013)* that examined existing and future sources of water in the county and long-term water needs. In addition, a build-out estimate of county population and water demand was developed (*Cache County Ultimate Development Water Demand Study, Bowen Collins and Associates, 2010*). This study examined developable areas within the county, and planning and zoning densities to estimate the build-out population and resulting water demand. Based on this analysis, and using the estimate of lower densities from the study, Cache County would have an ultimate water demand of 302,000 acre-feet. The future water supply estimated for the county is 61,523 acre-feet (not including BRD supply). JUB summarized the existing agricultural demand in their report and calculated it to be about 200,000 acre-feet. If full use of existing supplies is assumed, and a conversion of 75% of the agricultural water to M&I use (based on an estimate of developable area converted from farms to houses), the resulting additional water needed for build-out is about 90,477 acre-feet. Reductions in per capita water use (water conservation), agricultural to M&I conversions, as well as new supplies (BRD and others) will be used to meet this demand.

5.2.2. Bear River Water Conservancy District

BRWCD developed two build-out estimates of county population (*Bowen Collins and Associates, 2010; Hansen Allen and Luce, 2010*). The Bowen Collins study examined developable areas within the county and planning and zoning densities to estimate a county population at build-out and the resulting water demand. Based on this analysis, and using the estimate of lower densities from the study, Box Elder County would have an estimated ultimate water demand of 298,000 acre-feet. The estimates calculated only include the part of Box Elder County that is within the Bear River Basin. The future water supply estimated for the county is about 32,300 acre-feet (not including BRD supply). DWRe summarized existing agricultural use and estimated it to be about 200,000 acre-feet. Assuming full use of existing supplies, and conversion of 75% of the agricultural water to M&I use, then the resulting additional water supply needed for build-out is about 116,000 acre-feet.

BRWCD recently completed a Master Plan (*Drinking Water System Master Plan, HAL, 2017*). As part of this study, future demands were estimated based on the GOMB numbers for county growth from 2012. Future growth was examined for two different scenarios. The first was based on average historical growth numbers for Box Elder County, and the second was based on a Rapid Growth Scenario based on historical growth patterns for counties along the Wasatch Front as development began in those counties. The HAL Master Plan indicated that demand would surpass existing supplies as early as 2045 under the “Rapid Growth Scenario”.

Both studies projected future water demand well in excess of projected supply.

Reductions in per capita water use (water conservation), agricultural to M&I conversions, as well as new supplies (BRD and others) will be used to meet this demand.

5.2.3. Weber Basin Water Conservancy District

WBWCD developed a demand study for their service area (*Supply and Demand Study, Bowen Collins and Associates, 2011*). This study examined existing and future sources of water in their service areas as well as long-term water needs. In addition, the study developed a build-out estimate of water demand. Based on this report, WBWCD has an ultimate water demand of just over 696,000 acre-feet. This includes supplies needed for agricultural deliveries, secondary water, and M&I water for areas served by WBWCD. The projected water supplies from the study for WBWCD are about 590,000 acre-feet, which includes significant agricultural water conversion and water conservation. The resulting ultimate water supply needed by WBWCD for build-out is about 106,000 acre-feet. Reductions in per capita water use (water conservation), agricultural to M&I conversions, as well as new supplies (BRD and others) will be used to meet this demand.

5.2.4 Jordan Valley Water Conservancy District

JVWCD developed a demand study for their service area (*Demand, Supply, and Major Conveyance Study, Bowen Collins and Associates, 2005*) that examined existing and future sources of water in their service area and long-term water needs. In addition, the study developed a build-out estimate of water demand. Based on this report, JVWCD has an ultimate water demand of approximately 291,000 acre-feet. The projected future water supplies are estimated JVWCD are approximately 195,000 acre-feet (not including BRD supply), which includes anticipated agricultural to M&I water conversion. The resulting water supply needed is about 96,000 acre-feet. Reductions in per capita water use (water conservation), agricultural to M&I conversions, as well as new supplies (BRD and others) will be used to meet this demand.

5.3. WATER USE PROJECTIONS

Based on the population projections and resulting water demands, estimates of water supply needs for the Districts was made for each of the ten-year periods from 2020 through 2060. In addition, as discussed in the sections above, estimates were made of demands beyond 2060 (build-out) for each District. The projections are shown in Table 5-1.

The Districts and DWRe are continually updating their water demand projections. Table 5-1 indicates that significant new supplies will need to be delivered by 2050. The projection of build-out demand for the four Districts is over 400,000 acre-feet. This additional demand cannot be met solely by development of the Bear River. This demand will have to be met by a significant amount of conversion of agricultural water to M&I use. Future reductions in per capita use will also have to occur through water conservation.

When projecting the water demands and the needed supplies to meet those demands forty years into the future, there is uncertainty. This comes from the uncertainties in projecting population growth, the amount of water conservation that is achieved, agricultural conversion, as well as how climate change will impact water supplies and demand. These will all effect the timing and amount of water needed by the Districts from future water development.

This table does not include possible growth from the “Rapid Growth Scenario” from the BRWCD Master Plan discussed earlier. This scenario is shown on Page 2-5 of their master plan. This growth scenario would result in needs by BRWCD by 2040-2045.

Table 5-1
Estimated Additional Water Supply Needs (Acre-Feet)[1]

Water District	2020	2030	2040	2050	2060	Build-Out
Cache Water District	0	782	1,405	4,238	10,243	90,377
Bear River Water Conservancy District	0	0	0	0	0	115,750
Weber Basin Water Conservancy District	0	0	4,245	30,617	60,539	106,765
Jordan Valley Water Conservancy District	0	0	8,558	43,562	76,459	95,285
Totals	**0**	**782**	**14,208**	**78,417**	**147,241**	**408,177**

1. This table does not include possible growth from the "Rapid Growth Scenario" from the BRWCD Master Plan
2. 2030 and 2040 demand, because of its size, can be met without full project development.

CHAPTER 6

NEED FOR RESERVOIR STORAGE AND COMBINATIONS OF RESERVOIRS

6.0 RESERVOIR COMBINATIONS ANALYSIS

6.1 NEED FOR RESERVOIR STORAGE AND COMBINATIONS OF RESERVOIRS

As part of this study, the Bear River water supply data was updated. The hydrologic modeling previously used a period of record from 1966 through 2013. The simulations for this study include a 30-year period of record from 1981 to 2010. This data includes two of the worst droughts of the last 60 years. The data was needed to update facility sizing requirements, water supply reliability, and cost estimates, as documented in Chapter 8. The modeling included updated instream flow assumptions, revised reservoir storage capacity assumptions, and climate change-influenced hydrologic datasets. The climate change datasets were developed to estimate future water supply conditions. Combinations of potential reservoirs were developed and evaluated to determine the most effective and the least-costly potential reservoir combinations.

6.2 BEAR RIVER WATERSHED HYDROLOGY

The timing of availability of water on the Bear River does not generally match the timing of the Districts' water supply needs. Available water in the Bear River system occurs primarily in the winter and spring, while peak demands from the water users are in the summer and early fall. Figure 6-1 shows the historical monthly total inflow and divertible inflow (that water available for diversion based on DWRe water rights) and the historical average monthly water supply needs for the Districts (average percentage use of JVWCD times the needed BRD supply). Using this information to project the BRD water supply needs, the majority of the BRD water supply would need to come from reservoir storage. Additionally, because of the highly variable hydrology, a large volume of reservoir storage would be needed.

6.2.1 BearSim Model

DWRe has developed (and continues to update) a daily time-step computer model (BearSim) of the Bear River hydrology and water supply. The BearSim model includes long-term, historical records of estimated streamflow data for the Lower Bear River (starting at the Idaho-Utah border near Oneida). The model also includes time series of historical daily diversions for each major diversion on the Lower Bear River and for the Bear River Migratory Bird Refuge (BRMBR), as well as the projected water supply needs for the Districts. The model incorporates combinations of existing and potential storage reservoirs, as well as conveyance and delivery facilities. A period of record from 1966 through 2013 was previously used in the model. The simulations for this study include a period of record from 1981 to 2010. This time period includes the most significant dry periods of the longer record.

DWRe used the BearSim model to simulate the long-term operation of potential BRD system facilities using different combinations of reservoirs, storage volume, conveyance capacities, instream flows, and water delivery assumptions. Results from these simulation runs provide important information to establish the potential combinations of reservoirs needed for storage, and the capacity of the necessary pipelines and appurtenant facilities needed to deliver a reliable water supply.

6.2.2 Hydrology and Water Availability

The hydrology of the Bear River system is complex. Natural variations in meteorology affect the accumulation and melting of snowpack in the high elevation watershed areas. Meteorology also affects how much of the precipitation that falls on the watershed is depleted by evaporation, evapotranspiration from natural vegetation, or runs off into stream channels. Diversions for water use, hydropower generation, and flood control (as well as upstream reservoir operations) also affect how much water is divertible for future development of the Bear River. In addition, return flows from irrigation diversions, variability in meteorological conditions (i.e. flooding, drought, climate change), and possible changes in upstream reservoir operations and water use, will change the availability of water.

Some of the challenges in predicting the reliability of the water supply from the Bear River can be seen in Figure 6-1. Figure 6-1 indicates the variability of the annual flow of the Bear River with volumes ranging from as low as 500,000 acre-feet to and as high as 3,000,000 acre-feet.

Figure 6-2 shows the total and divertible flows for the years 1966-2012. The average annual flow between these years is 1,300,000 acre-feet. The average annual flow available to be diverted is 760,000 acre-feet. These volumes would tend to indicate that 220,000 acre-feet could be diverted annually. However, as the figure shows, historically there are prolonged dry periods over several years. For example, between 2001 and 2004, the average annual divertible flow was about 124,000 acre-feet. To develop a reliable annual supply of 220,000 acre-feet during four similar years, reservoir storage of more than 400,000 acre-feet would be needed. Based on this historical data and extensive use of the BearSim model, the 2001-2004 period presents the greatest challenge for modeling in terms of the reservoir storage capacity necessary to supply 220,000 acre-feet annually.

Figure 6-1 indicates the average monthly total flow and divertible flow of the Bear River as well as the average monthly pattern of supply. As shown, relatively little water is available for diversion to meet the supply needs between July and September. This period is when District needs are the highest. When divertible flow is compared with the pattern of demands, an average of about 100,000 acre-feet of the 220,000 acre-feet demand is directly divertible from Bear River flow and an average of nearly 120,000 acre-feet would need to come from reservoir storage. In the driest year in the historical record (2003), just 28,600 acre-feet is divertible directly from Bear River. Storage will be needed to meet the water supply needs of the Districts.

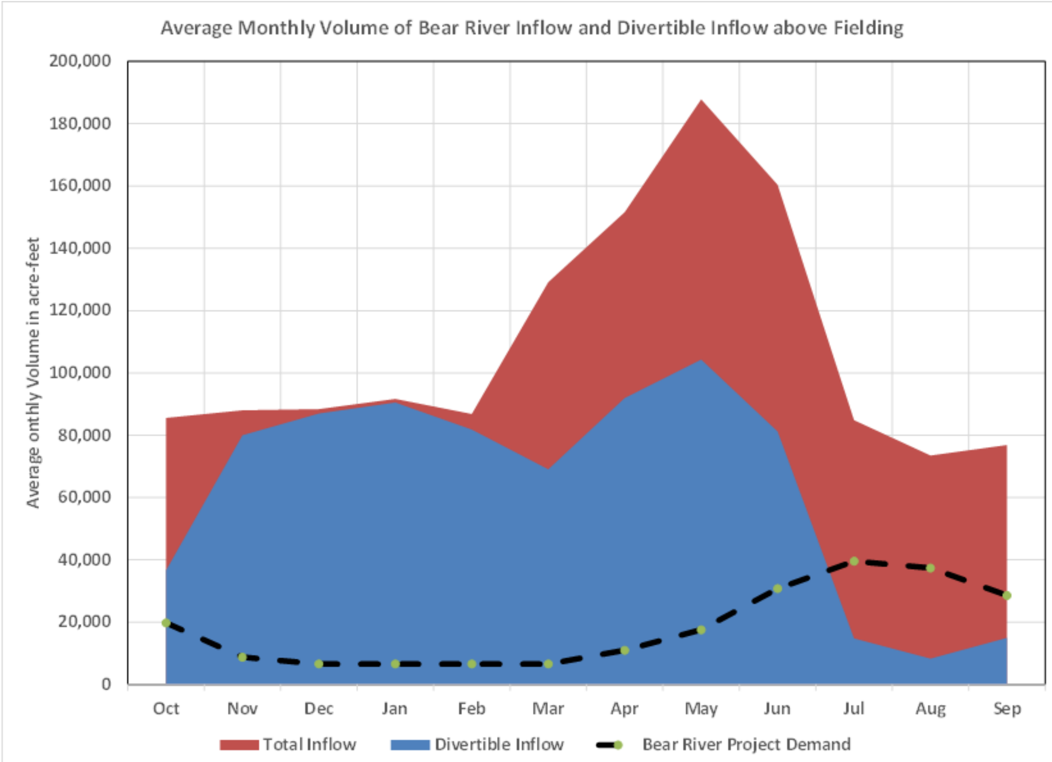


Figure 6-1: Average Monthly Total Inflow and Divertible Inflow

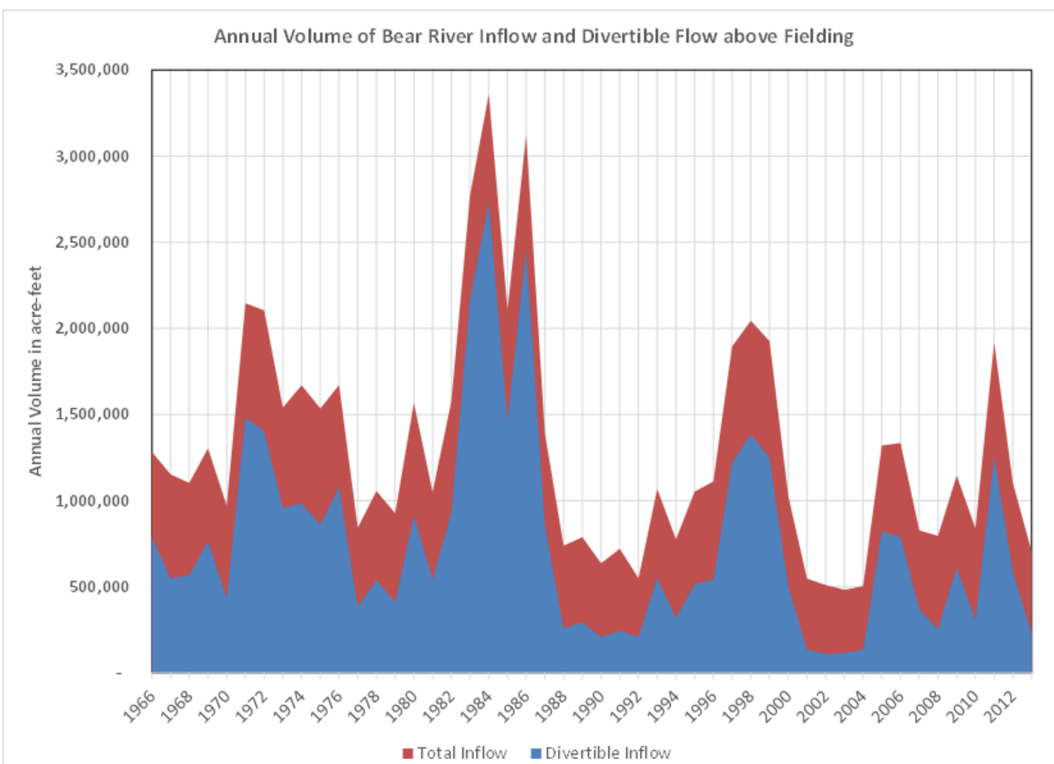


Figure 6-2: Annual Total Inflow and Divertible Inflow

6.3 COMBINATIONS OF POTENTIAL RESERVOIRS

Several scenarios were modeled to include different combinations of reservoir sites. The six reservoir sites recommended from the 2014 Pipeline Concept Report were used in the different combinations. The South Willard site was used instead of the Weber Bay site. Where possible, combinations were developed to provide 400,000 acre-feet or more of total storage. The BearSim model was used to simulate the potential combinations of facilities, including reservoirs, pipelines, and pumping stations. In total, about four dozen scenarios were evaluated in an attempt to find the most feasible set of facilities to meet the needed water supply objectives at the lowest expected cost and environmental impact. The Washakie site, which was studied in more depth in an earlier study and was discussed in the 2014 Pipeline Concept Report, was not studied further due to its high cost[1].

The modeling included a 90% reliability goal. That is, for any one year the supply from the BRD system cannot be less than 90% of the needed supply. Reservoir storage in the various scenarios was adjusted so that goal was met.

After the initial screening analyses of potential reservoir combinations, an analysis using the BearSim model was conducted to simulate ten refined scenarios, including scenarios that incorporated each potential reservoir site. After simulating these ten scenarios, most did not achieve the reliability goal of 90%. Three additional scenarios were simulated that included additional storage. The thirteen scenarios are summarized in Table 6-1. It should be noted that the Whites Valley site is included in all but one of the scenarios evaluated. Because of the large amount of storage needed, scenarios that include the Whites Valley Reservoir site provide the storage necessary to meet the 90% reliability goal.

1 The Washakie Reservoir site is hydrologically identical to the 170,000 acre-feet Whites Valley site, included in Scenario D.

Table 6-1
Reservoir Scenarios Simulation Results

Scenario	Cub River (acre-feet)	Above Cutler (acre-feet)	Temple Fork (acre-feet)	Fielding (acre-feet)	Whites Valley (acre-feet)	South Willard (acre-feet)	Total Storage (acre-feet)
A	-	-	-	40,000	360,000	-	400,000
B	-	-	-	70,000	330,000	-	400,000
C	-	-	-	-	400,000	-	400,000
D	27,000	51,000	41,000	70,000	170,000[1]	55,000	414,000
E	27,000	-	-	40,000	333,000	-	400,000
F	-	51,000	-	40,000	309,000	-	400,000
G	-	-	41,000	40,000	319,000	-	400,000
H	-	-	-	40,000	305,000	55,000	400,000
I	27,000	51,000	41,000	70,000	-	55,000	244,000
J	-	-	-	70,000	540,000	-	610,000
K	-	-	-	-	610,000	-	610,000
L	27,000	-	41,000	-	540,000	-	608,000
M	27,000		-	-	540,000	55,000	622,000

6.3.1 Scenario (Reservoir Combination) Descriptions

The scenarios listed in Table 6-1 were developed to more fully understand the necessary facilities for a functional system (reservoirs, pipelines, pump stations, etc.). This also led to a better understanding of the overall operational needs of the facilities, which also helped to further refine the hydrologic modeling approach. The results of the modeling iteration of each scenario is presented in the following sections. More details on the hydrologic results of the water supply aspect of each scenario, including shortage analyses, are presented in Chapter 8.

For scenarios that have inadequate or no storage within Cache County, a pipeline from Fielding Reservoir (Fielding Pump Station) to upstream of the existing Cutler Reservoir was included to deliver water to CWD.

6.3.1.1 Scenario A

Scenario A includes two reservoir sites for a total of 400,000 acre-feet of storage:

- Whites Valley: 360,000 acre-feet
- Fielding: 40,000 acre-feet (smaller reservoir)

The basic operation of this scenario would be on-stream storage at Fielding Reservoir, with pumped off-stream storage to the Whites Valley Reservoir. Figure 6-2 (Volume II**)** shows the facilities for this scenario.

6.3.1.2 Scenario B

Scenario B includes two reservoir sites for a total of 400,000 acre-feet of storage:

- Whites Valley: 330,000 acre-feet
- Fielding: 70,000 acre-feet (larger reservoir)

This scenario is similar to Scenario A with a larger reservoir at the Fielding site. Figure 6-3 (Volume II) shows the facilities for this scenario.

6.3.1.3 Scenario C

Scenario C includes a large 400,000 acre-feet Whites Valley Reservoir.

- Whites Valley: 400,000 acre-feet

This scenario is unique in that it only includes the Whites Valley Reservoir. A diversion structure would be constructed on the Bear River near Fielding Reservoir to pump directly from the river to Whites Valley. Figure 6-4 **(**Volume II**)** shows the facilities for this scenario.

6.3.1.4 Scenario D

Scenario D includes all of the six reservoir sites for a total of 414,000 acre-feet of storage:

- Whites Valley: 170,000 acre-feet (smaller reservoir)
- Fielding: 70,000 acre-feet (larger reservoir)
- Temple Fork: 41,000 acre-feet
- Cub River: 27,000 acre-feet
- Above Cutler: 51,000 acre-feet
- South Willard: 55,000 acre-feet

This scenario is unique in that it has the smallest-sized Whites Valley Reservoir and distributes the storage across all six reservoir sites studied. This scenario also includes the South Willard Reservoir, which allows operational storage in the system at the end of the pipeline to WHWTP. This scenario provides adequate storage in Cache County and a pump-back pipeline to Cutler Reservoir would not be needed. Figure 6-5 (Volume II) schematically shows the facilities for this scenario.

6.3.1.5 Scenario E

Scenario E includes three reservoir sites for a total of 400,000 acre-feet of storage:

- Whites Valley: 333,000 acre-feet

- Fielding: 40,000 acre-feet (smaller reservoir)
- Cub River: 27,000 acre-feet

Figure 6-6 (Volume II) schematically shows the facilities for this scenario.

6.3.1.6 Scenario F

Scenario F includes three reservoir sites for a total of 400,000 acre-feet of storage:

- Whites Valley: 309,000 acre-feet
- Fielding: 40,000 acre-feet (smaller reservoir)
- Above Cutler: 51,000 acre-feet

Figure 6-7 (Volume II) schematically shows the facilities for this scenario.

6.3.1.7 Scenario G

Scenario G includes three reservoir sites for a total of 400,000 acre-feet of storage:

- Whites Valley: 319,000 acre-feet
- Fielding: 40,000 acre-feet (smaller reservoir)
- Temple Fork: 41,000 acre-feet

Figure 6-8 (Volume II) schematically shows the facilities for this scenario.

6.3.1.8 Scenario H

Scenario H includes three reservoir sites for a total of 400,000 acre-feet of storage:

- Whites Valley: 305,000 acre-feet
- Fielding: 40,000 acre-feet (smaller reservoir)
- South Willard: 55,000 acre-feet

Figure 6-9 (Volume II) schematically shows the facilities for this scenario.

6.3.1.9 Scenario I

Scenario I includes five reservoir sites for a total of 244,000 acre-feet of storage:

- Fielding: 70,000 acre-feet (larger reservoir)
- Temple Fork: 41,000 acre-feet
- Cub River: 27,000 acre-feet
- Above Cutler: 51,000 acre-feet
- South Willard: 55,000 acre-feet

This scenario is unique as it does not include storage at the Whites Valley site and has less than 400,000 acre-feet of storage. Since there is storage located in Cache County in this scenario, pump-back pipeline to Cutler Reservoir would not be necessary. Figure 6-10 (Volume II) schematically shows the facilities for this scenario.

6.3.1.10 Scenario J

Scenario J includes two reservoir sites for a total of 610,000 acre-feet of storage:

- Whites Valley: 540,000 acre-feet
- Fielding: 70,000 acre-feet (larger reservoir)

Scenario J could meet the reliability goal of 90%. Figure 6-11 (Volume II) schematically shows the facilities for this scenario.

6.3.1.11 Scenario K

Scenario K is similar to Scenario C except it includes more storage (610,000 acre-feet) at the Whites Valley and a diversion directly from the Bear River.

- Whites Valley: 610,000 acre-feet

Scenario K could meet the reliability goal of 90%. Figure 6-12 (Volume II) schematically shows the facilities for this scenario.

6.3.1.12 Scenario L

Scenario L includes three reservoir sites for a total of 608,000 acre-feet of storage:

- Whites Valley: 540,000 acre-feet
- Cub River: 27,000 acre-feet
- Temple Fork: 41,000 acre-feet

Scenario L could meet the reliability goal of 90%. This scenario utilizes a diversion on the Bear River rather than Fielding Reservoir. Since there is storage located in Cache County in this scenario, pump-back pipeline to Cutler Reservoir would not be necessary. Figure 6-13 (Volume II) schematically shows the facilities for this scenario.

6.3.1.13 Scenario M

Scenario M includes three reservoir sites for a total of 622,000 acre-feet of storage:

- Whites Valley: 540,000 acre-feet
- Cub River: 27,000 acre-feet
- South Willard: 55,000 acre-feet

Scenario M could meet the reliability goal of 90%. This scenario includes a diversion on the Bear River rather than Fielding Reservoir. Figure 6-14 (Volume II) schematically shows the facilities for this scenario.

CHAPTER 7

RESERVOIR SITE INVESTIGATIONS

7.0 RESERVOIR SITE INVESTIGATIONS

The following sections summarize each of the six potential reservoir sites with their general site conditions and information, hydrology, summary of geology/geotechnical considerations, and conceptual layouts and sizing for the dam, outlet works, spillway, and other facilities. Figure 7-1 (Volume II) shows the general location of each of the reservoir sites, and Figure 7-2 (Volume II) shows the general hydraulic schematic of all the combined project facilities included in this chapter.

7.1 WHITES VALLEY DAM AND RESERVOIR (170,000 acre-feet)

The Whites Valley site can accommodate various reservoir sizes that yield a variety of capacities, from below 170,000 acre-feet up to more than 500,000 acre-feet. This site, with the addition of saddle dams and seepage control provisions for the foundation and reservoir bed, could have a storage volume of as much as 600,000 acre-feet. This site would be an off-channel storage reservoir and would be primarily a pumped-storage facility capable of generating power in release mode while storing water for seasonal deliveries. The following section describes the facilities and sizing for a 170,000 acre-feet reservoir at this site. Section 7.2 describes the facilities and sizing for a 400,000 acre-feet reservoir on this site. Drawing W-01(Volume II) shows the conceptual site plan for the site.

7.1.1 Location and Site Conditions

The potential Whites Valley Reservoir site is located in the West Hills north west of Tremonton, Utah. The site is about nine miles to the northwest via I-84, to Exit 32 and another four miles to the Whites Valley drainage from the freeway exit. There is a prominent valley in the main drainage, currently occupied by dry land farms and minor farming facilities. The valley is at an elevation of about 5,100 feet elevation above mean sea level (MSL), which is about 1,000 feet higher in elevation than the Bear River in the Collinston area.

Three county gravel roads bisect the reservoir area: the main access road up Whites Valley from the south, Johnson Canyon Road from the east, and Indian Trail Road from the west. Other minor farm access roads cross the reservoir area. All roads to this site are unpaved. There is no power infrastructure nor other utilities at this site. The nearest power corridor is south of I-84 and there are possibly some communications utilities along I-84.

7.1.2 Site Configuration

At the south end of Whites Valley, the valley narrows where a dam site could be located. A key benefit of this site is that the location allows for a relatively small dam footprint with a large reservoir volume. In addition, the dam height/width can be configured to allow for a variety of reservoir sizing options or for staged reservoir development. Drawing W-1 (Volume II) shows the conceptual site plan for the dam and reservoir.

The key design parameters of this configuration are as follows:

- Maximum Reservoir Pool:
  - Elevation = 5,264 feet MSL
  - Total Storage = 178,000 acre-feet
    - Active Storage = 170,000 acre-feet
    - Inactive Storage = 8,000 acre-feet
  - Surface Area = 2,100 acres
- Stage/Storage Curve.

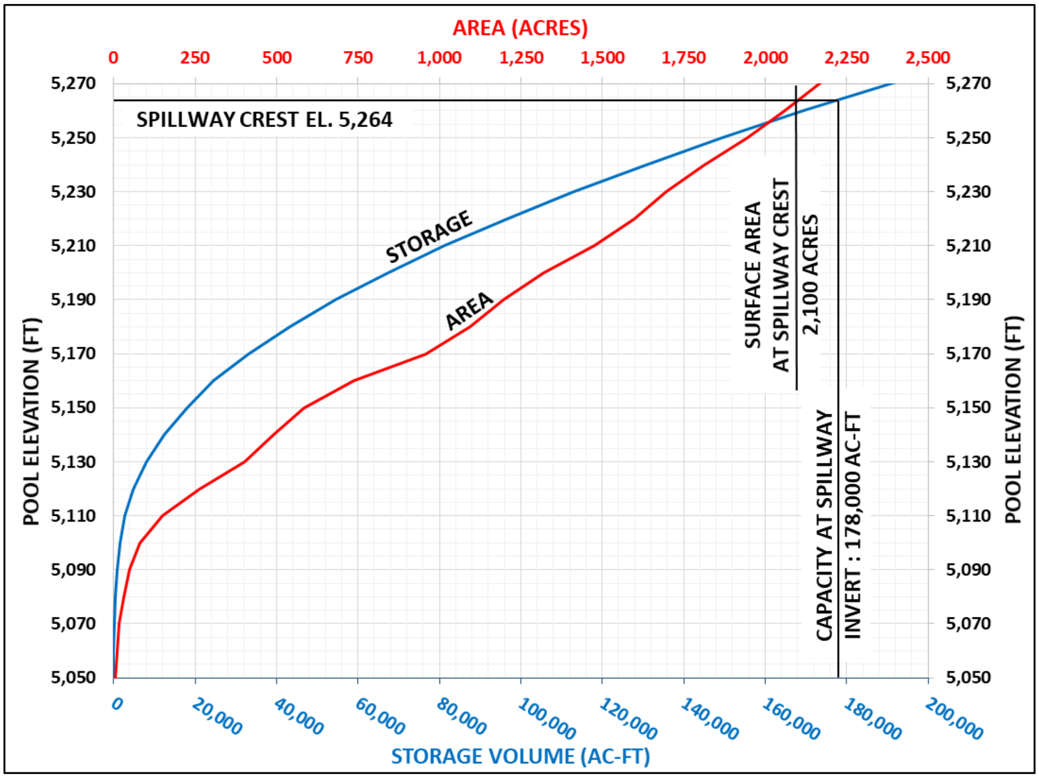


Figure 7-3: Whites Valley 170,000 acre-feet Stage Storage/Area Curves

- Dam:
  - Crest Elevation = 5,270 feet MSL
  - Hydraulic Height = 227 feet
  - Spillway Crest Elevation = 5,264 feet MSL
  - Low Level Outlet Intake Invert = 5,060 feet MSL
  - Downstream Toe Elevation = 5,043 feet MSL

7.1.3 Dam Type

The potential dam site is at the mouth of Whites Valley where the bedrock hills are the narrowest. HDR Engineering performed an analysis of the site feasibility to determine the type of dam best suited for this location. In general, the site appears feasible for a range of potential dam sizes. It was determined that an earth-core rock fill dam structure would best fit this site due to the bedrock foundation conditions and the large amount of readily available earth-fill and rock-fill borrow materials available for embankment fill in the basin. A more detailed summary of the dam type evaluation and site configuration are located in HDR's Report: *Conceptual Engineering Analyses for Potential Dam Sites,* provided in the Appendix.

The potential dam site is situated on about 25 feet of loose alluvium deposits (overburden) founded on hard calcareous sandstone formation, highly fractured with deformed bedding features. Gerhart Cole, Inc. (GCI) performed a feasibility level geologic and geotechnical assessment of the site geology and its suitability for a large dam site. GCI outlines the results of this investigation in a report entitled *Whites Valley Geotechnical Data Report*, provided in the Appendix) of this report. Three test holes were drilled along the potential centerline axis to evaluate the geology of the bedrock foundation. GCI also performed a seismic refraction survey and excavated test trenches to verify and evaluate the bedrock/alluvium in the area. These tests were performed to assess the potential for a fault under, or adjacent to, the potential dam site. Other field tests were performed to evaluate potential construction material borrow areas within the basin.

Following the initial site characterization work, additional analysis was completed to assess the potential for primary or sympathetic faulting at the dam site. GCI's previously mentioned report discusses the results of this supplemental investigation. This study found no evidence of faulting having occurred in the area.

The potential for sympathetic faulting and shear zone development would present an important design consideration related to foundation seepage at the dam site, including the potential for non-recoverable reservoir seepage losses. Additional site characterization studies and engineering evaluations would be needed to refine the types and extent of strategies for seepage mitigation. For this study, it is assumed that seepage mitigation strategies would include grout curtains beneath the foundation and clay lining of portions of the reservoir rim.

Key design parameters of the dam layout and configuration are shown in the drawings W1-W6 in Volume II and are as follows:

- Fill (total 4.8 million cubic yards):
    - Rock Fill (Shell Zone 3)
    - Transition (Zone 2)
    - Central Clay Core with Bedrock Cutoff Trench
    - Downstream Chimney and Blanket Filters/Drains
    - Riprap Rock Armor Upstream
    - Grout Curtain into Bedrock along Cutoff Trench

- Dimensions:
    - Lower Upstream Slope = 2.5:1 (H:V)
    - Upper Portion of Upstream Slope = 2:1
    - Downstream Slope = 2:1
    - Crest Width = 40 feet
    - Crest Length = 1,450 feet

7.1.4 Reservoir Hydrology

The drainage area of the Whites Valley site is about 16.2 square miles of sage and grasslands with an average watershed elevation of 5,568 feet MSL. Initial investigations into the Probable Maximum Precipitation (PMP) for this watershed, which generates a Probable Maximum Flood (PMF) into the reservoir, yielded the following results:

- PMP = 72-hour storm generating 14.1 inches of rainfall
- PMF = peak inflow of 7,800 cfs (cubic feet per second), generating about 15,100 acre-feet total inflow to the reservoir

Although the site would be an off-stream reservoir, the contributing watershed could generate a sizeable flood event. The reservoir flood volume and spillway should be sized to route the PMF safely past the dam without overtopping it. For this study, six feet of freeboard was added to the height of the dam. The freeboard could contain most of the PMF inflow, while only 1,500 cfs would need to pass over a small emergency spillway structure.

7.1.5 Site Challenges and Benefits

Initially identified challenges of this dam/reservoir site include:

- Costly additional pumping and conveyance facilities to make this site feasible.
- Achieving a positive leakage cutoff through the bedrock surrounding the foundation (abutments and below the central clay core cutoff trench).
- Non-recoverable seepage lost from the reservoir basin through the southeastern reservoir rim.
- Potential downstream flood damage during emergency spillway release or outlet release, as there is no existing established downstream drainage channel or facilities. This risk is low since it is an off-stream reservoir and spillway releases are highly unlikely.

Initially identified benefits of this site include:

- Reservoir capacity is expandable, depending on future projected storage needs prior to construction.
- Located on undeveloped private lands.
- Reservoir footprint has a minimal impact on existing infrastructure or developments.
- Potentially less environmental impacts due to the off-stream location.
- Dam safety implications are low.
- Earth and rockfill borrow materials may be available from the reservoir basin. Filter and drain material will likely have to be imported.

7.1.6 Dam Facilities and Layout

Figure 7-4 (Volume II) includes a schematic drawing of the Whites Valley site and associated key facilities. Drawings W-1 thru W-7 (Volume II) include site plans and sections. Both filling and draining of the reservoir would be controlled through a single outlet works systems designed for bi-directional pressurized flows. The location of the outlet works would be located near the left abutment. This site would include the following general spillway and outlet works facilities, which were sized based on conceptual hydraulic criteria, as described below:

- **Emergency Spillway Structure.** Concrete weir structure over right abutment with the following features:
  - Capacity = 1,500 cfs
  - Width = 50 feet
  - Sill elevation = 5,264 feet MSL
  - Walled concrete chute
  - Energy dissipation basin
- **Outlet Guard Gate Structure.** This would be located in the reservoir area with hydraulically actuated high-head slide gate housed in a reinforced concrete intake structure. It would be designed with appropriate debris screens and energy dissipation capabilities. Debris screens would be sized for two-directional flow. Provisions for installing a bulkhead in the structure would be provided in the event that the upstream portion of the outlet works requires dewatering, inspection, and repairs. The size of the gate opening is 8 feet by 8 feet.
- **Outlet Tunnel.** The upstream tunnel would be about 10 feet in diameter excavated in the left abutment bedrock and consist of reinforced concrete encased steel pipe. The downstream tunnel (after dam centerline) would be 15 feet in diameter reinforced concrete lined tunnel, containing a 10-foot diameter steel pipe.
- **Emergency Outlet Bypass Valve Vault.** This would be used to empty the reservoir and would include a concrete energy dissipation box and riprap (see Figure W-5, Volume II). This would discharge to an undeveloped drainage swale with no downstream drainage channel. The vault would also house a secondary isolation valve downstream of the Outlet Tunnel.
- **Pigging and Metering Vault.** Downstream of the Outlet Tunnel, a pigging launch sleeve would be located to send the pipe-cleaning pig downstream. The same vault would have a flow meter and a man-way for outlet pipe and tunnel inspection.
- **Relocation of County Roads.** The reservoir pool would inundate existing county dirt roads that would need to be relocated around the reservoir footprint.
- **Power Utility.** Power would be needed to operate the necessary instrumentation (see below).
- **Instrumentation.** Instrumentation would include valve operators/sensors, guard gate opening operators/sensors, flow meter, reservoir level sensors, piezometers, drain pipe flow measurement, SCADA system, and other monitoring and communication devices.

Appurtenant Facilities. In order for the Whites Valley Reservoir to be operable in the overall BRD system, water needs to be delivered to and from this site. These facilities include the following:

- **Pipeline.** The Whites Valley site would be filled by pumping water approximately 1,000 feet in elevation over a distance of about 18 miles. This same pipe would also be the outlet pipe from the reservoir to deliver water through hydropower plant(s) and into the overall delivery system.
- **Booster Pump Station.** A booster pump would be needed to convey pumped water from the Bear River (potential Fielding Reservoir or Bear River diversion) to Whites Valley. This site would also need a large power supply, pump surge facilities, and pig launch/receive vaults. See Figure 7-5 (Volume II).
- **Equalization Reservoir.** The Booster Pump Station site would also need a large regulating reservoir (about 500 acre-feet) to allow for a pumping pool to the Whites Valley site and a pool for discharging hydropower flows. See Figure 7-5 (Volume II).
- **Hydropower Station.** The Booster Pump Station and Equalization Reservoir site would also have a hydropower station to break head and generate power from flow out of the reservoir. See Figure 7-5 (Volume II).
- **Junction Vault.** This vault would be located at the junction of the Whites Valley Pipeline and the main Bear River Pipeline. It would act as flow control to and from Whites Valley, and to and from storage/diversion pumping out of the Bear River (Fielding Reservoir). See Figure 7-6 (Volume II).

7.2 WHITES VALLEY DAM AND RESERVOIR (400,000 acre-feet)

The following section describes the facilities and sizing for a 400,000 acre-foot reservoir at the Whites Valley site.

7.2.1 Location and Site Conditions

See Section 7.1.1.

7.2.2 Site Configuration

As discussed in Section 7.1.2, this site is an efficient location for a dam, and could be configured to allow for a variety of reservoir sizing options. Drawing W-8 (Volume II) shows the conceptual site plan for the dam and reservoir.

The key design parameters of this configuration are as follows:

- Maximum Reservoir Pool:
  - Elevation = 5,350 feet MSL
  - Storage = 400,000 acre-feet
  - Surface Area = 3,060 acres

- Stage/Storage Curve

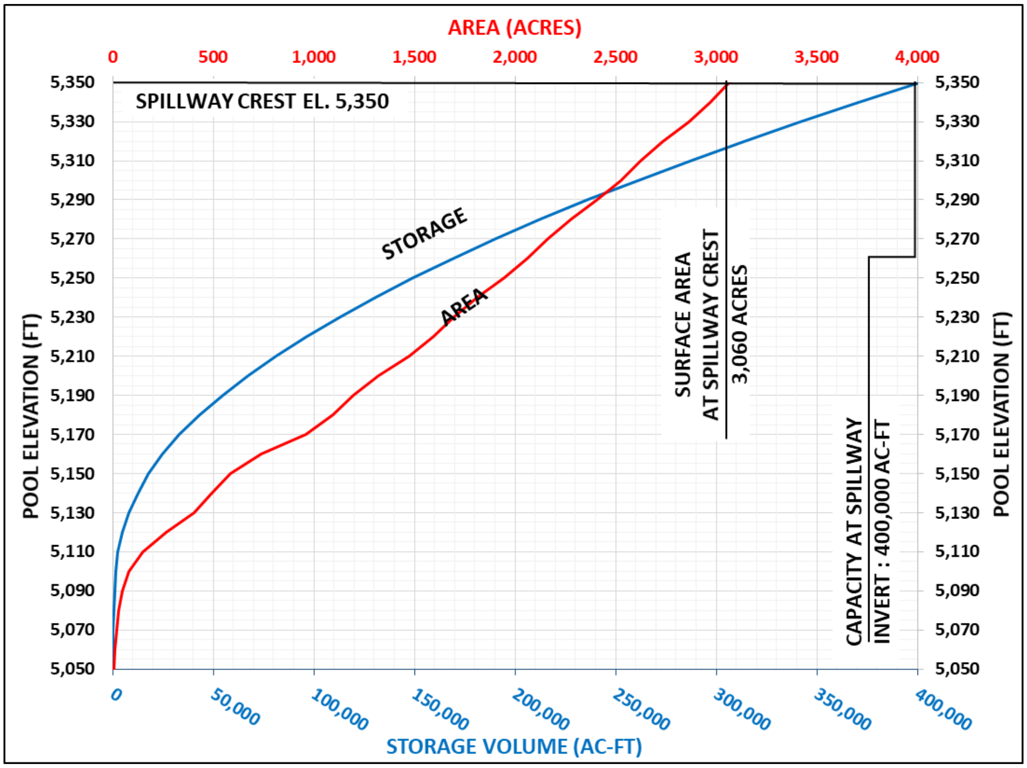


Figure 7-7: Whites Valley 400,000 acre-feet Stage Storage/Area Curves

- Dam:
  - Crest Elevation = 5,360 feet MSL
  - Hydraulic Height = 320 feet
  - Spillway Crest Elevation = 5,350 feet MSL
  - Low Level Outlet Intake Invert = 5,060 feet MSL
  - Downstream Toe Elevation = 5,040 feet MSL

7.2.3 Dam Type

As with a smaller Whites Valley reservoir, a larger reservoir would need an earth-core rock fill dam structure. A summary of the geology and geotechnical evaluations are in Section 7.1.3. The information applies with the following exceptions:

- **Increased Leakage.** A larger dam and increased hydraulic head would require increased leakage protection. This could include a deeper grout curtain and more extensive clay lining on the near surface and exposed bedrock.
- **Increase Quantity of Materials.** Further studies should be performed to verify that onsite materials would be of adequate quantity and quality to construct this larger dam. It was assumed that the dam slope dimensions listed below would apply to a larger dam.

Key design parameters of the potential dam layout and configuration are as follows and as shown in the conceptual drawings in Volume II:

- Fill (total 10.4 million cubic yards):
  - Rock fill (Shell Zone 3)
  - Transition (Zone 2)
  - Central Clay Core with Bedrock Cutoff Trench
  - Downstream Chimney and Blanket Filters/Drains
  - Riprap Rock Armor Upstream
  - Grout Curtain into Bedrock along Cutoff Trench

- Dimensions:
  - Lower Upstream Slope = 2.5:1 (H:V)
  - Upper Portion of Upstream Slope = 2:1
  - Downstream Slope = 2:1
  - Crest Width = 40 feet
  - Crest Length = 2,150 feet

7.2.4 Reservoir Hydrology

The larger reservoir does not change the hydrology of the reservoir substantially compared to the smaller reservoir. The PMF remains the same and could be attenuated in the reservoir's larger volume. Routing of the spillway flood was assumed the same as the smaller reservoir (spillway capacity of 1,500 cfs).

7.2.5 Site Challenges and Benefits

Initially identified challenges of this site are the same as those listed in Section 7.1.5, with the following additional comments:

- With the increased head (additional 100 feet) on the dam and reservoir area, , the potential leakage issues in the reservoir basin and at the abutments and foundation of the dam would need to be studied and addressed.
- Verification would be needed that adequate earth borrow materials for the larger dam are available from the reservoir basin.

The benefits initially identified for this reservoir are the same as those listed in Section 7.1.5 with the following additional comment:

- The larger reservoir could serve as the sole storage site for the full development of the Bear River Development supply with the possibility of planning for a phased implementation. a smaller dam could be constructed with the potential to raise the dam and enlarge the reservoir storage volume in the future.

7.2.6 Dam Facilities and Layouts

The facilities and layout for the larger reservoir are similar to the smaller reservoir. Figure 7-4 (Volume II) includes a schematic drawing of the site and key facilities. Drawings W-8 through W-12 (Volume II) include conceptual site plans and sections.

This larger configuration would include the following general infrastructure and facilities.

- **Emergency Spillway Structure.** Concrete weir structure over right abutment with the following features:
  - Capacity = 1,500 cfs
  - Width = 50 feet
  - Sill elevation = 5,350 feet MSL
  - Walled concrete chute on bedrock followed by bedrock drop channel
  - Energy dissipation basin
- **Outlet Guard Gate Structure.** See Section 7.1.6.
- **Outlet Tunnel.** See Section 7.1.6.
- **Emergency Outlet Bypass Valve Vault.** See Section 7.1.6.
- **Pigging and Metering Vault.** See Section 7.1.6.
- **Relocation of County Roads around Dam and Reservoir.** Similar to the smaller configuration with an additional county road needing to be relocated. See Section 7.1.6.
- **Power Utility.** See Section 7.1.6.
- **Instrumentation.** See Section 7.1.6.
- **Appurtenant Facilities.** See Section 7.1.6.

7.3 FIELDING DAM AND RESERVOIR (70,000 acre-feet)

The Fielding site was evaluated for two storage sizes: 70,000 acre-feet and 40,000 acre-feet located just upstream of the larger site. This section describes the facilities and sizing for a 70,000 acre-feet reservoir. The 40,000 acre-feet reservoir configuration with its facilities are discussed in Section 7.4.

7.3.1 Location and Site Conditions

The larger Fielding site is located in the Bear River Valley of Box Elder County, situated between the communities of Collinston and Riverside. The conceptual reservoir footprint extends from just below Cutler Dam, past Highway 30 to 14000 North (county axis grid) where the dam would be located. The elevation of the Bear River at this location is about 4,250 feet MSL. The elevation of the surrounding area ranges from about 4,360 to 4,400 feet MSL near the reservoir. Drawing F-1 (Volume II) shows the conceptual site plan for the dam and reservoir.

The site is comprised mostly of heavily vegetated river floodplain, with occasional farm fields and structures, with the notable exception of a water ski park residential development. The steeper walls of the Bear River floodplain channel mostly contain the reservoir boundaries. Drawings F-1 thru F-6 (Volume II) show the conceptual site plans and sections.

7.3.2 Site Configuration

The potential location of the dam site is located at a narrow section of the Bear River floodplain. The key design parameters of this site are as follows:

- Maximum Reservoir Pool:
  - Elevation = 4,300 feet MSL
  - Storage = 70,000 acre-feet
  - Surface Area = 1,700 acres
- Stage/Storage Curve

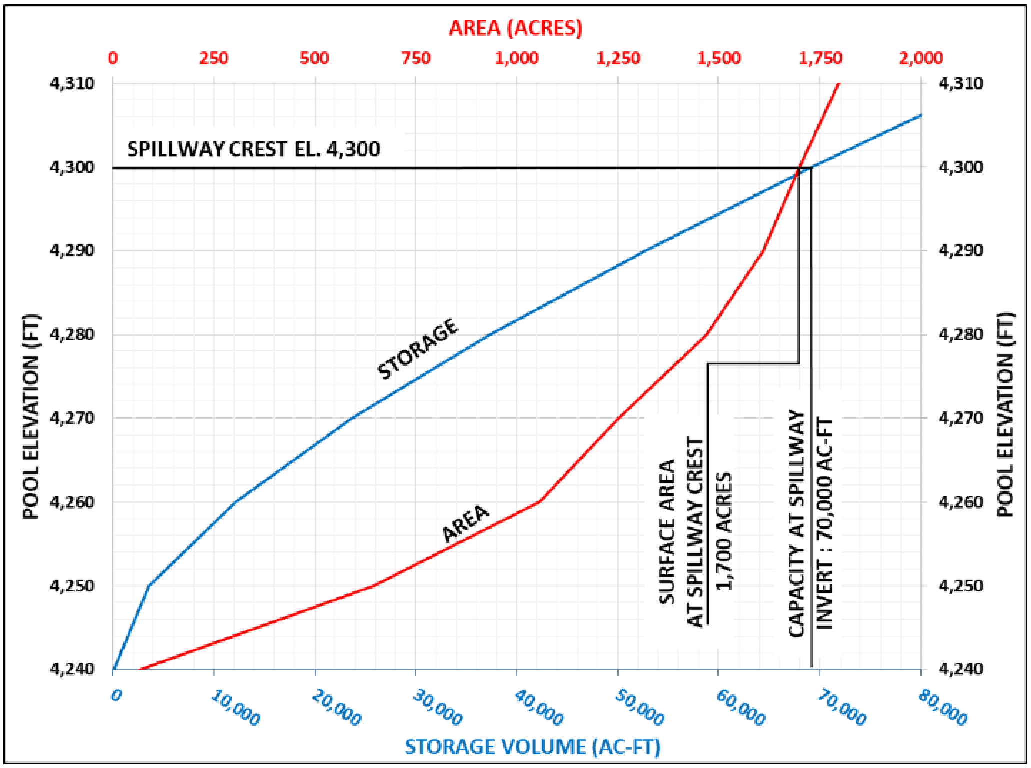


Figure 7-8: Fielding 70,000 acre-feet Stage Storage/Area Curves

- Dam:
  - Crest Elevation = 4,310 feet MSL
  - Hydraulic Height = 70 feet
  - Spillway Crest Elevation = 4,300 feet MSL
  - Low Level Outlet Intake Invert = 4,240 feet MSL
  - Downstream Toe Elevation = 4,240 feet MSL

7.3.3 Dam Type

The geologic conditions of the location of the site are mostly a layered mixture of fine Lake Bonneville sediments and alluvial deposits, ranging from soft clays to loose gravels and sands. There is a high groundwater table with some artesian influence at various depths. GCI drilled three test holes to investigate the subsurface conditions of the site. They also performed a feasibility level geologic and geotechnical assessment of the site geology and its suitability for a large dam site entitled *Fielding Dam Geotechnical Data Report* (see Appendix).

Due to the nature of the soft soils at this site, it was determined that a wide earth-fill embankment dam would be most suitable. The initial geotechnical evaluations indicate that this site would have design challenges to mitigate low soil strengths, seismic deformation potential, settlement, and overall seismic performance of the dam structure. A more detailed summary of the dam type evaluation, site configuration, and recommended dam layout are located in HDR's Report: *Conceptual Engineering Analyses for Potential Dam Sites* (see Appendix). The HDR report provided a conceptual outline of the basic earth-fill dam dimensions and configuration of the embankment zones. Since seismic stability was of major concern, the embankment slopes were flattened, and wide stability berms were included.

Within the reservoir footprint, the soils in the steep valley slopes are generally loose granular (sand and gravel) materials intermixed with silt, silty clay, and clay layers. These side slopes may be prone to slope failures once saturated and subjected to normal reservoir operating conditions. A large slope failure or landslide in the reservoir could create a wave that overtops and fails the dam. Further evaluation of reservoir slope stability including identification of landslide hazards should be completed prior to design. Designs should be updated to include appropriate slope stability and landslide mitigation measures. For the purposes of this study, it was assumed that steeper slopes near the dam would be excavated/flatted and stabilized by using the slope as borrow material for dam construction.

Key design parameters of the dam layout and configuration are summarized below and shown on the conceptual design drawings:

- Fill (total 1.0 million cubic yards):
    - Earthfill (Zone 3)
    - Central Clay Core with Cutoff Trench (into existing clay layer)
    - Downstream Chimney and Blanket Filters/Drains
    - Riprap Rock Armor Upstream
    - Abutment Leakage Protection Measures

- Dimensions:
    - Lower Upstream Slope = 4:1 (H:V)
    - Upper Portion of Upstream Slope = 3:1
    - Lower Downstream Slope = 4:1
    - Upper Portion of Downstream Slope = 2.5:1
    - Stability Berms Width = 150 feet (upstream and downstream)
    - Cutoff Trench Depth = 18 feet
    - Crest Width = 30 feet

- Crest Length = 1,125 feet

7.3.4 Reservoir Hydrology

The drainage area of the Bear River for the Fielding site is about 6,288 square miles, which comprises more than 80% of the Bear River watershed area. The Bear River watershed stretches into Idaho and Wyoming, reaching maximum elevations of more than 13,000 feet MSL.

Initial hydrologic investigations into the PMP and its generated PMF for this watershed, yielded the following results:

- PMP = 72-hour storm generates 5.0 inches rainfall
- PMF = Peak inflow of 197,000 cfs, generating about 1 million acre-feet of inflow to the reservoir

Since the dam and reservoir are located on the Bear River, the reservoir flood volume and spillway should be sized to route the sizeable PMF safely past the dam without overtopping it. A basic incremental damage assessment was performed to estimate the potential for reduction in the spillway design flow. The purpose of the incremental damage assessment is to determine if flood damage (peak flood water level) from a PMF, plus a breached Fielding Dam, would exceed the damage that would already occur without the dam. This assessment allows the spillway design flood to be reduced to passing only a percentage of the PMF, below which a dam breach flow would cause more damage than the PMF would. Based on the incremental damage assessment, it was determined that the spillway could be designed to pass approximately 100,000 cfs, or about 50% of the full PMF.

7.3.5 Site Challenges and Benefits

Initially identified challenges of this site are:

- Low soil strengths and the potential for seismic deformations, significant embankment settlement, and overall seepage and seismic safety of the dam structure and foundation.
- Large emergency spillway.
- Leakage from the spillway channel and potential impacts on slope stability between the spillway channel and the natural valley slopes near the dam.
- Landslide potential of the existing steep slope hazards within the reservoir footprint.
- Large amount of wetlands would be inundated.
- Potential leakage through the abutment material.
- Community impacts of the reservoir footprint (i.e. transportation).

Initially identified benefits of this site are:

- In-stream storage and centralized location would benefit the overall system and its operation.

- The majority of earth borrow materials may be available from the reservoir basin and spillway excavation.

7.3.6 Dam Facilities and Layout

The site would include a large pumping station and a potential hydropower plant. Figure 7-9 (Volume II) includes a schematic drawing of the site and associated key facilities. Drawings F-1 thru F-6 (Volume II) show conceptual site plans and sections of this site. This site would include the following general facilities:

- **Zoned Earthfill Embankment Dam with Central Clay Core.** See Section 7.3.3.
- **Emergency/Service Spillway Structure.** Intake channel leading to a downstream concrete weir discharge control structure in the left abutment area with the following features:
    - Capacity = 100,000 cfs
    - Gated structure: six 30 x 40 feet radial gates
    - Width = 225 feet
    - Channel invert elevation = 4,280 feet MSL
    - Sill elevation 4,300 feet MSL
    - Walled concrete drop chute downstream of gates
    - Concrete energy dissipation basin
- **Outlet Guard Gate Structure.** Located in the reservoir area, with hydraulically actuated high-head slide gate housed in a reinforced concrete intake structure with appropriate debris screens. The gate opening size was assumed to be 8 feet x 8 feet.
- **Outlet Tunnel.** The outlet tunnel would be 10 feet in diameter, excavated in the right abutment alluvium with a reinforced concrete encased steel pipe.
- **River Outlet Valve Vault.** The vault would regulate river flows out of the reservoir and include a flow meter, control valve, and a concrete energy dissipation box.
- **Outlet Pipe to Pump Station.** The outlet pipe from the reservoir to the pump station suction would include a large isolation valve.
- **Highway 30 Bridge over Reservoir.** The dam and subsequent reservoir pool would inundate Highway 30. A bridge would need to be constructed.
- **Instrumentation.** The instrumentation would include valve operators/sensors, guard gate operators/sensors, flow meter, reservoir level sensors, piezometers, drain pipe flow measurement, SCADA system, and other monitoring and communication devices.

Fielding Appurtenant Facilities. Water would be pumped from the reservoir to the Bear River Pipeline. The appurtenant facilities include the following:

- **Pump Station.** The pump station would convey pumped water from the Bear River to either the Whites Valley Reservoir or the Bear River Pipeline system. This site also includes a large power supply connection and pump surge facilities. Figure 7-9 (Volume II) includes a schematic drawing of these facilities.
- **Power Utility.** Power would be needed to operate the pump station. A power substation

and transmission from large power facilities located on the west side of the valley could provide power for the pumps.

- **Hydropower Station (Optional).** The site could also have a hydropower station to break head and generate power if there is a pumped-hydropower included from Whites Valley Reservoir.

7.4 FIELDING (40,000 acre-feet)

The following section describes the facilities and sizing for a 40,000 acre-feet reservoir at the Fielding site.

7.4.1 Location and Site Conditions

A smaller Fielding Reservoir site would be located immediately upstream of Highway 30 on the Bear River. The reservoir pool would extend nearly to Cutler Dam. Other general site descriptions are similar to the larger Fielding site (See Section 7.3). Drawing F-7 (Volume II) shows the conceptual site plans and sections.

7.4.2 Site Configuration

The site is located at a wider section of the Bear River floodplain than the larger site. The key design parameters of this site are as follows:

- Maximum Reservoir Pool:
  - Elevation = 4,300 feet MSL
  - Storage = 40,000 acre-feet
  - Surface Area = 1,130 acres
- Stage/Storage Curve

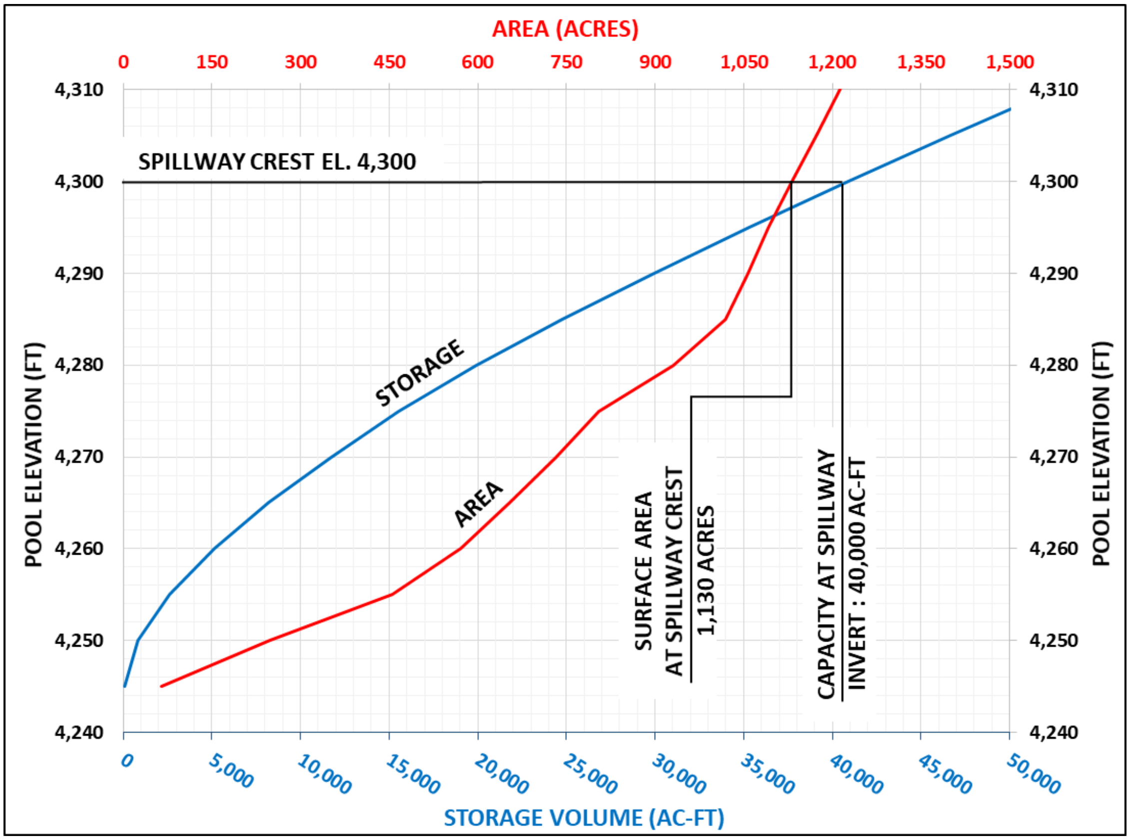


Figure 7-10: Fielding 40,000 acre-feet Stage Storage/Area Curves

- Dam:
  - Crest Elevation = 4,310 feet MSL
  - Hydraulic Height = 63 feet
  - Spillway Crest Elevation = 4,300 feet MSL
  - Low Level Outlet Intake Invert = 4,238 feet MSL
  - Downstream Toe Elevation = 4,247 feet MSL

7.4.3 Dam Type

As with the larger Fielding Dam, this dam would be an earthfill embankment dam with a central clay core for seepage control. It is assumed the geologic and geotechnical conditions of the smaller site are similar to those listed for the larger site.

This site has similar challenges concerning subsurface seepage, stability, settlement, and seismic response. This includes potential landslide hazards on the steep valley side slopes and the stability of the valley slopes between the spillway channel and the dam location.

Key design parameters of this site are the same as the larger downstream site (Section 7.3.3), with the following exceptions:

- Fill (total 3.2 million cubic yards)

- Crest Length = 3,580 feet

See conceptual drawings for more details of the conceptual design and layout.

7.4.4 Reservoir Hydrology

The drainage area of the Bear River at this site is assumed to be the same as the larger downstream site as follows:

The drainage area of the Bear River for the site is about 6,288 square miles, which comprises more than 80% of the Bear River watershed area. The Bear River watershed stretches into Idaho and Wyoming, reaching maximum elevations of more than 13,000 feet MSL.

Initial hydrologic investigations into the PMP and its generated PMF for this watershed, yielded the following results:

- PMP = 72-hour storm generates 5.0 inches rainfall
- PMF = Peak inflow of 197,000 cfs, generating about 1 million acre-feet of inflow to the reservoir

7.4.5 Site Challenges and Benefits

The identified challenges of this smaller, upstream site are the same as those listed for the larger downstream site (See Section 7.3.5). An additional challenge at this site is that the size of the dam would need to be significantly larger for less storage. The site location would reduce impacts to the surrounding community.

7.4.6 Dam Facilities and Layout

Figure 7-9 (Volume II) includes a schematic drawing of the site and associated key facilities. Drawings F-7 thru F-11 (Volume II) show conceptual site plans and sections. This site would include the following general facilities:

- **Earthfill Embankment Dam with Central Clay Core.** See Section 7.4.3.
- **Emergency/Service Spillway Structure.** Concrete weir structure over right abutment with the following features:
    - Capacity = 100,000 cfs
    - Gated structure: six 30 x 40 foot radial gates
    - Width = 225 feet
    - Channel invert elevation = 4,280 feet MSL
    - Sill elevation = 4,300 feet MSL
    - Walled concrete drop chute downstream of gates
    - Concrete energy dissipation
- **Outlet Guard Gate Structure.** Located in reservoir area, with hydraulically actuated high-head slide gate housed in a reinforced concrete intake structure with appropriate debris screens. Provisions are included for installing a bulkhead in the structure in the event that

the upstream portion of the outlet works requires dewatering, inspection, and repairs. The assumed size of the gate opening is 8 x 8 feet.

- **Outlet Tunnel.** The diameter of the outlet tunnel would be 10 feet, excavated in left abutment alluvium outside the footprint of the dam embankment, with a reinforced concrete-encased steel pipe.
- **River Outlet Valve Vault.** Used to regulate river flows out of the reservoir and includes a flow meter and control valve.
- **Outlet Pipe to Pump Station.** Outlet pipe from reservoir to pump station intake; includes a large isolation valve.
- **Instrumentation.** Instrumentation would include valve operators/sensors, guard gate operators/sensors, flow meter, reservoir level sensors, piezometers, drain pipe flow measurement, SCADA system, and other monitoring and communication devices.

Appurtenant Facilities. The appurtenant facilities are the same as the larger, downstream site (See Section 7.3.6).

7.5 TEMPLE FORK DAM AND RESERVOIR

7.5.1 Location and Site Conditions

The potential Temple Fork site is located in Logan Canyon (Cache County) about 14 miles east of Logan City. It is located just off the main canyon in the Temple Fork tributary. The site elevation is about 5,900 feet MSL.

The drainage from Temple Fork Creek generally drains westward from the surrounding mountains. The reservoir basin area contains mostly sage and grasses with thick pine and aspen groves on the north facing slopes and in the small drainages. The reservoir area exists entirely on US Forest Service lands. Drawing T-1 (Volume II) shows the conceptual site plans and sections for the site.

Three main Forest Service gravel roads bisect the reservoir: Temple Fork Road (main access road), Temple Fork Mill Trail and Spawn Creek Road. There are undeveloped areas for camping and parking within the reservoir basin at the intersection of these three roads. There is no infrastructure or utilities at or near this site.

7.5.2 Site Configuration

There is a prominent narrowing of the Temple Fork canyon, with a large bedrock outcropping where the potential dam would be located. The location would allow a dam to be located on bedrock.

The key design parameters of the site are as follows:

- Maximum Reservoir Pool:
  - Elevation = 6,170 feet MSL

- Storage = 41,350 acre-feet
- Surface Area = 400 acres

- Stage/Storage Curve

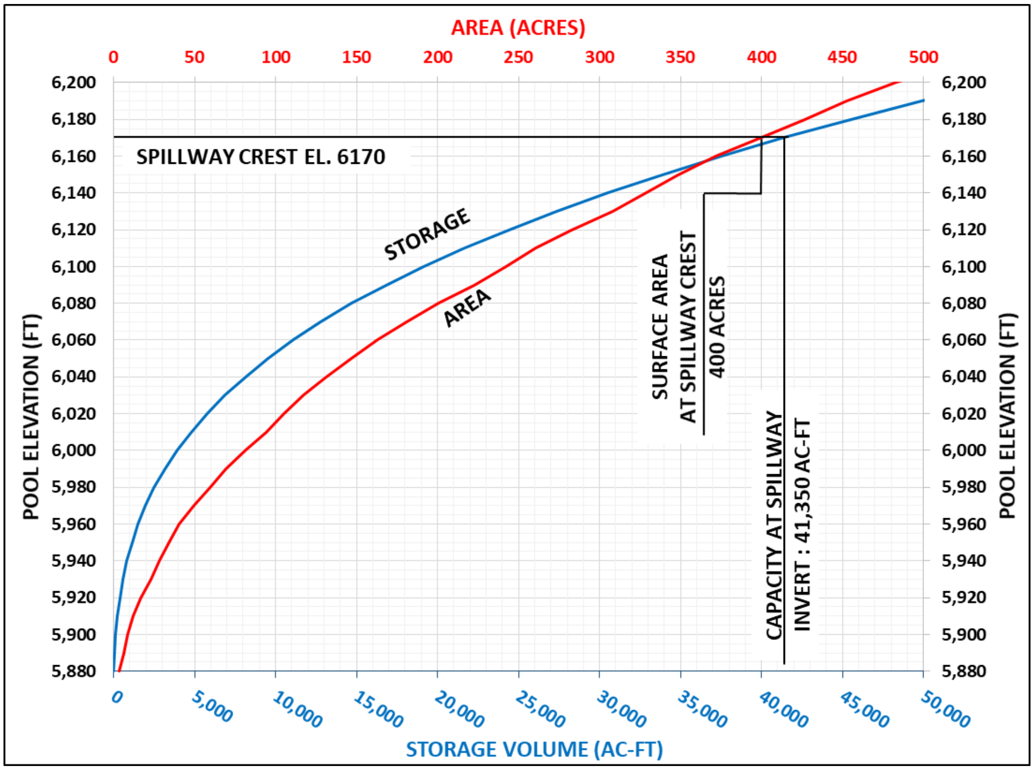


Figure 7-11: Temple Fork Stage Storage/Area Curves

- Dam:
  - Crest Elevation = 6,178 feet MSL
  - Hydraulic Height = 327 feet
  - Spillway Crest Elevation = 6,170 feet MSL
  - Low Level Outlet Intake Invert = 5,860 feet MSL
  - Downstream Toe Elevation = 5,851 feet MSL

7.5.3 Dam Type

This site would be best suited for a roller compacted concrete (RCC) dam structure due to the bedrock foundation and abutment conditions, the dam height and narrow canyon opening.

A more detailed summary of the dam type evaluation and site configuration is included in HDR's Report: *Conceptual Engineering Analyses for Potential Dam Sites* (See Appendix)

The potential dam site would be located on 20-25 feet of loose alluvium deposits in the maximum section area over limestone bedrock. Gerhart Cole performed an initial concept design level geologic and geotechnical assessment of the site geology and the suitability for a dam. Results of the analysis are summarized in the report *Temple Fork Geotechnical Data Report* (See Appendix).

Three test holes were drilled along the potential dam centerline to evaluate site geology and engineering characteristics of the bedrock foundation. Geologic mapping indicates some faulting in the immediate vicinity of the potential dam site. Further studies would be needed to characterize the location and hazards associated with faulting at the site.

An additional regional hazard associated with the limestone bedrock is the potential for localized karst. Although there is no direct evidence of karst in bedrock exposure near the site or within the test holes, additional studies should focus on the potential for karst hazards at the dam site. For the purposes of this study, it was assumed that there were no major karst hazards at the site and that pressure grouting would provide adequate treatment of the foundation and abutments.

Key design parameters of the dam layout and configuration are as follows (See Drawings T-1 thru T-6, Volume II):

- Materials:
    - Roller Compacted Concrete (RCC)
    - Grout Curtain about 120 feet into bedrock
    - Volume of RCC = 791,000 cubic yards
- Dimensions:
    - Upstream Slope Wall = 0.15:1 (H:V)
    - Downstream Slope Wall = 0.75:1
    - Crest Width = 25 feet
    - Neck Height = 40 feet
    - Crest Length = 1,020 feet

7.5.4 Reservoir Hydrology

The drainage area for the site is about 15.8 square miles of mountainous terrain between 6,000 and 9,000 feet MSL. Initial hydrologic investigations into the PMP and its generated PMF for this watershed, yielded the following results:

- PMP = 72-hour storm generates 17.5 inches rainfall
- PMF = Peak reservoir inflow of 8,600 cfs. Total PMF runoff of about 13,400 acre-feet of inflow

The dam would need to be designed to safety pass the PMF without overtopping of the dam. A simplified reservoir routing analysis suggested that a freeboard of seven feet would be needed with a peak outflow of 7,100 cfs flowing over a spillway structure in the central portion of the dam.

7.5.5 Site Challenges and Benefits

Initially identified challenges of this site are:

- Further characterization of faulting is needed near the dam site as well as regional seismic hazards required for design.

- A positive leakage cutoff through the bedrock surrounding the abutments and foundation would be needed.
- The site is located entirely on US Forest Service.
- Environmentally sensitive area (i.e. Bonneville Cutthroat).
- Short construction season with difficult access and tight work area for construction.

Initially identified benefits of this site are:

- Would provide storage high in the Bear River system within Cache County.
- The majority of the RCC aggregate materials may be available from the basin.

7.5.6 Dam Facilities and Layout

Figure 7-12 (Volume II) includes a schematic drawing of the Temple Fork site and associated key facilities. Drawings T-1 thru T-6 (Volume II) include conceptual site plans and sections. This site would include the following general infrastructure and facilities:

- **RCC Dam.** See Section 7.5.3.
- **Spillway Structure.** Concrete structure over the center of the dam with the following features:
  - Capacity = 7,100 cfs
  - Width = 80 feet
  - Sill elevation = 6,170 feet MSL
  - Ogee weir over dam face
  - Concrete stair-step chute on dam face.
  - Concrete energy dissipation basin.
- **Outlet Guard Gate Structure.** The outlet structure would be located on the face of the dam and would include a multiple-level gated intake structure. The 6 x 6 foot gates would be operated hydraulically.
- **Outlet Pipe in Dam.** 6-foot diameter pipe cast into the RCC structure.
- **Stream Outlet Valve Vault.** Would release flow into the Temple Fork creek between the Temple Fork site and the Logan River. The vault would also have an energy dissipation structure.
- **Relocation of US Forest Service Roads.** The dam and reservoir would inundate existing Forest Service roads. About 5 miles of road would need to be relocated to provide access to the dam and around the reservoir.
- **Instrumentation.** Instrumentation includes valve operators/sensors, guard gate opening operators/sensors, flow meter, reservoir level sensors, piezometers, drain pipe flow measurement, SCADA system, and other monitoring and communication devices.

Appurtenant Facilities. The appurtenant facilities include the following:

- **Outlet/Inlet Pipe Downstream.** A 54-inch diameter outlet/inlet pipe would be needed to deliver water to and from the Logan River. This pipe would be both the fill and drain pipeline and would include a bi-directional flow meter and isolation valves. See Figure 7-12 (Volume II).
- **Pump Station.** To divert water from the Logan River to the site, a pump station would be needed. This pump station would include an intake with screens, a power supply, and pump surge facilities. See Figure 7-12 (Volume II).
- **Power Utility.** Power would be required to operate the pump station and dam facilities. For the purpose of this study, it was assumed that new transmission lines would be routed from Logan City to the pump station site.
- **Hydropower Station.** This site would have potential to generate power from releases into the Logan River. A bypass with a control valve would also part of the hydropower station to bypass the turbines. See Figure 7-12 (Volume II).

7.6 SOUTH WILLARD DAM AND RESERVOIR

7.6.1 Location and Site Conditions

The potential South Willard Reservoir site is located in Weber County, immediately south of the existing Willard Bay Reservoir, near the shore of the Great Salt Lake. The site would be an off-stream facility, filled and emptied by the Bear River Pipeline. The site elevation ranges between 4,210 and 4,225 feet MSL. The site is located entirely on privately-owned lands that have little development with the exception of a few structures. The site is located adjacent to large power conveyance facilities. Drawing SW-1 (Volume II) shows the conceptual site plan for the dam and reservoir.

7.6.2 Site Configuration

The reservoir would be a rectangular in shape with features similar to the existing Willard Bay. The depth would range between 5 and 20 feet deep with a large surface area. The location of this site allows for flexibility in reducing the overall volume/footprint.

The key design parameters of this dam/reservoir site are as follows:

- Maximum Reservoir Pool:
  - Elevation = 4,230 feet MSL
  - Storage = 55,500 acre-feet
  - Surface Area = 3,740 acres
- Stage/Storage Curve

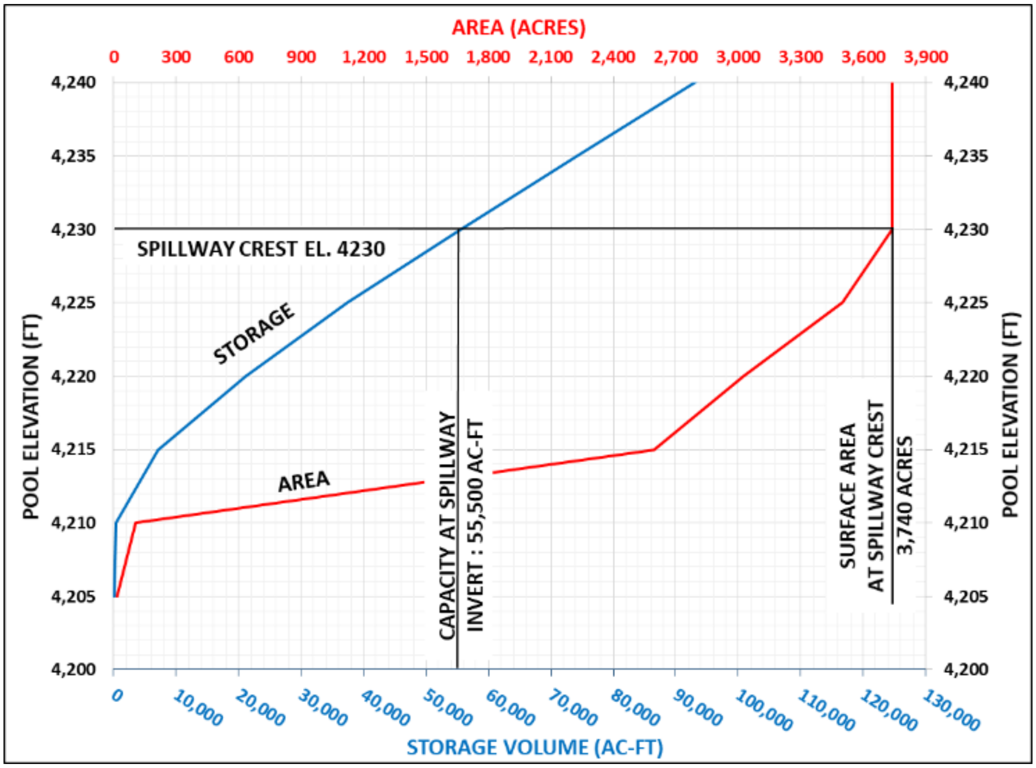


Figure 7-13: South Willard Stage Storage Curves

- Dam:
  - Crest Elevation = 4,240 feet MSL
  - Hydraulic Height = 35 feet
  - Spillway Crest Elevation = 4,230 feet MSL
  - Low Level Outlet (Pump Station Intake) Invert = 4,214 feet MSL

7.6.3 Dam Type

The site is located on soft, flat lakebed soils. HDR performed an analysis to determine the type of dam best suited for this location. It was determined that an earthfill embankment dam structure would best fit this site.

A more detailed summary of the dam type evaluation and site configuration are located in HDR's Report: *Conceptual Engineering Analyses for Potential Dam Sites* (See Appendix).

GCI performed an initial geologic and geotechnical assessment of the site entitled *South Willard Geotechnical Data Report* (See Appendix). Two test holes were drilled along the south embankment. The site is located on a layered system of soft lakebed clays and silts with a high groundwater table.

The geotechnical investigations at this site indicate that seismic stability and settlement would be key determining issues for design. The design of the embankment would need to offset the stability issues by having large stability berms on either side of the embankment. Potential settlement could be addressed by allowing for 10 feet of freeboard.

This site does not have significant fatal flaws and is generally suitable for this dam type with appropriate mitigation measures. It is recommended that additional studies be conducted to provide estimates on anticipated settlement and to determine settlement mitigation during construction. Key design parameters of the embankment layout and configuration are as follows and as shown in the conceptual drawings SW-1 thru SW-3 in Volume II:

- Fill (total 15.2 million cubic yards):
  - Earthfill Embankment
  - Chimney and Blanket Filters/Drains
  - Riprap Rock Armor Inside (Upstream)
- Dimensions:
  - Inside Slopes = 4:1 (H:V)
  - Outside Slopes = 4:1
  - Stability Berms width = 100 feet
  - Crest Width = 20 feet
  - Embankment Crest Length = 10 miles (53,100 feet)

7.6.4 Reservoir Hydrology

There is not a contributing drainage basin for this site other than the direct rainfall. The reservoir would be filled through the Bear River Pipeline, which has an estimated capacity of 300 cfs at this site. The reservoir outlet works would be designed to be adequate to control a storm event or to drain the reservoir in an emergency. A spillway with a capacity of 350 cfs would be located over the west embankment.

7.6.5 Site Challenges and Benefits

Initially identified challenges of this site are:

- Low soil strengths, seismic deformation potential, settlement, and overall seismic performance.
- Overall community impacts of the reservoir footprint.
- Wetland impacts near the Great Salt Lake and Bear River Migratory Bird Refuge.

Initially identified benefits of this site are:

- Off-stream storage with operational benefits near the end of the pipeline.
- Borrow materials may be available from the reservoir basin.

7.6.6 Dam Facilities and Layout

Figure 7-14 (Volume II) shows the key facilities the site. Drawings SW-1 thru SW-3 (Volume II) include conceptual site plans and sections. The dam would include the following general infrastructure and facilities:

- **Earthfill Embankment Dam.** See Section 7.6.3.

- **Emergency Spillway Structure.** Concrete weir structure over west embankment with the following features:
  - Capacity = 350 cfs
  - Width = 20 feet
  - Sill elevation = 4,230 feet MSL
  - Walled concrete drop chute
  - Concrete energy dissipation basin

- **Pump Station Inlet Channel.** Large channel excavated in the southeast corner of the reservoir footprint would connect the deeper portions of the reservoir to the pump station intake.

- **Pump Station Inlet Bay.** An embankment-lined bay would convey water to the pump station intake.

- **Instrumentation.** Instrumentation includes valve operators/sensors, guard gate opening operators/sensors, flow meter, reservoir level sensors, piezometers, drain pipe flow measurement, SCADA system, and other monitoring and communication devices.

Appurtenant Facilities. To make this site operable in the overall system, water would need to be delivered to and from this site. The following additional facilities would be needed for operation:

- **Inlet and Outlet Pipelines.** The Bear River Pipeline would need to be routed to the site. The pipeline would be configured so that flows could bypass the reservoir.

- **Reservoir Inlet Structure.** A flow control valve would discharge into an energy dissipation structure.
- **Pig Retrieval Vault.** A pig receiving vault with a full port isolation valve would be located just upstream of the inlet structure. This facility would include a pig wastewater bypass valve, pipeline, and waste holding pond.

- **South Willard Pump Station (Reservoir Outlet).** The pump station would have an intake invert set at about 4,214 feet MSL. The pump station piping would extend from the inlet bay into the pump station inlet. From there, water would be pumped into the Bear River Pipeline.

7.7 ABOVE CUTLER DAM AND RESERVOIR

7.7.1 Location and Site Conditions

The potential Above Cutler Reservoir site is located in the Bear River Valley of Cache County just upstream of the existing Cutler Reservoir. The reservoir footprint would begin above the existing Cutler Reservoir, proceed upstream past Highway 218 (100 North in Smithfield), and end near Cornish. The reservoir footprint would inundate the Bear River floodplain and a small portion of the Cub River Valley. The footprint would be located entirely on privately-owned land. The Bear River floodplain elevation at the site is about 4,420 feet MSL. The elevation of the surrounding valley is between 4,440 and 4,450 feet MSL.

The site is comprised mostly of heavily vegetated river floodplain, with a few farm fields and structures and a few local roads. The reservoir footprint would be entirely within the floodplain channel. Drawing AC-1 (Volume II) shows the conceptual site plan for the dam and reservoir.

7.7.2 Site Configuration

The reservoir would be very long and shallow, stretching nearly 19 miles to the north. The placement of a dam at this site would require embankment berms to maintain the freeboard elevation. The key design parameters of this dam/reservoir are as follows:

- Maximum Reservoir Pool:
  - Elevation = 4,432 feet MSL
  - Storage = 51,240 acre-feet
  - Surface Area = 5,240 acres
- Stage/Storage Curve

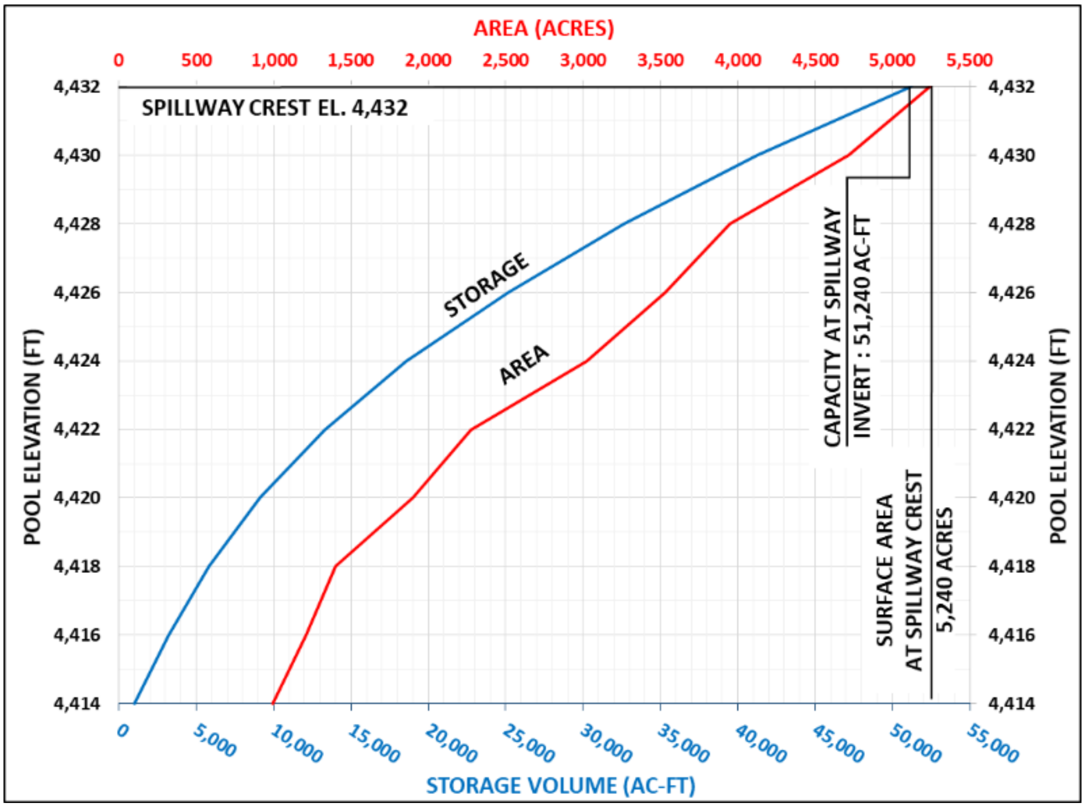


Figure 7-15: Above Cutler Stage Storage/Area Curves

- Dam:
  - Crest Elevation = 4,442 feet MSL
  - Hydraulic Height = 30 feet
  - Spillway Crest Elevation = 4,442 feet MSL
  - Low Level Outlet Intake Invert Elevation = 4,412 feet MSL
  - Downstream Toe Elevation = 4,412 feet MSL

7.7.3 Dam Type

GCI only drilled one test hole at this site due to land ownership issues. To determine a dam type, assumptions were made about soil type from knowledge of the area's soft soils that have the potential for settlement and stability challenges. The site was found to be best suited for an earthfill embankment dam. Initial evaluation of the site indicates that there would be concerns for placement of a large earthfill structure. A more detailed summary of the dam type evaluation, site configuration, and recommended dam layout are located in HDR's Report, *Conceptual Engineering Analyses for Potential Dam Sites* (See Appendix).

The HDR report provided a conceptual outline of the basic earthfill dam dimensions and configuration of the embankment zones. Since seismic stability was of major concern, the embankment slopes were flattened, and wide stability berms were added to stabilize the structure.

Key design parameters of the dam layout and configuration are as follows and as shown in the conceptual drawings AC-1 thru AC-3, Volume II:

- Fill (total 1.1 million cubic yards):
    - Earthfill Embankment Shell
    - Clay Core with Cutoff Trench
    - Downstream Chimney and Blanket Filters/Drains
    - Riprap Rock Armor Upstream
- Dimensions:
    - Upstream Slopes = 4:1 (H:V)
    - Downstream Slopes = 4:1
    - Stability Berms Width = 200 feet
    - Cutoff Trench Depth = 13 feet
    - Crest Width = 20 feet
    - Main Dam Crest Length = 1,945 feet
    - Extended Embankment Berms = 3.3 miles (17,345 feet)

7.7.4 Reservoir Hydrology

The drainage area of the Bear River at the site is about 5,260 square miles, which is a significant portion of the Bear River watershed area. For the purposes of this study, the hydrologic criteria were assumed to be similar to the Fielding site as follows:

- PMF = 197,000 cfs
- Spillway Design Flood = 100,000 cfs (50% of PMF)

A similar approach was used for the Above Cutler site hydrology as was used for the Fielding site, assuming that a reduced PMF flow could be utilized for the spillway sizing (see Section 7.3.4).

7.7.5 Site Challenges and Benefits

Initially identified challenges of this dam/reservoir site are:

- Challenges of low soil strengths, seismic deformation potential, settlement, and overall seismic performance of the dam structure.
- Large size of the emergency spillway compared to the dam.
- Community impacts of the reservoir footprint.

Initially identified benefits of this site are:

- On-stream storage on the Bear River.
- Provides reservoir storage in Cache County that benefits the overall system operation.
- The majority of earth borrow materials may all be available from the reservoir basin after

7.7.6 Dam Facilities and Layout

The site is located generally near smaller communities with adequate transportation for facility access. Drawings AC-1 thru AC-3 (Volume II) show conceptual plans and sections. This dam would include the following general infrastructure and facilities:

- **Earthfill Embankment Dam with Clay Core.** See Section 7.7.3**.**
- **Emergency Spillway Structure.** Open earthen channel intake, with gated weir structure over left abutment with the following features:
    - Capacity: 100,000 cfs
    - Gated structure: six 30 x 30-foot radial gates
    - Width = 225 feet
    - Channel invert elevation = 4,412 feet MSL
    - Top of gate elevation = 4,442 feet MSL
    - Walled concrete drop chute
    - Concrete energy dissipation basin
- **Dual Outlet Guard Gate Structure.** This is located in the spillway on the left abutment, with hydraulically actuated slide gate mounted on the concrete spillway headwall structure. Intake structure has a pipe invert elevation of 4,412 feet MSL (same invert elevation as the spillway).
- **Outlet Pipe.** 10-foot diameter pipe encased in concrete and buried in the left abutment adjacent to the spillway structure. The outlet guard gate would be part of the spillway structure.
- **Regulating Valve.** Used to regulate flows out of the reservoir and discharges into the spillway plunge pool.
- **Highway 218 Embankment and Bridge over Reservoir.** The dam and reservoir footprint would inundate Highway 218. A bridge would need to be constructed to replace the highway.
- **Dam Instrumentation.** Instrumentation includes valve operators/sensors, guard gate opening operators/sensors, flume readings, reservoir level sensors, piezometers, drain pipe flow measurement, SCADA system, and other monitoring and communication devices.

- **Power Utility.** Only a small amount of power would be required to operate the dam facilities. It was assumed that the local power supply/distribution would provide the power needs of this site.

7.8 CUB RIVER DAM AND RESERVOIR

7.8.1 Location and Site Conditions

The potential Cub River Reservoir site is located on a tributary to the Bear River in Cache County, just upstream of the Above Cutler Reservoir site and west of the community of Richmond. The reservoir footprint starts from just above the confluence of the Cub River with the Bear River, upstream past Highway 142 (Main Street in Richmond), and proceeds up to the Idaho border. The reservoir footprint generally occupies the Cub River floodplain that ranges in elevation from 4,430 feet to 4,470 feet MSL and exists entirely on private lands. The elevation of the upper valley surrounding the floodplain ranges between 4,470 and 4,500 feet MSL. Drawing C-1 (Volume II) shows the conceptual site plan and sections for the dam and reservoir.

The reservoir basin is mostly comprised of heavily vegetated river floodplain, with occasional farm fields and structures, and a few local roads. The reservoir footprint would be contained within the Cub River floodplain channel. The site is surrounded mostly by agricultural development, with occasional home and farm structures, smaller farm roads, a few dairy farms, sewage lagoons, and a notable exception of a large factory.

7.8.2 Site Configuration

The reservoir would be long and shallow, stretching nearly 7 miles to the north. The placement of a dam at this site in the Cub River floodplain would require extended embankment berms to maintain reservoir freeboard. The key design parameters of this dam/reservoir are as follows:

- Maximum Reservoir Pool:
  - Elevation = 4,465 feet MSL
  - Storage = 27,640 acre-feet
  - Surface Area = 1,510 acres
- Stage/Storage Curve

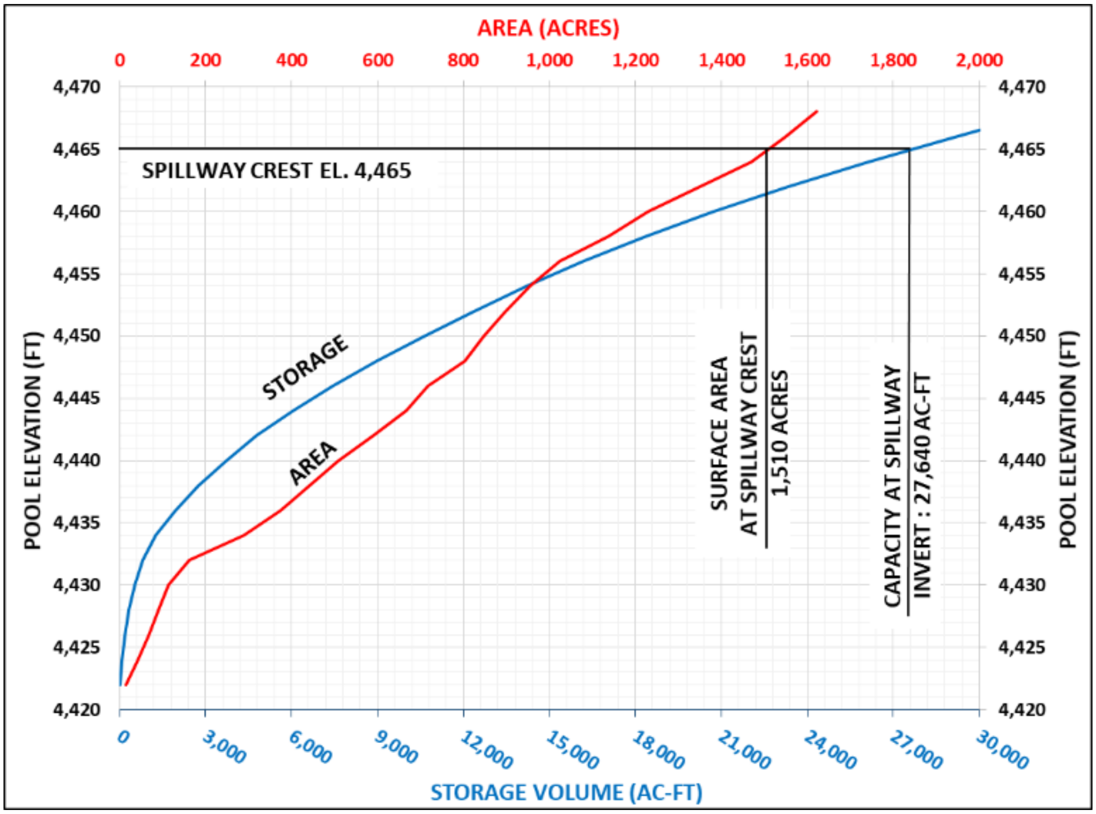


Figure 7-16: Cub River Stage Storage Curves

- Dam:
  - Crest Elevation = 4,475 feet MSL
  - Hydraulic Height = 53 feet
  - Spillway Crest Elevation = 4,465 feet MSL
  - Low Level Outlet Intake Invert = 4,425 feet MSL
  - Downstream Toe Elevation = 4,422 feet MSL

7.8.3 Dam Type

The geologic conditions of the site are mostly a layered mixture of fine Lake Bonneville sediments and alluvial deposits and soft clays interbedded with sands and silts. GCI drilled three test holes along the approximate centerline of the potential dam. The results are provided in a geotechnical report entitled *Cub River Geotechnical Data Report* (See Appendix).

Based on the area's soft soils and potential for settlement, the site was found to be best suited for a widened earthfill embankment dam. Initial evaluations of the site do not indicate any geologic or geotechnical fatal flaws for the placement of a large dam structure. The analysis indicates that this site is significantly better suited for a large dam structure than the Above Cutler Dam site. The initial geotechnical evaluations indicate that this site would have the challenge of low soil strengths, seismic deformation potential, settlement, and overall seismic performance of the dam structure. A more detailed summary of the dam type evaluation, site configuration, and recommended dam layout are outlines in HDR's Report, *Conceptual Engineering Analyses for Potential Dam Sites* (See Appendix).

The HDR report provided a conceptual outline of the basic earthfill dam dimensions and configuration of the embankment zones. Since seismic stability was of major concern, the embankment slopes were flattened slightly to better stabilize the structure.

Key design parameters of the dam layout and configuration are as follows and as shown in the conceptual drawings C-1 thru C-3, Volume II:

- Fill (total 811,000 cubic yards):
  - Earthfill Embankment Shell
  - Clay Core with Cutoff Trench
  - Downstream Chimney and Blanket Filters/Drains
  - Riprap Rock Armor Upstream

- Dimensions:
  - Low Upstream Slopes = 4:1 (H:V)
  - High Upstream Slopes = 3:1 (H:V)
  - Low Downstream Slopes = 4:1
  - High Downstream Slopes = 2.5:1
  - Cutoff Trench Depth = 20 feet
  - Crest Width = 30 feet
  - Main Dam Crest Length = 1,795 feet
  - North Saddle Dam Crest Length = 1,465 feet
  - Extended Embankment Berms = 3,625 feet

7.8.4 Reservoir Hydrology

The drainage area of the Cub River for this site is about 226 square miles, with the upper watershed elevations reaching almost 10,000 feet MSL. Initial investigations into the PMP for this watershed, which generates a PMF into the reservoir, yielded the following results:

- PMP = 72-hour storm generates 12.3 inches rainfall

- PMF = 38,000 cfs, generating about 120,000 acre-feet total inflow to the reservoir

The reservoir flood volume and spillway would need to be sized to route the PMF safely past the dam without overtopping it. For this dam, 10 feet of freeboard was included to partially attenuate the PMF inflow, requiring that 36,000 cfs be passed over the spillway structure.

7.8.5 Site Challenges and Benefits

Initially identified challenges of this site are:

- Low soil strengths, seismic deformation potential, settlement, and overall seismic performance of the dam structure would need to be addressed

- Small amount of storage compared to overall system needs.

- Community impacts of the reservoir footprint.
- A small amount of the reservoir footprint would located within Idaho when the reservoir reaches maximum pool or higher.
- Average annual yield of the Cub River may not be able to fill the reservoir in some years.

Initially identified benefits of this site are:

- Provides a storage location in Cache County that benefits overall system operation.
- The majority of earth borrow materials may be available from the reservoir basin.

7.8.6 Dam Facilities and Layout

The Cub River Dam and Reservoir site is located generally near smaller developed communities with adequate transportation for dam access and utility infrastructure for dam facilities. Drawings C-1 thru C-3 (Volume II) shows conceptual site plans and sections of this site. This site would include the following general infrastructure and facilities:

- **Earthfill Embankment Dam with Clay Core.** See Section 7.8.3.
- **Emergency Spillway Structure.** Open earthen channel intake, with concrete weir structure over right abutment with the following features:
  - Capacity = 36,000 cfs
  - Gated structure: two 30 x 35-foot radial gates
  - Width = 85 feet
  - Channel invert elevation = 4,440 feet MSL
  - Top of gate elevation = 4,465 feet MSL
  - Walled concrete drop chute downstream of gates
  - Concrete energy dissipation basin
- **Dual Outlet Guard Gate Structure.** Located in the reservoir area near the right abutment, with hydraulically actuated slide gates mounted on a concrete intake structure. Intake structure has a bar rack intake with invert elevation of 4,425 feet MSL. Two 6 feet x 6 feet sized gate openings would be needed.
- **Dual Outlet Pipes.** The outlet pipes are 6-feet diameter, encased in concrete and buried in the right abutment adjacent to the spillway.
- **Regulating Valves.** Used to regulate flows out of the reservoir and include a discharge channel. The flow rate would be measured with a downstream flow measurement flume structure.
- **Highway 142 Embankment and Bridge over Reservoir.** The dam and subsequent reservoir footprint would inundate Highway 142. This would require a constructed highway embankment with a bridge over the deeper section of the reservoir.
- **Access Road.** Due to the location of the site, an access road would need to be constructed on either side of the dam with access from Highway 142.

- **Instrumentation.** Instrumentation includes valve operators/sensors, guard gate opening operators/sensors, flume readings, reservoir level sensors, piezometers, drain pipe flow measurement, SCADA system, and other monitoring and communication devices.
- **Power Utility.** Only a small amount of power would be needed to operate the dam facilities. It was assumed that the local power supply/distribution would provide the power needs at this site.

The potential operations of the different facilities are discussed in Chapter 8 and 9. The recommended project operational narratives, conceptual site schematics, and conceptual site layouts of each facility for each site are discussed in Chapter 11.

7.9 WASHAKIE DAM AND RESERVOIR

In 2010, DWRe completed an updated preliminary design for the Washakie off-stream storage site (CH2M Hill, 2010, *Washakie Reservoir Project Preliminary Engineering and Design Report*). The report focused on the geologic and geotechnical setting of the potential reservoir site, and included a description of the major facilities (including the dam and reservoir, Malad River bypass channel, and inflow and outflow piping and pump stations), as well as the hydrology, water quality, and environmental considerations associated with the site. The hydrologic and water quality review assumed the use of Willard Bay as a second storage site. The report includes a conceptual cost estimate for the 160,000 acre-foot capacity reservoir, Malad River bypass facilities, and conveyance facilities ranging from $876M to $1,022M. Because of the high cost and environmental impacts of having to reroute the Malad River, and other challenges at the site, this current study was undertaken to explore other reservoir options.

7.10 WEBER BAY SITE

In the 1990's, informal discussions between DWRe and the management at the Bear River Migratory Bird Refuge (BRMBR) included the possibility of building storage within the BRMBR boundaries as part of the Bear River Development. The storage would have allowed the BRMBR to have needed storage for their water rights and to manage the flows within the BRMBR. When this current study began, the potential for a storage site (Weber Bay) within the BRMBR was included. DWRe and the BRMBR have had additional discussions about this idea. The BRMBR indicated that they would not support the idea of locating a reservoir within their boundaries.

CHAPTER 8

WATER SUPPLY ANALYSIS

8.0 WATER SUPPLY ANALYSIS

8.1 BEAR RIVER WATERSHED

The Bear River Basin covers approximately 7,500 square miles including approximately 3,300 square miles in northern Utah, 2,700 square miles in Idaho, and 1,500 square miles in southwestern Wyoming. Figure 3-1 shows a map of the Bear River Basin.

The Bear River Basin is in the northeastern portion of the Great Basin. The Great Basin is enclosed entirely by mountains, thus forming a huge bowl with no external drainage outlet. The Bear River is the largest river in the western hemisphere that does not reach the ocean. The headwaters of the Bear River are in Summit County, Utah on the north slope of the Uinta Mountains. It follows a 500-mile circuitous route, crossing the Utah-Wyoming state line three times before flowing into Idaho. It then turns south into Utah and ultimately flows into Great Salt Lake, less than 100 miles from its headwaters.

A main storage feature of the watershed is Bear Lake. Bear Lake is near the mid-point of the river's course from the Uinta Mountains to Great Salt Lake. A few miles after entering Idaho, the Bear River flows westward into the Bear Lake Valley. Bear Lake, at the south end of this valley, is about twenty miles long and seven miles wide. Historically, the river did not naturally flow into the lake. In the early 1900s, Telluride Power (predecessor to Rocky Mountain Power) began constructing inlet and outlet canals in an effort to divert the Bear River into Bear Lake for later release for agricultural irrigation. Telluride Power constructed a pumping plant at the north end of Bear Lake to pump water from the lake into the outlet canal. These improvements, and later modifications, have created an active storage capacity of about 1,452,000 acre-feet in Bear Lake and the ability to regulate the flow of Bear River.

8.2 WATER SUPPLY ANALYSIS

During the current BRD analysis, additional studies were completed regarding the reliability of the water supply. These studies were needed in order to clarify facility sizing requirements and cost estimates. Updated hydrologic modeling studies were completed using a 30-year period of record that included the two worst droughts of the last 60 years. The modeling also included updated assumptions about instream flows assumptions and reservoir storage capacities. Additionally, the modeling included climate change-influenced hydrologic datasets that were developed to represent potential future conditions.

The BearSim model was used to simulate combinations of potential BRD System facilities including reservoirs, pipelines, and pumping stations. In total, about four dozen combinations were evaluated to find the most feasible set of facilities to reliably meet water supply objectives with the lowest expected cost and environmental impacts.

Among the many important pieces of information provided by these simulations is that the BRD System will need more than 400,000 acre-feet of storage to deliver a reliable supply of 220,000 acre-feet annually. Even with this storage capacity, supply shortages of 10 percent or more occur in about half of the years simulated. The modeling indicates that in order to deliver a reliable supply of 220,000 acre-feet annually, with supply shortages that do not exceed 10 percent (90 percent reliability goal), about 600,000 acre-feet of reservoir storage would be needed. The updated modeling results of 600,000 acre-feet is more than twice what was estimated in Bear River planning studies from 10 years ago. The primary reason for this change is the updated flow data that includes a four-year drought period (2001-2004).

8.2.1 Effects of Hydrologic Variability on Water Supply

The hydrologic variability affects the planning of the BRD as capacities, operations, and potential diversion locations may need to change as hydrologic conditions change. To evaluate the reliability of potential combinations of reservoir sites, an analysis using the BearSim model was conducted to simulate thirteen refined scenarios. The thirteen scenarios of reservoir combinations are shown in Table 6-1 in Chapter 6.

Until a full environmental review is completed and permitting activities advance, additional uncertainties will exist concerning instream flows for aquatic habitat, fisheries purposes at the site of potential reservoirs, and diversions to water users. In addition, future enlarged or modified diversions by higher priority Bear River water users, including Idaho, could affect the water supply availability. In the interim, the assumptions documented in Table 8-1 were included in the analysis. The minimum bypass and minimum instream flow releases shown in Table 8-1 were assumed specifically for this analysis. A more in-depth analysis will be needed. For the purposes of the modeling, the "Minimum Bypass" indicates that water would not be diverted unless the instream flow is higher. The "Minimum Instream Flow" is the amount of water released from reservoir storage whenever the reservoir is not empty.

Table 8-1
Diversion Assumptions by Location

Diversion Location	Maximum Diversion Rate (cfs)	Minimum Bypass of Inflow (cfs)	Minimum Instream Flow Release (cfs)
Logan River at Diversion to Temple Fork Reservoir	100	50	Not applicable since minimum flow is left in Logan River
Temple Fork Creek at Temple Fork Reservoir	Unlimited	5	5
Logan River at Diversion to CWD	160	0	0
Cub River at Cub River Reservoir	Unlimited	10	0
Bear River at Diversion to CWD	160	0	0
Bear River at Above Cutler Reservoir	Unlimited	100	0
Bear River at Fielding Reservoir	Unlimited	100	0
Bear River at Diversion	850	100	0

In addition to the operating assumptions in Table 8-1, in order to preserve reservoir storage during extreme drought years, the BearSim Model was run to reduce deliveries by 10 percent every year when reservoir storage was not filled to a minimum of 80 percent of capacity.

Future hydrologic modeling should include additional water supply assumptions and options. As mentioned earlier, refined shortage criteria, combined with long-term forecasting of available supply, should be evaluated. During drought years, water supply exchanges with higher priority Bear River water right holders could improve the BRD water supply reliability and reduce the reservoir storage requirement. Water efficiency projects to reduce conveyance losses by existing agricultural water users should also be evaluated.

8.2.2 Modeling Results with Historic Hydrology

The thirteen scenarios summarized in Table 6-1 were evaluated using results from the BearSim model. The results are shown in Table 8-2. The average annual delivery volume and maximum annual supply shortage were compared to the demand of 220,000 acre-feet. Under normal and wet year conditions, all the scenarios could meet the water supply requirements with no more than a 10 percent supply shortage. However, during the worst drought year conditions, Scenarios A through H are only able to deliver about 138,000 acre-feet of supply, which represents a shortage of about 37 percent. Only Scenarios J through M, each with more than 600,000 acre-feet of storage, can meet the water supply reliability goal. Scenario I, with the least storage volume, is only able to deliver about 100,000 acre-feet (approximately 54 percent shortage) during the worst drought year.

Table 8-2
Historic Hydrology-Bear River Development Modeling Results

Scenario	Total Storage (acre-feet)	Average Annual Delivery (acre-feet)	Maximum Annual Supply Shortage (acre-feet)	Maximum Supply Shortage (percent)
A	400,000	202,000	82,715	38%
B	400,000	201,800	82,715	38%
C	400,000	200,700	81,752	37%
D	414,000	197,700	81,515	37%
E	400,000	201,300	82,682	38%
F	400,000	201,700	82,715	38%
G	400,000	201,900	82,665	38%
H	400,000	200,300	81,513	37%
I	244,000	187,900	119,830	54%
J	610,000	217,800	22,000	10%

Scenario	Total Storage (acre-feet)	Average Annual Delivery (acre-feet)	Maximum Annual Supply Shortage (acre-feet)	Maximum Supply Shortage (percent)
K	610,000	217,800	22,000	10%
L	608,000	217,800	22,000	10%
M	622,000	217,800	22,000	10%

Figure 8-2 shows an example of the potential effect of prolonged drought periods on reservoir storage for Scenario B. During similar drought conditions as 2001 through 2004, both Fielding and Whites Valley would progressively empty until a reliable supply could no longer be delivered.

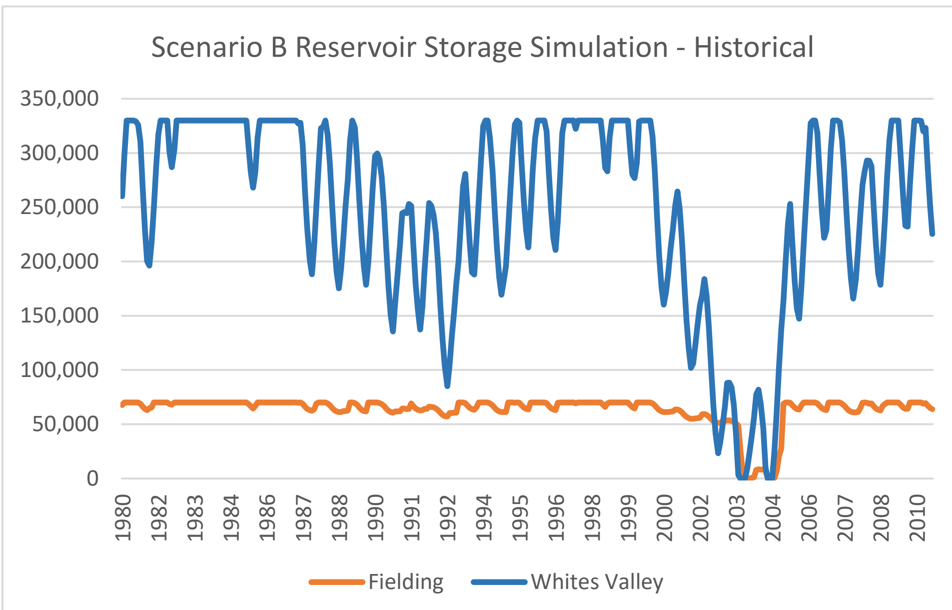


Figure 8-2: Simulated Reservoir Storage – Scenario B

8.2.3 Modeling Approach to Incorporate Potential Climate Change Hydrology

Many hydro/meteorological studies have shown that worldwide climatic conditions are changing, and that future conditions will be warmer than in the recent past. A large number of climate and hydrology projections have been developed under the Coupled Model Intercomparison Project Phase 5 (CMIP5) (http://gdo-dcp.ucllnl.org/). These projections show that future meteorological conditions in the Bear River watershed will be significantly warmer, and generally somewhat wetter, than historic conditions. Figure 8-3 summarizes results from each of the 97 global climate models (GCMs) included in the CMIP5. Each of the dots represents the average results of each of the 97 models. All the models predict a temperature increase (between 1.6- and 10-degrees Fahrenheit), and 79 of the models predict an increase in precipitation (between 0.01 and 0.89 inches per month). The CMIP5 datasets also include estimates of the effect of climate change on runoff, simulated using the Variable Infiltration Capacity (VIC) model. The simulated runoff results indicate that 47 percent of the models show a decrease in average runoff, with the range of results from the 97 models varying between -0.35 to +0.59 inches per month. For comparison purposes, the average historical runoff for this area of the watershed is roughly 20 inches per year, or 1.7 inches per month.

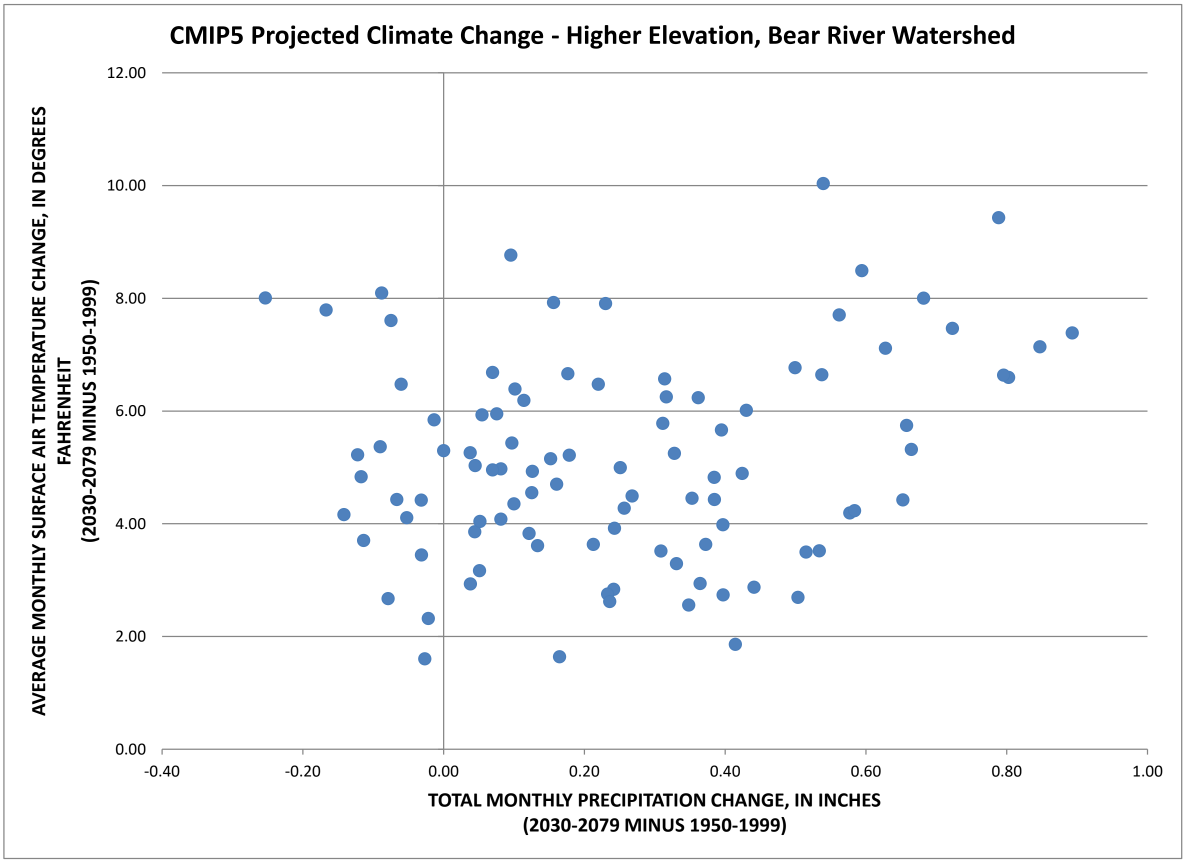


Figure 8-3: CMIP5 Results for Total Monthly Precipitation and Average Monthly Temperature Change in the Upper Bear River Watershed

Applying these projected climate change results to estimate the Bear River flows that may occur in the future is challenging. The CMIP5 datasets represent projected changes to natural, unmodified runoff. The flows that will be available to divert are significantly modified by upstream water use, including diversion and release from reservoir storage (particularly Bear Lake), and diversion, depletion, and return flows from agricultural water use. To convert the CMIP5 modeling results into available flows at the potential diversion locations would require a detailed hydrology study. This should include the development of calibrated hydrology models of runoff from each upstream watershed and a detailed system operations model of all significant upstream water uses.

One study of the potential effects of climate change on northern Utah hydrology was determined to be relevant to this study; Wood and Bardsley, 2015, *VIC Model Calibration and Future Hydroclimate Analysis in Selected Utah Watersheds*. Wood and Bardsley (2015) used CMIP5 data to estimate the effects of climate change on streamflow at eight long-term stream gages, including one within the Bear River watershed (Combined Flow Logan River). The study indicated that flows in the Logan River would be between three percent lower and 17 percent higher. As described below, the potential effects of future climate change were evaluated on potential BRD System operations at a preliminary level by using some of the detailed findings from that study.

Wood and Bardsley (2015) developed simulated Logan River flows for three future periods (2010-2039, 2040-2069, and 2070-2099). Three scenarios were selected from each of these simulations, representing the 90 percent driest, 50th percentile, and 10 percent wettest of the projected Global Climate Model (GCM) results for each of the three future periods. This resulted in nine potential scenarios. These three scenarios are individual models that fall closest to the 90 percent driest, 50 percent, and 10 percent wettest levels. It is not suggested that any of these to be more probable than another, but they are included to show a range of possible future flows. The average change in runoff from the historical to the future period for each of these nine scenarios was calculated. The daily inflow datasets from the BearSim model were adjusted by these average changes. BearSim flows were also adjusted to account for the average change in timing of the runoff hydrograph between the historical and the projected future periods. BearSim runoff flows were shifted earlier by up to 30 days to incorporate the GCM-predicted changes in earlier runoff. Small differences in minimum flows between November and February were observed in the climate change results were applied by reducing BearSim flows in those periods by 5 to 10 percent. Table 8-3 summarizes the resulting changes in BearSim flows and the potential effects of climate change on the timing of Bear River flow into Cutler Reservoir. Figure 8-4 shows these results graphically.

Table 8-3
Effects of Climate Scenarios on Average Monthly Inflow to Cutler Reservoir

Climate Scenario	Average Annual Flow (acre-feet)	% Change from Historical	Maximum Annual Flow (acre-feet)	Minimum Annual Flow (acre-feet)	2001-2004 Average Annual Flow (acre-feet)
Historical: 1981-2010	**1,196,300**	**-**	**3,281,200**	**426,500**	**455,000**
2010-2039					
90% Driest	1,171,000	-2.1%	3,197,300	417,000	444,600
50%	1,311,600	9.6%	3,580,900	461,500	495,900
10% Wettest	1,424,200	19.0%	3,866,400	502,900	540,900
2040-2069					
90% Driest	1,179,700	-1.4%	3,220,700	421,500	448,200
50%	1,291,100	7.9%	3,519,300	454,700	488,900
10% Wettest	1,482,000	23.9%	4,021,700	526,500	564,800
2070-2099					
90% Driest	1,174,300	-1.8%	3,206,100	417,700	445,800
50%	1,379,182	15.3%	3,743,600	488,300	524,600
10% Wettest	1,572,981	31.5%	4,278,200	559,700	597,100

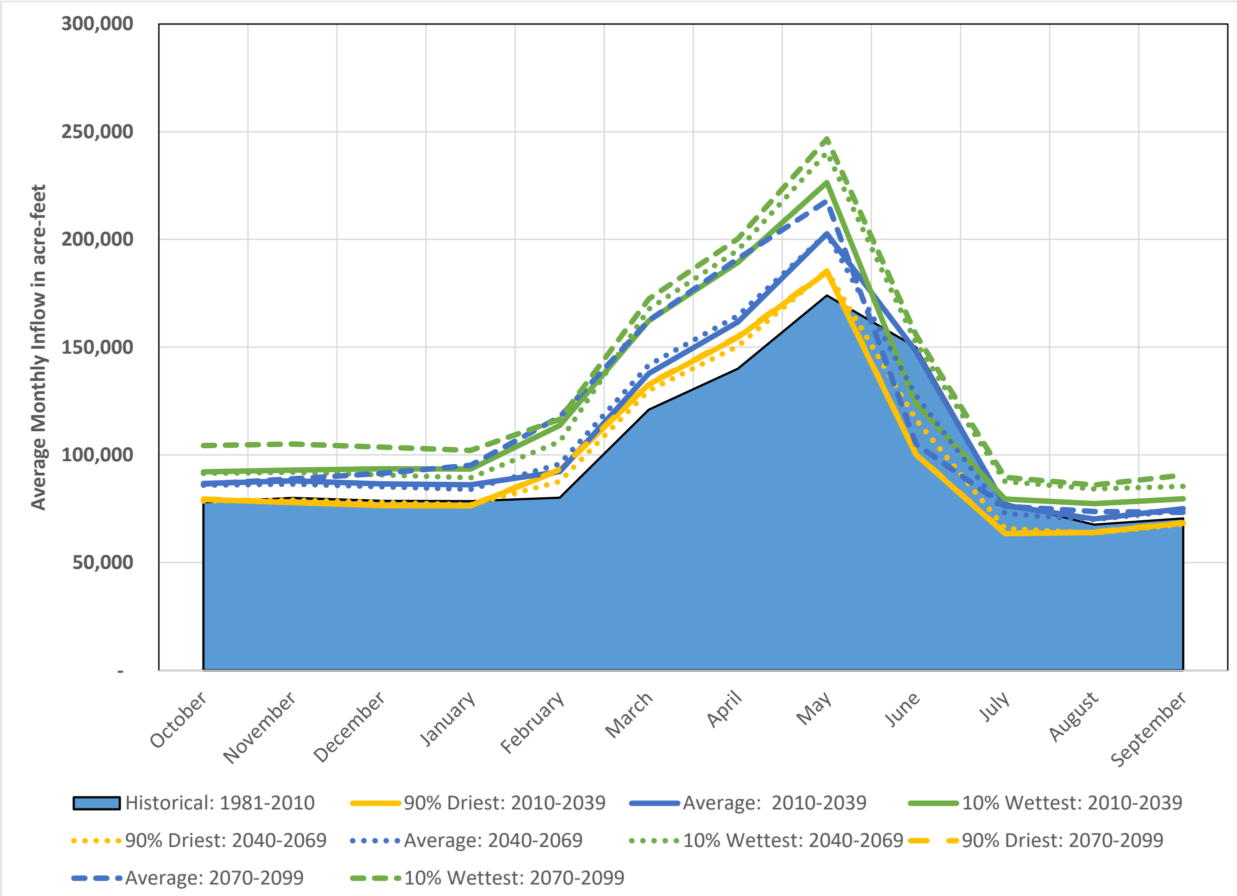


Figure 8-4: Effect of Climate Scenarios on Average Monthly Inflow to Cutler Reservoir

8.2.4 Modeling Results Incorporating Potential Climate Change Hydrology

The BearSim model was run using the nine scenarios of potential future Bear River flows. The storage characteristics of each of the 13 reservoir combination scenarios (A through M) were then simulated, resulting in more than 100 sets of results. Tables 8-4, 8-5, and 8-6 summarize the results of the three time-periods. Figure 8-5 displays the effects of climate change on average deliveries versus storage capacity results. Figure 8-6 displays the effects of climate change on maximum shortage versus storage capacity.

Figure 8-7 displays the effects of climate change on reservoir performance for Scenario B for these three scenarios. During water years 2001 through 2004, both the Fielding and Whites Valley sites progressively empty, but are still able to meet BRD System supply needs with only minor (10 percent) supply shortages.

The hydrologic modeling results, adjusted for the simulated effects of climate change, indicate that water supply could be more secure in the future based on the 50th percentile model result over historic hydrology. This is consistent with the general CMIP5 results, which show somewhat wetter conditions for the Bear River watershed. Average annual deliveries increase by as much as

15,000 acre-feet. Maximum annual water supply shortages decrease by as much as 60,000 acre-feet. Inversely, based upon historical hydrology, the BRD System would need as much as 610,000 acre-feet of storage to provide delivery shortage of no more than 10 percent.

Using the 50th percentile results, the reliability goal could be met with 400,000 acre-feet of storage. When modeling potential climate change conditions, there is a lot of uncertainty. As stated before, to understand the potential implications of climate change, a more detailed modeling analysis will need to be completed.

Table 8-4
Bear River Development Modeling Results
Time-Period Simulated: 2010 – 2039

		10% Wettest		50% Percentile		90% Driest	
Scenario	Total Storage (acre-feet)	Average Annual Delivery (acre-feet)	Maximum Annual Supply Shortage (acre-feet)	Average Annual Delivery (acre-feet)	Maximum Annual Supply Shortage (acre-feet)	Average Annual Delivery (acre-feet)	Maximum Annual Supply Shortage (acre-feet)
A	400,000	203,500	33,600	203,500	31,500	201,000	76,900
B	400,000	204,600	22,000	204,600	22,000	202,600	70,200
C	400,000	203,900	22,000	203,900	22,000	201,600	79,500
D	414,000	204,600	22,000	203,900	22,000	202,100	64,100
E	400,000	203,900	22,000	203,900	22,000	201,700	75,500
F	400,000	204,600	22,000	204,600	22,000	203,600	41,400
G	400,000	204,600	22,000	204,600	22,000	202,300	78,500
H	400,000	203,900	22,000	202,900	42,000	199,900	78,600
I	244,000	193,900	70,600	192,600	93,600	189,100	111,100
J	610,000	220,000	-	219,300	22,000	217,800	22,000
K	610,000	220,000	-	219,300	22,000	217,800	22,000
L	608,000	220,000	-	219,300	22,000	217,800	22,000
M	622,000	220,000	-	219,300	22,000	217,800	22,000

Table 8-5
Bear River Development Modeling Results
Time-Period Simulated: 2040 – 2069

		10% Wettest		50% Percentile		90% Driest	
Scenario	Total Storage (acre-feet)	Average Annual Delivery (acre-feet)	Maximum Annual Supply Shortage (acre-feet)	Average Annual Delivery (acre-feet)	Maximum Annual Supply Shortage (acre-feet)	Average Annual Delivery (acre-feet)	Maximum Annual Supply Shortage (acre-feet)
A	400,000	203,800	31,600	203,300	33,300	200,300	79,800
B	400,000	204,600	22,000	204,600	22,000	201,800	74,200
C	400,000	203,900	22,000	203,900	22,000	201,500	81,100
D	414,000	204,600	22,000	203,900	22,000	199,800	65,800
E	400,000	203,900	22,000	203,900	22,000	201,700	77,900
F	400,000	204,600	22,000	204,600	22,000	202,800	43,500
G	400,000	204,600	22,000	204,600	22,000	201,500	80,200
H	400,000	203,900	22,000	202,700	49,300	199,800	80,200
I	244,000	194,700	69,500	192,100	96,500	189,300	111,800
J	610,000	220,000	-	219,300	22,000	217,800	22,000
K	610,000	220,000	-	219,300	22,000	217,800	22,000
L	608,000	220,000	-	219,300	22,000	217,800	22,000
M	622,000	220,000	-	219,300	22,000	217,800	22,000

Table 8-6
Bear River Development Modeling Results
Time-Period Simulated: 2070 – 2099

		10% Wettest		50% Percentile		90% Driest	
Scenario	Total Storage (acre-feet)	Average Annual Delivery (acre-feet)	Maximum Annual Supply Shortage (acre-feet)	Average Annual Delivery (acre-feet)	Maximum Annual Supply Shortage (acre-feet)	Average Annual Delivery (acre-feet)	Maximum Annual Supply Shortage (acre-feet)
A	400,000	217,100	25,300	202,900	35,800	201,100	75,100
B	400,000	217,800	22,000	204,600	22,000	202,700	67,700
C	400,000	217,800	22,000	203,900	22,000	201,700	77,100
D	414,000	211,200	22,000	204,600	22,000	202,200	62,300
E	400,000	216,300	22,000	203,900	22,000	201,800	72,900
F	400,000	217,800	22,000	204,600	22,000	203,700	39,500
G	400,000	213,400	22,000	204,600	22,000	202,400	76,800
H	400,000	211,900	22,000	203,900	22,000	200,000	77,800
I	244,000	198,800	52,000	193,000	73,400	189,200	110,600
J	610,000	220,000	-	220,000	-	217,800	22,000
K	610,000	220,000	-	220,000	-	217,800	22,000
L	608,000	220,000	-	220,000	-	217,800	22,000
M	622,000	220,000	-	220,000	-	217,800	22,000

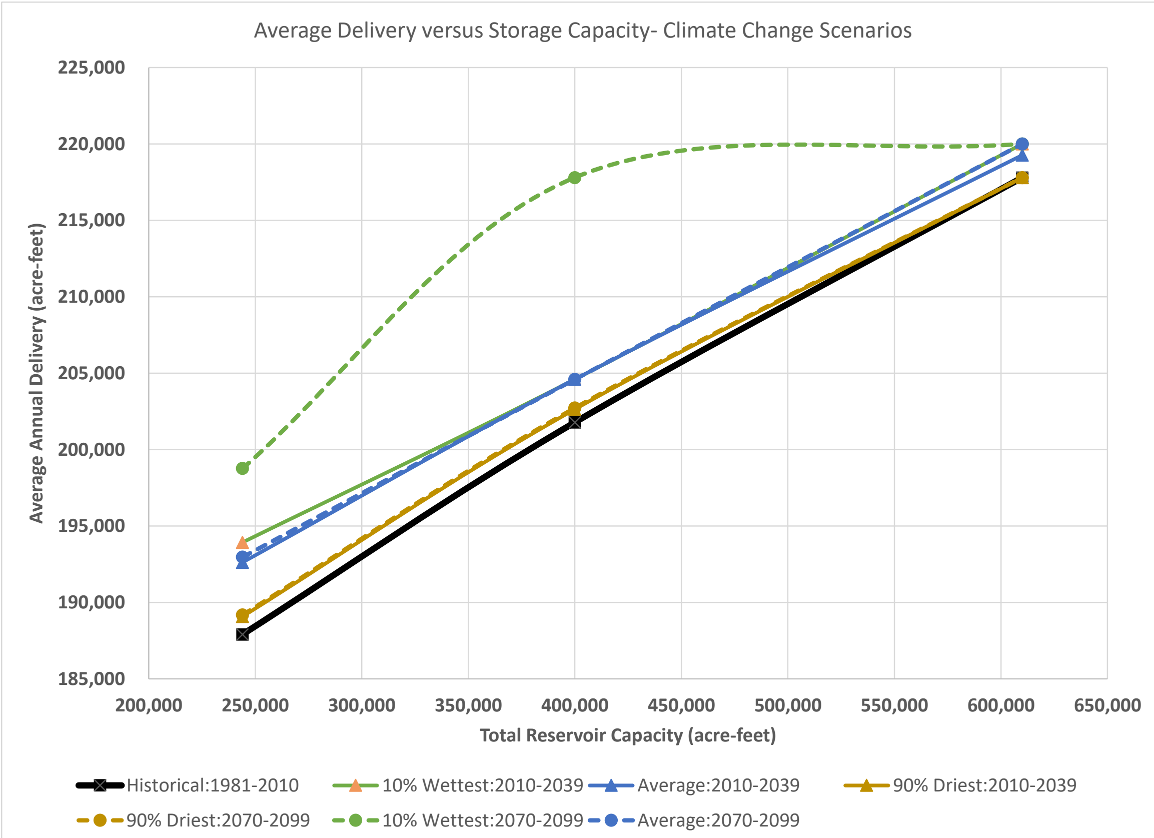


Figure 8-5: Simulated Effect of Climate Change on Average Annual Delivery versus Storage Capacity (2040-2079 excluded for clarity)

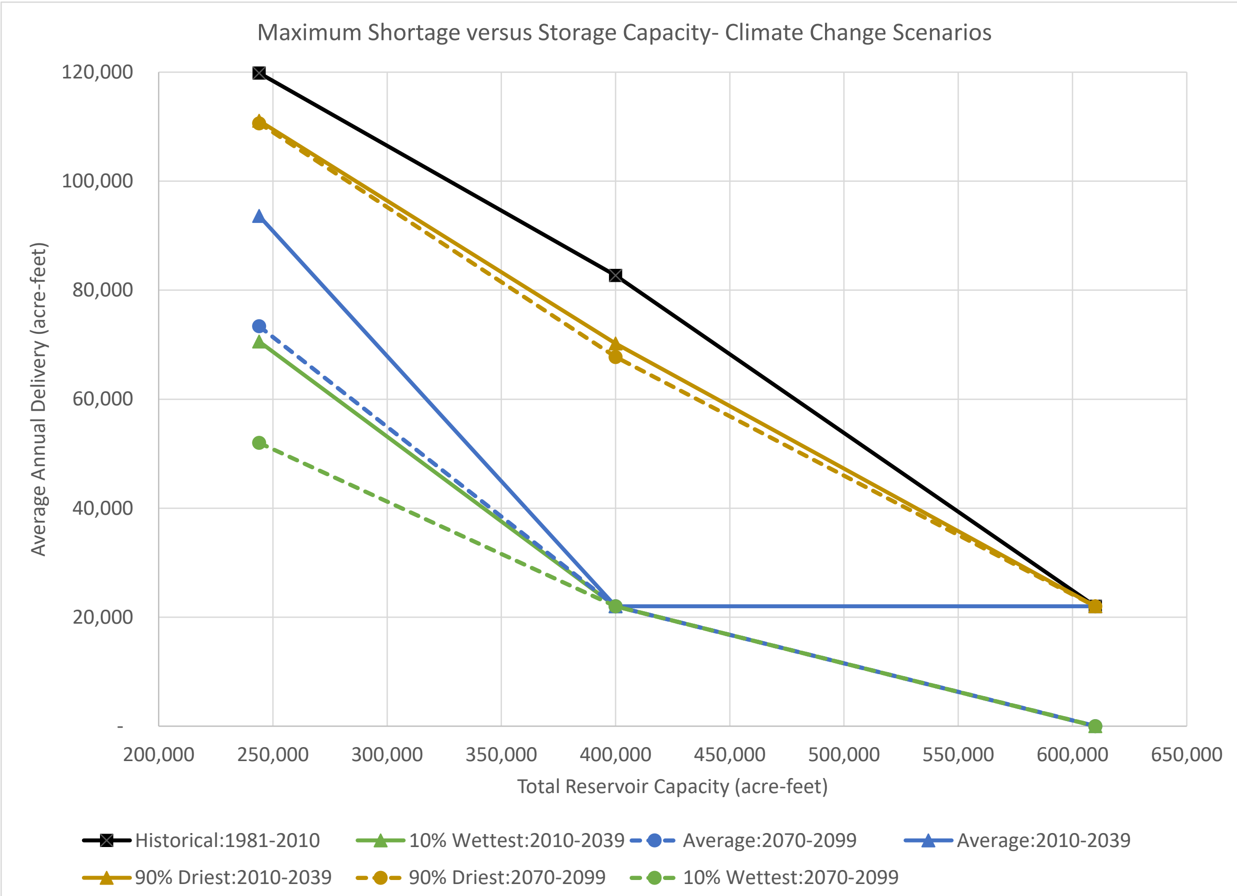


Figure 8-6: Simulated Effect of Climate Change on Maximum Annual Shortage versus Storage Capacity – Scenario B (2040-2079 excluded for clarity)

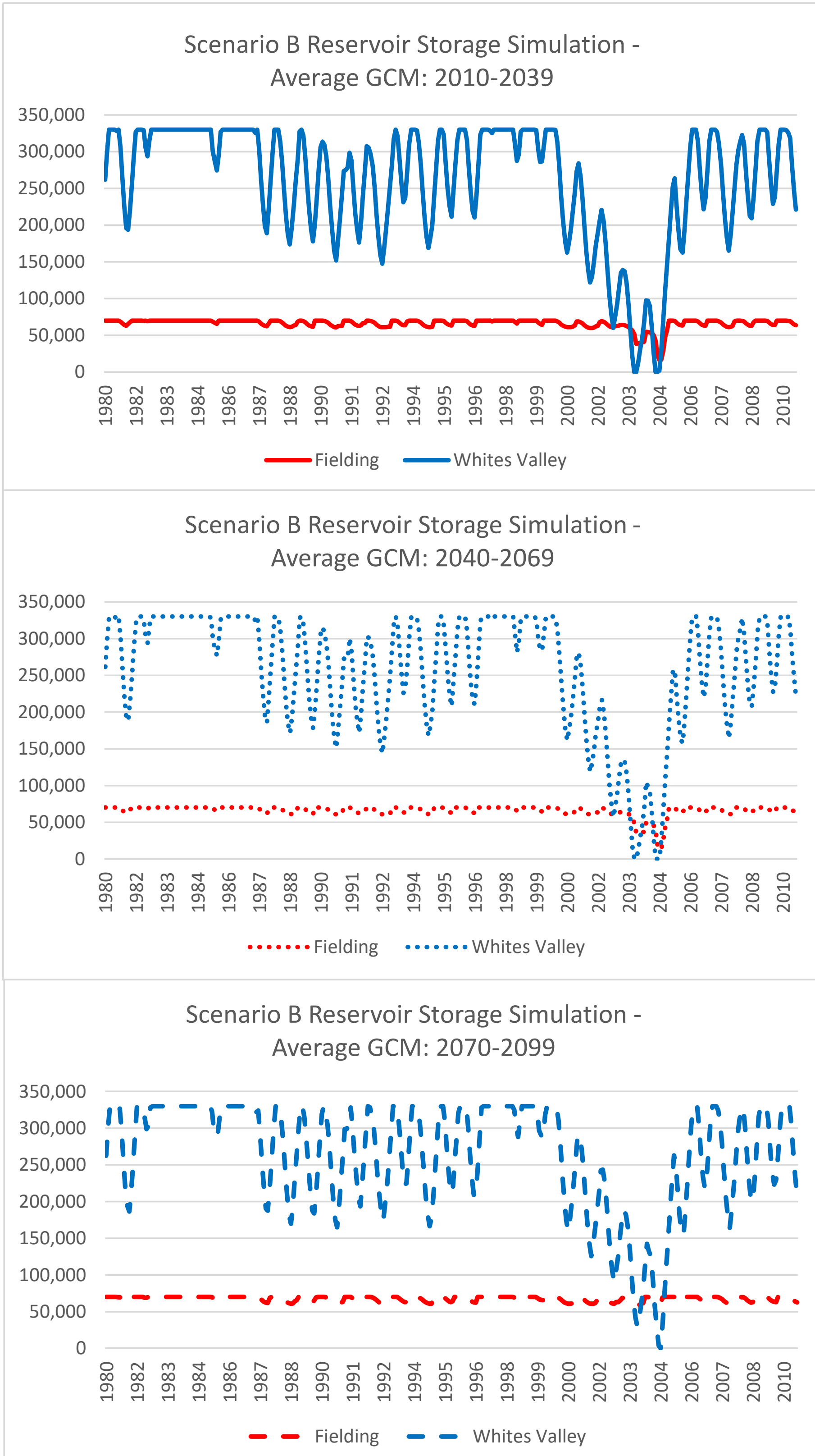


Figure 8-7: Simulated Effect of Climate Change on Reservoir Storage – Scenario B

8.3 Hydrology and Water Availability Conclusions

As described above, the large hydrologic variability results in the need for a large volume of storage to meet the reliability goal of no more than 10 percent annual supply shortage. Based upon streamflow data from 1981-2010, the BRD would need a storage capacity of about 600,000 acre-feet to meet these criteria. With this capacity, the average annual supply would be about 218,000 acre-feet. Alternatively, with a storage capacity of 400,000 acre-feet, the scenarios show a maximum supply shortage of about 83,000 acre-feet, and an average annual delivery of about 202,000 acre-feet.

The inclusion of the simulated climate change scenarios tends to reduce the volume of storage capacity needed to meet the supply shortage criteria. With a storage capacity of 400,000 acre-feet, and using results from the 50th percentile, a majority of the scenarios could deliver an average annual volume of between 202,000 and 206,000 acre-feet, with a maximum annual supply shortage of 22,000 acre-feet.

CHAPTER 9

PIPELINE ROUTING ANALYSIS

9.0 PIPELINE ROUTING ANALYSIS

9.1 BACKGROUND AND PURPOSE

The Bear River Pipeline Concept Report (Concept Report) was completed in 2014, which included a network analysis of potential pipeline corridor options used to determine the least-cost alignment alternative for the Bear River Pipeline. In the report, the area east of Willard Bay was identified as having limited north-south pipeline corridor options. This area is critical to the overall pipeline routing.

This area is narrow, situated between Willard Bay and the mountains with major transportation corridors, existing communities, utilities, and land development. Potential alignment options will be further limited as development increases. Preserving a utility corridor now can reduce costs and future impacts to the surrounding communities.

Since the Concept Report was completed, additional information has become available regarding ROW acquisition. It was important that additional routing options be analyzed through this critical corridor. The purpose of this chapter is to summarize the approach and results of this updated routing analysis.

Two additional pipeline alignments were evaluated as part of this study. These routing options include the following:

- **Whites Valley Pipeline.** The transmission pipeline from the Bear River or Fielding Reservoir to the Whites Valley Reservoir site.
- **South Willard Reservoir Pipeline.** The transmission pipeline from the Willard Bay area to the potential South Willard Reservoir site and to the West Haven WTP. This pipeline alignment will be included in reservoir scenarios that include South Willard Reservoir.

Basic routing analyses on these two options were performed to model a potential pipeline option to each reservoir location. These analyses are presented in Sections 9.3 and 9.4. The following sections summarize the approach for the additional pipeline option through the Willard Bay area.

Key Term Definitions:

Pipeline Alignment: The pipeline location, or proposed centerline, as established by a survey.

Pipeline Corridor: A wide strip of land that could accommodate a pipeline. A corridor runs the entire pipeline length from the beginning point to the termination point.

Alignment Segment: A section of the pipeline alignment with common physical features (i.e. within a road, crossing, open area, etc.). Segments may be as short as a railroad crossing or as long as thousands of feet along a canal. The final alignment will include numerous segments.

Equivalent Length: The theoretical length of an alignment required to normalize length with respect to a given variable, such as cost. In this study, we use equivalent length to normalize cost of construction in differing site conditions. For example, if the cost of an alignment in a congested ROW were 10 times the cost of an alignment in an open field, then the equivalent length of the congested ROW would be 10 times the length of alignment in the open field. A summary of the cost factors is presented in Table 9-2 at the end of chapter.

9.1.1 Bear River Pipeline Concept Report

The Concept Report identified an optimum pipeline alignment corridor based on construction costs and other important non-cost factors. The optimum alignment was to be used as a basis to enable DWRe either to preserve existing ROW or to acquire easements and ROW as needed. The optimum pipeline alignment was used to estimate construction costs of the pipeline.

Re-Evaluation of Willard Bay Corridor

A variety of alignment options were originally considered for the Willard Bay Corridor. The corridor is the area east of Willard Bay and west of the mountains, from Perry to just north of South Willard. Figure 9-1 (Volume II) shows the routing alternative studied in this area. Through this corridor, the location of the alignment was primarily along US-89. Figure 9-2 (Volume II) shows the recommended alignment (from Concept Report) through this area. This alignment location was recommended for the following reasons:

- Low-Cost Land Acquisition. The construction easement for the pipeline could be maintained completely within the US-89 ROW; no land acquisition would be required through this area.
- Low Construction Cost. US-89 has a wide ROW for potential construction of the pipeline. US-89 has higher utility congestion than other routes considered through the town of Willard, but those other routes often had a higher construction cost due other issues such as narrow available ROWs or the presence of high groundwater.

Limitations of the 2014 Bear River Pipeline Concept Report

The limitations within the original examination of the Willard Bay Corridor study area were as follows:

- The routing analysis only considered open public corridors (roads, canals, or railroads, etc.) for the pipeline alignment. It did not include any routing analysis through developed areas that required the purchase of homes, businesses, or large amounts of ROW on private farmland.
- Real estate costs used in the analysis were merely a generalized representation of cost per acre, based on low-resolution land usage/zoning maps (the best information available at that stage of the study).
- There was limited information on Utah Transit Authority (UTA) plans for a future Frontrunner Corridor in this area along the Union Pacific Railroad (UPRR).

- There was limited information on future development and associated future underground utilities along US-89 through this area.
- There was limited information on plans for trail corridors through this area.

9.1.2 Purpose of Re-evaluation of the Willard Bay Corridor

The purpose of the re-evaluation of the Willard Bay Corridor is to provide a more detailed routing analysis in this critical area, while also addressing the limitations or information gaps identified in the Concept Report. This updated study provides DWRe with information for revising the optimum alignment.

This updated routing study incorporates an expanded scope and more information for the following aspects of the routing analysis, including:

- An evaluation of potential alignments that route through privately owned farmland and private homes/lots.
- A more accurate and updated real estate cost model for estimating ROW acquisition costs on private land and for private homes.
- New information from UDOT and local communities about existing and planned utilities in US-89 corridor. This information refined the understanding of potential replacement costs of future utilities within the US-89 ROW.
- New information from UDOT on its plans to expand US-89.
- More in-depth analysis of the potential UPRR corridor alignment, taking into account the planned UTA Frontrunner Corridor. This includes a potential shared corridor that could reduce costs.

9.2 WILLARD BAY CORRIDOR ROUTING ANALYSIS

9.2.1 Segment Development

The Concept Report included many potential alignment segments through the Willard Bay Corridor. New alignment segments were developed and combined with the previously studied segments. The different combinations were then compared based on relative total construction costs. Figure 9-3 (Volume II) shows the updated pipeline corridor options through the Willard Bay Corridor.

9.2.2 Data Collection

The majority of the data gathered as part of the original study consisted of two types: GIS data and field observations. The GIS data included coverage’s of physical features, parcel data, land cost data and recent aerial photographs. This information was used to populate attributes of the individual segments. Field observation were used to verify specific physical features such as locating crossings, extents of groundwater and wetlands, utility density, potential public and private disruptions, and other special conditions. Underground utilities and land costs were both difficult to verify in field observations. The land costs and utilities costs are both critical in the overall routing analysis and selection of an optimal pipeline alignment, especially through the Willard Bay Corridor.

For this updated study, both utility density assumptions in US-89 and land cost data were updated to update construction costs through the Willard Bay Corridor.

Original Land Costs

Figure 9-4 (Volume II) shows the land costs assumptions used in the Concept Report with land use categories and assumed land acquisition cost per square foot. This data set was generated by defining swathes of land within the 324 square mile study area based on general land use and zoning properties. From the Concept Report, much of the land was classified as residential due to its potential for development. However, a review of the aerial imagery and field observations indicated that the majority of the land use is open fields and orchards.

Updated Land Costs

Land cost data was updated based on property acquisition data obtained from UTA. In July of 2013, a UTA study was commissioned to determine land acquisition costs along the future Frontrunner North Extension from Ogden to Brigham City. The study identified parcels along the potential Frontrunner Corridor that would require land purchase and applied a cost per square foot to those parcels. The total land cost was obtained by multiplying the total area of land purchased at its applicable cost per square foot and included 40 percent markup to account for overhead, legal, and fee costs.

Land acquisition costs for the segments in the Willard Bay Corridor were updated based on the UTA cost estimates, including the 40 percent overhead. In locations where the UTA land cost data did not overlap segments in the Willard Bay Corridor, land costs were updated by applying the UTA costs to similar properties near-by. Figure 9-5 (Volume II) shows the extents of the UTA land cost data and the range of estimated cost per square foot.

9.2.3 Construction Cost Factor Analysis

The construction cost factor analysis that was utilized in the Concept Report was also used in this study. The analysis consists of applying cost factors based on various construction conditions to a baseline pipeline cost. The assumptions for the baseline pipeline cost are as follows:

- 132-inch (11-feet) welded steel pipe
- No underground utilities
- No groundwater conditions
- No hard surface restoration (concrete or asphalt)
- No easement or ROW acquisition required
- No special crossings, tunneling, or earthwork requirements

A pipeline built with the conditions defined above would have a cost factor of 1.0 (baseline condition). Utility conflicts, public and private facility disruptions, presence of groundwater or wetlands, etc. all would contribute to increased pipeline installation cost. Each of these conditions has an associated cost factor. A summary of these cost factors and pipeline unit costs is included in Table 9-2 (end of chapter).

In addition to the construction cost factors, utility and land acquisition cost factors were also developed. The land acquisition cost factors for this routing study, and the wetland mitigation factor for segments within US-89, are based on the following assumptions:

- **ROW Width**. The recommended width for ROW acquisition is 100 feet. For segments in public corridors, such as roads, it was assumed that the public ROW could be utilized. In alignment segments where the public ROW is less than 100 feet, the cost of purchasing additional land to ensure a 100-foot construction ROW was included. ROW purchase through open fields or other private property would be 100 feet wide.
- **UTA Property Acquisition Data**. In general, the property acquisition costs for each segment is based on the updated land costs obtained from UTA.
- **House Purchase**. In cases where an alignment would require the purchase of a house, it was assumed that the entire property would be purchased. The purchase price for these situations was based on current market real estate values.
- **UTA ROW Sharing**. DWRe and UTA could have a shared corridor through some areas and share the cost of land acquisition. Reduction factors were applied to the ROW acquisition cost for alignments adjacent to potential UTA corridors.
- **Updated US-89 Utility Cost Factors**: The utility cost factor was adjusted to account for the assumed higher utility density in US-89, with the assumption that additional development will result in more utilities. A range of higher utility cost factors was applied to US-89 segments to evaluate the impact of increasing utilities in this corridor.

Figure 9-6 (Volume II) illustrates the cost factors for the Willard Bay Corridor routing analysis applied to individual route segments.

In the Concept Report, a non-cost analysis was performed to help further refine and evaluate potential corridors. A non-cost analysis of the Willard Bay Corridor was not included in the scope of this updated study.

9.2.4 Routing Analysis Procedure

The analysis approach for this updated study was based on the approach used in the Concept Report. The general approach includes applying the updated cost factors to the individual segments to calculate an equivalent length for each segment. The network was divided into three main reaches as shown in Figure 9-7 (Volume II). Segments were then combined to create routing options. Routing options within each reach were then combined with linked routing options to create various alignment options. The alignment options were then ranked based on their total equivalent length and cost.

9.2.5 Willard Bay Corridor Alignment Options

The updated routing analysis resulted in four alignment options within the corridor, with a few sub-options to reflect variable utilities and land cost factors. Figure 9-8 (Volume II) shows the four alignment options described below:

- **US-89.** This Concept Report option is similar to the alignment from the Concept Report. The alignment is within the US-89 ROW from the Box Elder/Weber County border to Perry, then west along 2700 South. The equivalent length of this option varies depending on the range of utility cost factors applied. Therefore, two sub-options were added to show higher cost utility ratings.
- **200 West**. This alignment runs just west of I-15 starting at the Box Elder/Weber County border and heads north. It then crosses under the freeway and the railroad at 7800 South and heads north on the east side of the railroad. It then follows 200 West, then runs west along 2700 South.
- **Railroad**. This alignment runs west of I-15, crosses under the freeway, and then continues adjacent to the railroad, similar to the 200 West alignment. This alignment goes through open fields for a short distance, then follows the railroad corridor until 2700 South. The equivalent length of this option could vary depending on the level of cost sharing with UTA along the railroad easement. A sub-option was included to reflect the possibility of no cost sharing with UTA.
- **Open Fields**. This alignment runs west of I-15, crosses under the freeway, and then continues running adjacent to the railroad, similar to the Railroad option. It then generally follows the shortest path through open fields to connect to 2700 South. This option has the overall shortest actual length.

All the options west of US-89 (Railroad, Open Fields, 200 West) provide improved hydraulic operation of the pipeline by avoiding a high point along US-89. This allows for a significant reduction in the sizes of the main pump station and power costs compared to the US-89 option.

9.2.6 Cost Comparison

Equivalent lengths were calculated for the four alignment options. Two additional sub-options were developed with modified equivalent lengths based on variable utility density cost factors in US-89. One sub-option was developed for the Railroad option to include no ROW cost sharing. The baseline pipeline cost was applied to each of these equivalent lengths to determine total construction cost for each option. Figure 9-9 provides a summary of the estimated construction costs for the alignment options, including the sub-options.

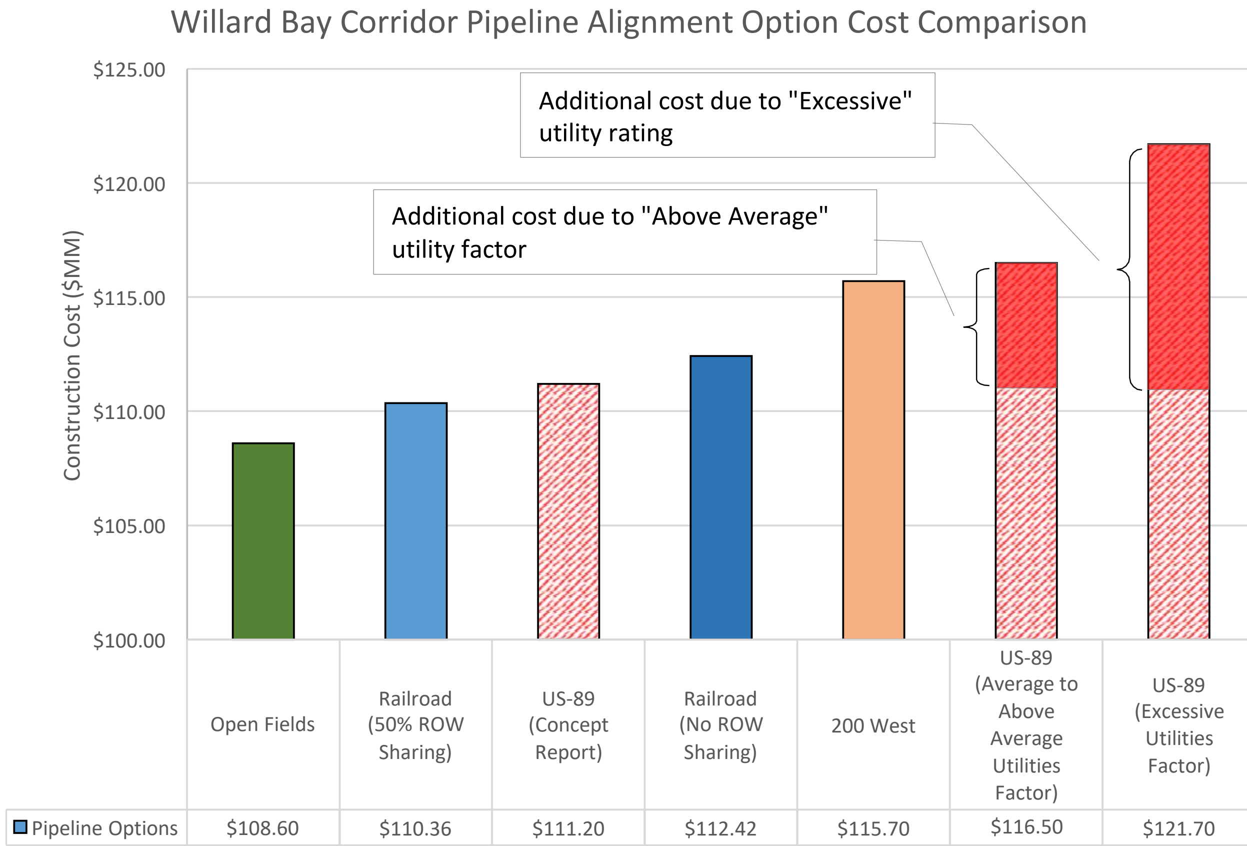


Figure 9-9: Construction Cost Comparison for Willard Bay Alignment Options

9.2.7 Willard Bay Corridor Analysis

Based on the results of the analysis described above, the least-cost alignment for the pipeline through the Willard Bay Corridor is the Open Fields option. Figure 9-10 (Volume II) shows this alignment, including adjacent areas that could allow minor alignment adjustments without significantly increasing costs. These alignment adjustments could also be part of the Railroad option, where shared corridor with UTA could reduce costs. The US-89 and 200 West options both have higher costs, and have the potential cost increases as this area continues to develop.

This Open Fields option provides the following general benefits:

- Ongoing coordination with UTA on a shared corridor is an advantage for early ROW acquisition efforts. It could reduce costs and future impacts to the surrounding communities.
- Reduced pump station sizes and ongoing operation costs.
- Various minor deviations from the alignment allow flexibility on ROW acquisition.
- Acquired ROW that is undeveloped could continue to operate with lease-back options.

- Purchase of homes or structures would not be considered priority acquisitions. Homeowners could sell on a willing-seller basis.
- Ongoing coordination with Box Elder County could potentially allow for dual use of the ROW (i.e. trail system).
- An alignment west of I-15, south of Willard Bay, allows for ease of connectivity to the South Willard site (if constructed).
- This alignment is further away from the Wasatch Fault Zone than the US-89 option.

The following is a list of recommendations related to the pipeline alignment:

- **Incorporate New Alignment into the Overall System.** Incorporate this alignment change into the potential overall system. Update hydraulic profiles and pumping requirements.
- **Environmental Evaluations.** Incorporate further environmental evaluations for this alignment to identify any critical environmental concerns that may exist.
- **Identify Critical ROW Acquisition Parcels and Areas.** Perform further detailed real estate evaluations on parcels and begin the process for ROW acquisition. Some activities may include:
  - Track upcoming sales of parcels within the corridor area, especially critical parcels.
  - Enter into discussions/collaboration with municipalities on zoning efforts within the corridor area.
  - Work with developers to acquire ROW.
  - Coordinate ROW acquisitions with project engineering and planning efforts.
- **Keep Alignment Options in Planning Process.** Alignment options should be kept in the planning process as potential alternatives to the least-cost corridor.
- **UTA Coordination.** Continue coordination with UTA for ROW sharing opportunities.
- **Trails Coordination.** Continue coordination with Box Elder County, BRAG, municipalities, and local trails groups.

9.3 WHITES VALLEY PIPELINE ROUTING ANALYSIS

To evaluate the total costs of a reservoir at the Whites Valley site, potential pipeline alignments were evaluated. The following section outlines the approach and results of a pipeline routing study from a Bear River diversion point to the Whites Valley site.

9.3.1 Whites Valley Pipeline Routing Approach

The routing study approach for Whites Valley Pipeline is similar to the approach for the Willard Bay Corridor routing analysis. Four potential alignment segments were created for this analysis. In addition to using some alignment segments evaluated in the Concept Report, a network of potential alignment segments were created from the Bear River to Whites Valley. Figure 9-11 (Volume II) shows the routing analysis area with the potential routing segments.

The area generally consists of rural farmland with occasional rural communities, narrow roads and moderate development. Potential pipeline routing segments were analyzed through open terrain. Updated real estate values were utilized as described in the previous section.

Segments were not created for corridors narrower than 100 feet in width, thus many of the small streets through the rural towns were not evaluated.

9.3.2 Routing Results and Recommendations

The potential pipeline segments were evaluated by cost and combined to create a list of three least-cost alignment options. An alignment with a tunneling option (Option 4) was also evaluated.

Option 4 has the shortest actual pipeline length of the four options as it tunnels through the mountain. However, tunnel construction is very costly. Tunneling cost factors per linear foot were estimated using data from four national tunneling specialty contractors. These costs were based on using various methods from the drill and blast approach to utilization of a large tunnel-boring machine (TBM). The estimates utilizing a TBM had the lowest unit cost and were best suited for long tunnels with accessible entry and exit. Since there is significant uncertainty in the geologic tunneling conditions and approach, the cost for Option 4 were developed as a range (low, average, high). The higher tunneling cost reflects a more difficult geology and excessive groundwater using a TBM approach. The lower cost assumes less problematic geology and low groundwater. A memorandum by Lithos Engineering describing tunneling unit cost for this analysis is provided in the Appendix.

For Option 4, since the “Low” tunneling cost is close to the cost of the other routing options, it is recommended that it be studied further. However, a major drawback would be its inability to deliver water to potential Box Elder County connections along a major portion of the pipeline route.

The two lowest-cost options (Options 2 and 3) are very similar in cost and location, though Option 3 likely has less overall impact to adjacent communities as much of its alignment is through open fields. Option 3 was utilized as the conceptual pipeline route to Whites Valley site and as a basis for developing cost estimates. Figure 9-14 (Volume II) provides an overview of this pipeline alignment option.

An additional pipeline alignment would potentially needed to convey water from Whites Valley Reservoir to Cache County. If there is inadequate storage in Cache County to supply the CWD, or if water exchanges cannot be made with the Bear River Canal Company, a pipeline would be needed to convey water from a reservoir site in Box Elder County to CWD. The potential alignment of this pipeline is included in Figure 9-14 (Volume II).

Table 9-1 and Figure 9-12 provide a summary of the alignment options and their associated estimated costs. Figure 9-13 (Volume II) shows the four alignment options.

Table 9-1
Summary of Whites Valley Pipeline Alignment Analysis

Alignment Option	Actual Length (feet)	Equivalent Lengths (feet)			*Cost Total ($MM)
		Construction	Land	Total	
1	95,525	103,614	6,314	109,928	$185.9
2	93,145	99,989	6,417	106,406	$179.9
3	92,621	99,410	6,323	105,733	$178.8
4 Low	73,156	106,649	3,851	110,500	$186.8
4 Average	73,156	128,710	3,851	132,561	$224.1
4 High	73,156	176,842	3,851	180,693	$305.5

* Costs presented in this table are for comparison purposes and do not reflect final cost estimates.

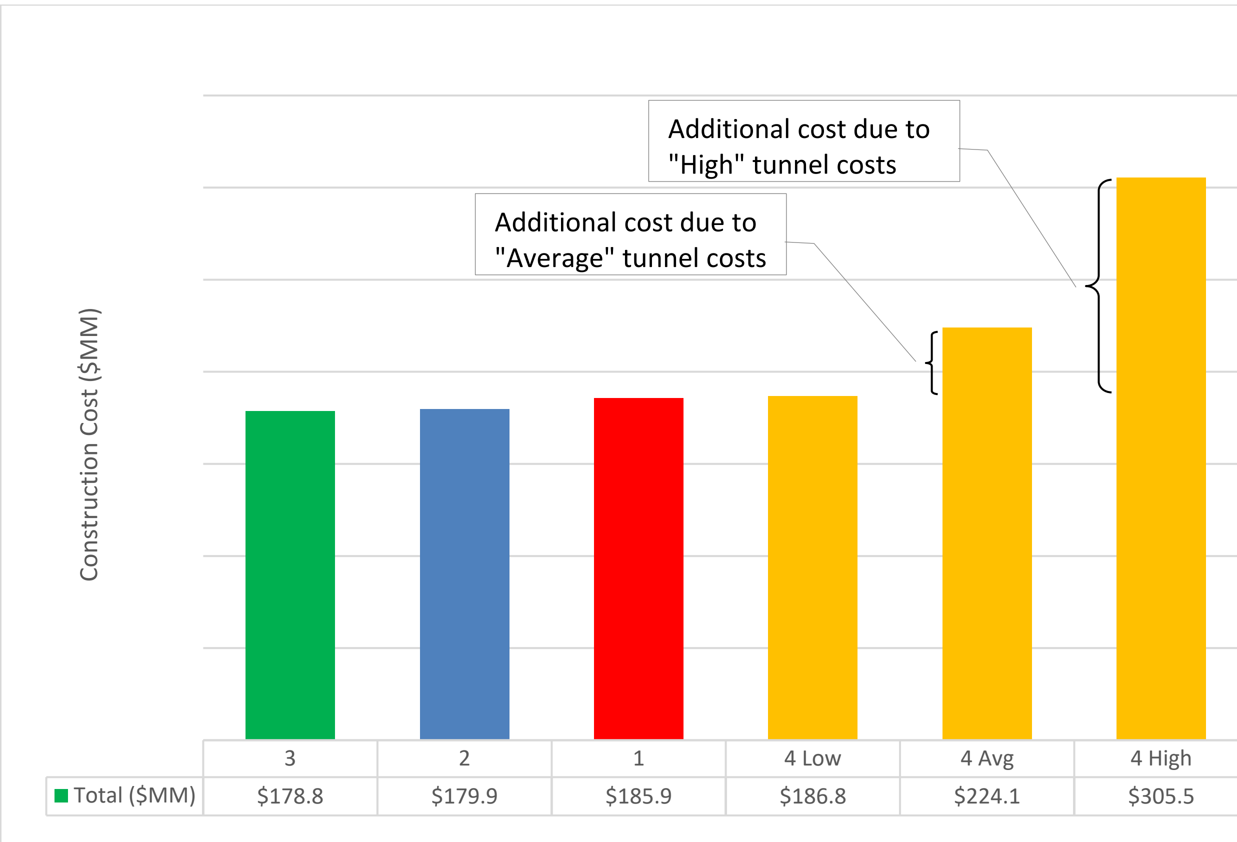


Figure 9-12: Construction Cost Comparison for Whites Valley Alignment Options

9.4 SOUTH WILLARD RESERVOIR PIPELINE ALIGNMENT ANALYSIS

If the South Willard Reservoir site is part of the overall BRD system, it would require a re-alignment of the main pipeline to West Haven WTP so that deliveries to and from the reservoir could be made. As part of the study to determine costs associated with a reservoir at the site, it was necessary to estimate the cost of an extended pipeline route. An additional alignment was studied from the South Willard site to West Haven WTP. This route follows currently undeveloped open land. The alignment outlined in the Concept Report mostly followed roadways adjacent to I-15 (1900 West) and was developed under the same study limitations discussed in Section 9.1.1.

9.4.1 South Willard Reservoir Pipeline Alignment Approach

The pipeline routing analysis for South Willard Reservoir Pipeline was similar to the approach used for the Willard Bay corridor analysis, with some exceptions. The route segments utilized in this routing analysis were those developed in the Concept Report, with added segments through open terrain. These added segments were concentrated mostly along the north-south power corridor at about 3200 West (County address grid).

The routing segments used in this study are shown in Figure 9-15 (Volume II), with the alignment from the Concept Report shown for reference.

9.4.2 Routing Results and Recommendations

A simplified routing study was performed on the potential alignment from South Willard Reservoir to West Haven WTP. Additional routing options were evaluated through open terrain and in public corridors, using a similar cost-based approach.

Through the simplified routing study, it was found that the least-cost pipeline route would follow-the power corridor from near the pump station location for South Willard Reservoir to the West Haven WTP. This alignment was also the shortest actual length. This alignment was utilized to develop cost estimates associated with South Willard Reservoir. Figure 9-16 (Volume II) provides an overview of the pipeline alignment.

This alignment should be studied further and considered an alternative to the 1900 West option evaluated in the Concept Report. Future ROW acquisition and real estate studies should evaluate the north-south power corridor as an alternative to the roadway corridors.

9.5 POTENTIAL ALIGNMENTS FOR BEAR RIVER PROJECT PIPELINES

These pipeline alignments were utilized for the BRD cost estimates. Small refinements and variations may be made to the alignments based on operational requirements or changes in the final BRD configuration. Details of the pipeline alignments are presented in Chapter 11. Further ongoing refinements to the pipeline alignments could be made in the future due to potential changes in ROW conditions (future development), overall system concepts and operations, and environmental permitting approach and requirements.

Figure 9-17 (Volume II) shows the overall pipeline alignments for the BRD with the associated potential reservoir sites.

Table 9-2
Summary of Anticipated Construction Conditions and Associated Cost Factors

Urban Rating	
Open field or farm road	1.00
Collector Street	1.07
Arterial - Rural Zone	1.08
Arterial - Residential Zone	1.10
Arterial - Commercial Zone	1.20
Utility Factors	
No utilities	0.00
Average to above average utilities	0.15
Excessive utilities	0.30
Narrow ROW Factor	
100' or greater	1.00
Between 70' and 100'	1.16
Between 60' and 70'	1.30
Groundwater Condition	
No groundwater	1.00
Stagnant groundwater in clays	1.20
Flowing groundwater	1.80
Steepness Factor	
Grades less than 25%	1.00
Grades 25% or more	1.40
Special Conditions	
No special conditions	1.00
Ditch crossing (Crossing, plus 50 feet)	1.10
Above ground buried pipe (West of Willard Bay)	1.75
Small canal crossing (Crossing, plus 50 feet)	1.30
Large canal - Open cut (Crossing, plus 100 feet)	1.80
River crossing - Open cut (Crossing, plus 100 feet)	2.00
Large canal - Tunneled (Crossing, plus 100 feet)	2.80
River crossing - Tunneled (Crossing, plus 100 feet)	2.90
Freeway crossing - Tunneled (ROW lines, plus 100 feet)	3.00
Railroad crossing - Tunneled (ROW lines, plus 100 feet)	3.00

CHAPTER 10

BEAR RIVER DEVELOPMENT COST ESTIMATES

10.0 BEAR RIVER DEVELOPMENT COST ESTIMATES

This chapter presents the results of the conceptual-level cost estimates for the BRD system. Costs for the overall system and for the various combinations of reservoirs are included.

For WBWCD and JVWCD, additional costs will be required to deliver water from the West Haven Water Treatment Plant (WHWTP), to their respective service areas. Costs for these facilities were developed by JVWCD and WBWCD. These costs were updated and are summarized to provide an overall cost estimate for those two water districts.

10.1 COST ESTIMATING

The cost estimates are considered a combination of Class 5 and Class 4 for planning purposes by the Association for the Advancement of Cost Engineering—International (AACE). AACE defines the class estimates as follows:

> **Class 5.** This class of estimate is prepared based on limited information, where little more than proposed facility type, its location, and the capacity and operating characteristics are known. This class of estimate includes, but is not limited to, market studies, assessment of viability, evaluation of alternate schemes, project screening, location and evaluation of resource needs and budgeting, and long-range capital planning. Examples of estimating methods used would be cost/capacity curves and factors, scale-up factors, and parametric modeling techniques. Less time is expended in the development of this estimate compared to other estimate classes. The typical expected accuracy range for this class estimate is -20 to -50 percent on the low side and +30 to +50 percent on the high side.
>
> **Class 4.** This class of estimate is prepared based on information where the preliminary engineering is from 1 to 15 percent complete. They are typically used for project screening, determination of feasibility, concept evaluation, and preliminary budget approval. Typically, engineering is from 1 percent to 15 percent complete, and would comprise, at a minimum, the following: plant capacity, block schematics, indicated layout, process flow diagrams (PFDs) for main process systems, and preliminary engineered process and utility equipment lists. This estimate requires more time expended in its development. The typical expected accuracy range for this class estimate is -15 to -30 percent on the low side and +20 to +50 percent on the high side.

10.2 BEAR RIVER DEVELOPMENT RESERVOIR SCENARIO COSTS

These include the costs to deliver water to and from the different reservoir combinations and additional major facilities as discussed in Chapters 6 and 8. Figure 10-1 (Volume II) shows an overall BRD System schematic, showing the major cost components used in the various scenarios. Table 10-1 shows a summary of costs for each scenario. These costs include construction costs for potential reservoirs and delivery facilities to the WHWTP location. The estimates do not include construction contingency, engineering, legal or administrative costs. Those costs are included in final estimates at the end of this chapter.

Table 10-1
Bear River Development Reservoir Scenarios Cost

		Reservoir Storage (acre-feet)								Aug 2017 ENR 10,842	
Scenario	Combination Description	Cub River Storage	Above Cutler	Temple Fork	Fielding*	Whites Valley	South Willard	Total Storage	Projected Shortage **	Construction Cost ($MM)	$/Acre-Foot
A	Small Fielding, Whites Valley				40,000	360,000		**400,000**	38%	**$1,218**	$3,044
B	Fielding (Large), Whites Valley				70,000	330,000		**400,000**	38%	**$1,138**	$2,845
C	Whites Valley Only				-	400,000		**400,000**	37%	**$1,064**	$2,659
D	All Reservoirs	27,000	51,000	41,000	70,000	170,000	55,000	**414,000**	37%	**$1,986**	$4,797
E	Cub, Fielding, Whites Valley	27,000			40,000	333,000		**400,000**	38%	**$1,322**	$3,304
F	Above Cutler, Fielding, Whites Valley		51,000		40,000	309,000		**400,000**	38%	**$1,490**	$3,726
G	Temple Fork, Fielding, Whites Valley			41,000	40,000	319,000		**400,000**	38%	**$1,306**	$3,264
H	South Willard, Fielding, Whites Valley				40,000	305,000	55,000	**400,000**	37%	**$1,630**	$4,074
I	No Whites Valley	27,000	51,000	41,000	70,000	-	55,000	**244,000**	54%	**$1,511**	$6,192
J	Whites Valley (Large), Fielding (Large)				70,000	540,000		**610,000**	10%	**$1,232**	$2,020
K	Whites Valley (Large) Only					610,000		**610,000**	10%	**$1,183**	$1,939
L	Whites Valley (Large), Cub, Temple	27,000		41,000		540,000		**608,000**	10%	**$1,346**	$2,213
M	Whites Valley (Large), Cub, South Willard	27,000				540,000	55,000	**622,000**	10%	**$1,673**	$2,691

* All 40,000 acre-foot Fielding Options can be replaced with 70,000 acre-foot Fielding option by adding $71.5 M to the total construction cost

** Projected Shortage represents maximum annual shortage experienced with the given storage ,based on hydrologic model output (see Chapter 8)

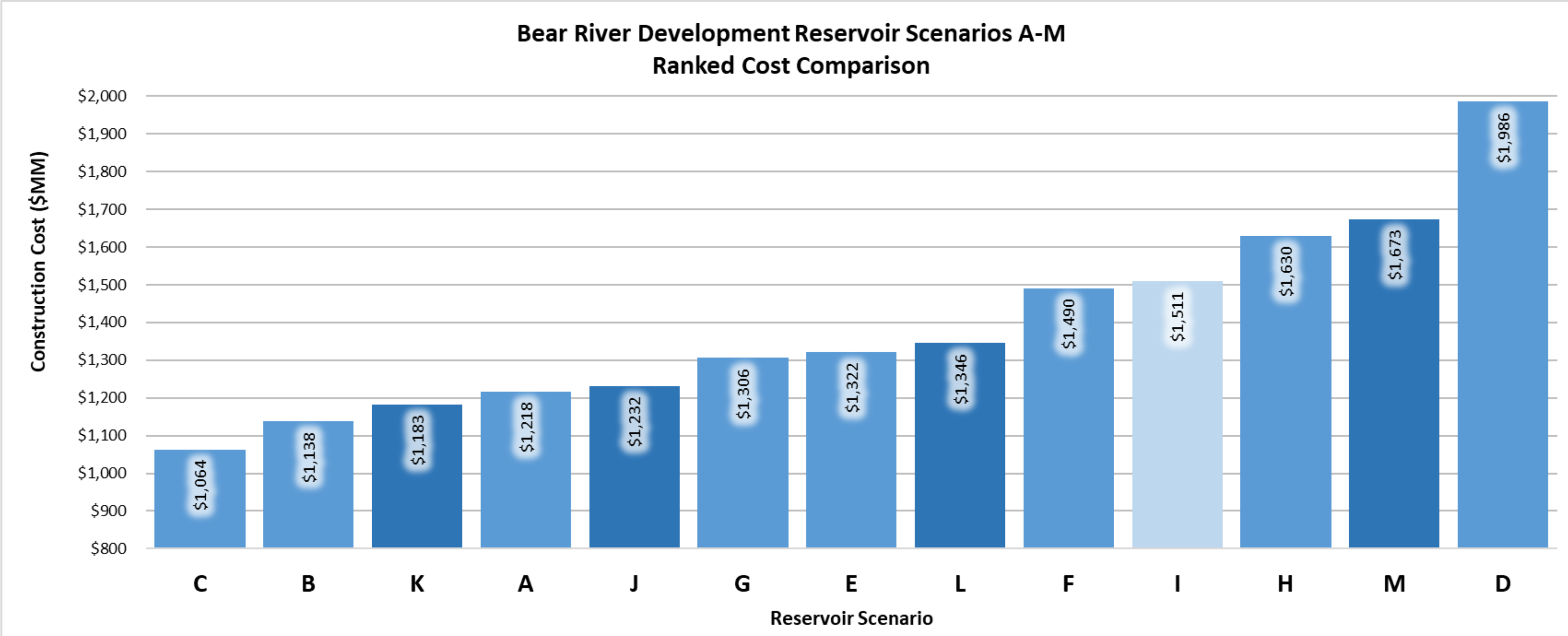


Figure 10-2: Bear River Development Reservoir Scenarios, Ranked Cost Comparison

Figure 10-2 shows the construction cost estimates for each of the reservoir scenarios. Costs vary from $1.0 billion to over $1.9 billion. These estimates do not include contingency, engineering, legal, or administrative costs. Scenario J and K, which both meet the shortage reliability goal and include a large Whites Valley Reservoir, appear to be the most cost effective at this time. Figures 10-3 through 10-15 (Volume II) include cost estimates for the major components of each scenario shown in Table 10-1 and Figures 10-1 (Volume II) and Figure 10-2. These include costs for each reservoir, pump station, transmission pipeline, and other project features.

Figure 10-16 (Volume II) includes the facilities needed to deliver water from the WHWTP south to JVWCD and WBWCD. These facilities include the WHWTP, the transmission pipeline from WHWTP to 2100 South in Salt Lake County, a 100-MG reservoir, and a pump station. Costs for these facilities were obtained from previous studies and reports. Costs for the finished water transmission pipeline and 100-MG reservoir were from the *Wasatch Front Regional Water Project Reservoir Site Selection and Alignment Study* for WBWCD (BC&A, February 2005). The 2005 study referenced the *Bear River Pipeline Alignment Study* (Boyle, 1997) for the finished water pipeline alignment and provided updated costs for the pipeline and 100-MG reservoir. The cost allocation between WBWCD and JVWCD for these facilities was included in this report. Costs for the pipeline and 100-MG reservoir are considered Class 4 estimates.

Costs were adjusted to the August 2017 Engineering News Record (ENR) Index, 20-cities cost indexing system value of 10,842 to be consistent with project costs in this report. Facilities located upstream of the proposed WHWTP will be cost shared between CWD, BRWCD, WBWCD, and JVWCD. The costs for the WHWTP and facilities located downstream will be shared between WBWCD and JVWCD. Table 10-2 shows the construction cost estimates for each reservoir scenario as well as contingency, engineering, legal, and administrative costs. Detailed cost estimates are included in the Appendix.

10.3 WASHAKIE RESERVOIR

In 2010, DWRe completed a preliminary design for the potential Washakie Reservoir (CH2M Hill, 2010, *Washakie Reservoir Project Preliminary Engineering and Design Report*). The report focused on the geologic and geotechnical setting of the reservoir, and also includes a description of the major facilities (including the dam and reservoir, Malad River bypass channel, and inflow and outflow piping and pump stations), as well as the hydrology, water quality, and environmental considerations associated with the site. The hydrologic and water quality review included the assumed use of Willard Bay as a second storage site. The report includes a conceptual cost estimate for the 160,000 acre-foot capacity reservoir, Malad River bypass facilities, and conveyance facilities (to and from the Bear River) ranging from $876M to $1,022M. While this site was included in the previous Bear River Report cost tables, it was not included in this study due to its high construction cost, pumping costs to and from the reservoir, environmental and archeological concerns, and storage limitations.

10.4 COST SUMMARY

Table 10-2 includes the costs for each District for the overall BRD System for each scenario. Table 10-2 also included in the estimated capital costs per acre-foot of water developed, based on the allocations described in the BRD Act. The cost breakdown for each District was based on an overall cost estimate of approximately $1.7 billion (Scenario J or K) with total capital costs estimated at $7,840 per acre-foot. For this scenario, annual re-payments were based on 50-year financing at an interest rate of 4 percent for an annual re-payment of $365 per acre-foot.

Table 10-3 details the costs for WBWCD and JVWCD for their overall system, which includes the additional costs of the finished water facilities discussed earlier in this chapter. Total capital costs for the overall systems for WBWCD and JVWCD were estimated to be $4,246 per acre-foot for WBWCD and $6,629 per acre-foot for JVWCD. The total annual costs per acre-foot were based on an interest rate of 4 percent over 50 years on the BRD System costs, and 4 percent interest over 30 years the WBWCD and JVWCD costs. Annual costs per acre-foot were calculated as $610 per acre-foot for WBWCD and $748 per acre-foot for JVWCD.

Table 10-2
Bear River Development Cost – Raw Water Portion (State of Utah)

		Cost Estimates													Costs for Project Cost of $1.7248 Billion			
Water District or Cost Component	**BRD Allocation (Acre-Feet)**	**Scenario A**	**Scenario B**	**Scenario C**	**Scenario D**	**Scenario E**	**Scenario F**	**Scenario G**	**Scenario H**	**Scenario I**	**Scenario J**	**Scenario K**	**Scenario L**	**Scenario M**	**Project Totals by Stakeholder**	**Total $/ AC-FT**	**Annual Payment Amortized 4% for 50 years**	**Annual Cost $/Ac-Ft**
Construction Cost Estimate		$1,218,000,000	$1,138,000,000	$1,064,000,000	$1,986,000,000	$1,322,000,000	$1,490,000,000	$1,306,000,000	$1,630,000,000	$1,511,000,000	$1,232,000,000	$1,183,000,000	$1,346,000,000	$1,673,000,000	$ 1,724,800,000			
Contingency (25%)		$304,500,000	$284,500,000	$266,000,000	$496,500,000	$330,500,000	$372,500,000	$326,500,000	$407,500,000	$377,750,000	$308,000,000	$295,750,000	$336,500,000	$418,250,000				
Engineering, Legal, Admin (15%)		$182,700,000	$170,700,000	$159,600,000	$297,900,000	$198,300,000	$223,500,000	$195,900,000	$244,500,000	$226,650,000	$184,800,000	$177,450,000	$201,900,000	$250,950,000				
Total Cost Estimate		**$1,705,200,000**	**$1,593,200,000**	**$1,489,600,000**	**$2,780,400,000**	**$1,850,800,000**	**$2,086,000,000**	**$1,828,400,000**	**$2,282,000,000**	**$2,115,400,000**	**$1,724,800,000**	**$1,656,200,000**	**$1,884,400,000**	**$2,342,200,000**				
Water District																		
Cache Water District	60,000	$ 465,054,545	$ 434,509,091	$ 406,254,545	$ 758,290,909	$ 504,763,636	$ 568,909,091	$ 498,654,545	$ 622,363,636	$ 576,927,273	$ 470,400,000	$ 451,690,909	$ 513,927,273	$ 638,781,818	$ 470,400,000	$ 7,840	($21,897,214)	$ 365
Bear River Water Conservancy District	60,000	$ 465,054,545	$ 434,509,091	$ 406,254,545	$ 758,290,909	$ 504,763,636	$ 568,909,091	$ 498,654,545	$ 622,363,636	$ 576,927,273	$ 470,400,000	$ 451,690,909	$ 513,927,273	$ 638,781,818	$ 470,400,000	$ 7,840	($21,897,214)	$ 365
															$ -			
Weber Basin Water Conservancy District	50,000	$ 387,545,455	$ 362,090,909	$ 338,545,455	$ 631,909,091	$ 420,636,364	$ 474,090,909	$ 415,545,455	$ 518,636,364	$ 480,772,727	$ 392,000,000	$ 376,409,091	$ 428,272,727	$ 532,318,182	$ 392,000,000	$ 7,840	($18,247,679)	$ 365
															$ -			
Jordan Valley Water Conservancy District	50,000	$ 387,545,455	$ 362,090,909	$ 338,545,455	$ 631,909,091	$ 420,636,364	$ 474,090,909	$ 415,545,455	$ 518,636,364	$ 480,772,727	$ 392,000,000	$ 376,409,091	$ 428,272,727	$ 532,318,182	$ 392,000,000	$ 7,840	($18,247,679)	$ 365
															$ -			
Total	220,000	$ 1,705,200,000	$ 1,593,200,000	$ 1,489,600,000	$ 2,780,400,000	$ 1,850,800,000	$ 2,086,000,000	$ 1,828,400,000	$ 2,282,000,000	$ 2,115,400,000	$ 1,724,800,000	$ 1,656,200,000	$ 1,884,400,000	$ 2,342,200,000	$ 1,724,800,000	$ 7,840	($80,289,786)	$ 365

Notes:
1. Annual costs do not include normal operation and maintenance.
2. Alternatives that include Whites Valley Reservoir include the present worth of 20 years of pumping costs

Table 10-3
Bear River Development Cost – Raw Water (State of Utah) and Finished Water (JVWCD and WBWCD)

Water District	BRD Water Allocation (Acre-Feet)	West Haven WTP	Finished Water Pipeline to WBWCD/ JVWCD	Finished Water Reservoir and Pump Station	Total Cost ($)	Total $/Acre-Feet	Annual Payment Amortized 4% for 30 years	Annual Cost $/Ac-Ft	BRD System Cost Share (Table 10-2)	Total Costs for WBWCD and JVWCD	Annual Payment (State Project) (Table 10-2)	Total Annual Payment	Total Annual Cost $/Acre-Feet
		$ 295,500,000	**$ 173,170,000**	**$ 75,062,000**									
Weber Basin Water Conservancy District	50,000	$ 147,750,000	$ 45,024,200	$ 19,516,120	$ 212,290,320	$ 4,246	($12,276,770)	$ 246	$ 392,000,000	$ 604,290,320	($18,247,679)	($30,524,449)	$ 610
										$ -			
Jordan Valley Water Conservancy District	50,000	$ 147,750,000	$ 128,145,800	$ 55,545,880	$ 331,441,680	$ 6,629	($19,167,305)	$ 383	$ 392,000,000	$ 723,441,680	($18,247,679)	($37,414,984)	$ 748
Total	100,000	$ 295,500,000	$ 173,170,000	$ 75,062,000	$ 543,732,000	$ 5,437	($31,444,075)	$ 314					

1. Finished water pipeline, reservoir, and pump station cost breakdown between WBWCD and JVWCD is based on the February 2004 Cost Allocation Study for the Wasatch Front Regional Water Project, Table 4-1, page 4-2, 26% WBWCD and 74% JVWCD.

CHAPTER 11

BRD SYSTEM CONCEPTUAL DESIGN

11.0 BRD SYSTEM CONCEPTUAL DESIGN

11.1 OVERALL DESCRIPTION

As discussed in Chapter 10, Scenario J is the least-cost BRD alternative. The following sections provide a summary of this conceptual design with storage at Whites Valley Reservoir and Fielding Reservoir. This includes the associated facilities necessary to make the overall system operationally functional to deliver water reliably to the Districts.

The main features of each dam, pipeline, and pump station facility for this scenario were summarized in Chapter 7, with the exception of the larger 540,000 acre-foot Whites Valley Reservoir (see Section 11.5.2). The following sections provide more information regarding specific design criteria, hydraulics, facility operations, sizing, and recommendations for further study.

The Bear River Development Planning is in an initial concept stage and the language used in this chapter, as with other chapters, may not always infer or convey the actual conceptual nature of the potential sites and associated facilities. It should be noted that the overall purpose of this study is to provide a conceptual design to be analyzed, with descriptions for location and sizing of functional facilities. Due to this, the following sections will utilize language in describing the potential facilities without encumbering the report with adjectives describing the conceptual nature of the study, like "potential site" or "potential location" or "conceptual sizing," though it is inferred throughout.

11.1.1 Reservoirs/Dams, Pipelines and Pump Stations

The main features of the BRD would include an off-stream, 540,000 acre-foot Whites Valley Reservoir, and an on-stream 70,000 acre-foot Fielding Reservoir. The Whites Valley Reservoir would be filled by pumping from Fielding Reservoir and emptied with the same pipeline. The main Bear River Pipeline runs from near the Fielding site, south to the proposed WHWTP. Figure 11-1 shows an overall map of the facilities.

The potential pipeline alignments for this scenario are also included in Figure 11-1 (Volume II), with additional information in Chapter 9. Maps of each pipeline alignment are included in Figures 11-4 through 11-9 (Volume II).

The main pump stations are the Fielding Pump Station and the Whites Valley Booster Pump Station. The Fielding Pump Station conveys the water either to the Whites Valley Booster Pump Station or directly to the WHWTP through the main Bear River Pipeline. The Whites Valley Booster Pump Station pumps water to Whites Valley Reservoir.

The Whites Valley Booster Pump Station site also has a large hydropower facility to generate power when water is released from the reservoir. In conjunction with this facility, there is a 500 acre-foot regulating reservoir to add operational flexibility to the Whites Valley system. See Figures 7-4, 7-5, 7-6, and 7-9, (Volume II).

11.2 HYDRAULIC ANALYSIS

The purpose of this section is to summarize the basic design criteria as well as the overall system hydraulics and operations.

11.2.1 Hydraulic Criteria

The main hydraulic criteria and assumptions used in the sizing of the facilities includes:

1. Delivery flow rates (peak delivery flows)
2. Delivery locations (pipeline reaches)
3. Required conveyance flow rates (peak design flows)
4. Hydraulic parameters and assumptions

To size the conveyance facilities, the location and delivery flow rates to the Districts is needed. This information is as follows:

Cache Water District (Cache County)

The deliveries to CWD would generally be in-stream flows taken out near Cutler Reservoir. As described in Chapter 6, the entire storage for this scenario is located within Box Elder County, requiring that a pipeline be installed to deliver water back to CWD. The pipeline would transmit water to CWD when the Bear River does not have available in-stream flows at Cutler Reservoir. The peak delivery flow for the pipeline to CWD is 180 cfs.

BRWCD (Box Elder County)

The peak delivery flow to BRWCD is 180 cfs. The deliveries to BRWCD are flexible as the main storage and conveyance facilities are all located within the county. There are various options for BRWCD deliveries:

1. Deliver entire supply to the north (near Fielding)
2. Deliver some or all supplies to the west (below Whites Valley)
3. Deliver entire supply to the south at Brigham City
4. Deliver a smaller supply of 18 cfs further south near South Willard

WBWCD and JVWCD (Weber, Davis, and Salt Lake Counties)

The delivery point for these two Districts would be at the WHWTP with a peak flow of 300 cfs.

Table 11-1 summarizes the peak delivery flow rates and locations.

Table 11-1
Peak Delivery Flows

Delivery	Peak Flow (cfs)
CWD* (at Cutler Reservoir)	180
BRWCD Delivery Options:	
Fielding	180
Below Whites Valley	180
Brigham City	180
South Willard	18
JVWCD & WBWCD (WHWTP)	300

*Delivery to CWD made when adequate flow is not available in the Bear River at Cutler Reservoir

Figure 11-2 (Volume II) shows the overall scenario schematic, delivery locations and key facilities, including:

- Pipeline reaches
- Delivery locations and flow rates
- Pipeline (conveyance) peak design flow rates with flow direction
- Peak pump station flow rates
- Storage and other facilities

The peak pumping and conveyance flow rates were calculated from the BEAR-SIM model. See Chapters 6 and 8 for a description of the model.

The hydraulic parameters and assumptions used in development and sizing of the facilities is summarized below:

- Hazen-Williams friction coefficient: 120
- Pipe operational velocity: 5-7 feet per second (fps)
- Pipe peak velocity: < 10 fps
- Pipe diameter increment: 6 inches
- Pump efficiency: 88%
- Motor efficiency: 94%
- Pump redundancy: See 11.2.4

11.2.2 Operational Scenarios

The operation of the overall system generally includes the filling of the reservoirs from the Bear River and conveyance to the District delivery points. Other types of potential system operations include combined storage filling and delivery, transfer of storage from one reservoir to another, pumped storage and potential hydropower development.

Given the complexity of Bear River hydrology and its integration into the BRD delivery system, this section is intended to provide a conceptual overview of operational scenarios that generally meet the basic storage and delivery requirements. It is anticipated that further engineering work will be completed to finalize design criteria, refine the hydrologic simulations and hydraulics, and develop more detailed operational scenarios.

Three basic operational scenarios are summarized below and shown schematically in Figure 11-3 (Volume II).

Scenario I. Filling Whites Valley Reservoir. Filling Fielding Reservoir and pumping to Whites Valley Reservoir

Scenario II. Delivering Water from Whites Valley Reservoir. Delivering water from Whites Valley Reservoir to WHWTP and/or Fielding Reservoir and/or Cutler Reservoir

Scenario III. Pumping Fielding and Delivering From Whites Valley Reservoir. Pumping out of Fielding Reservoir and/or delivering water from Whites Valley Reservoir to WHWTP and/or Cutler Reservoir

Included in each scenario is the option to convey water back to CWD either by pumping from Fielding Reservoir or by gravity flow from Whites Valley Reservoir into Cutler Reservoir.

Scenario I

This scenario includes pumping water from Fielding Reservoir to Whites Valley Reservoir for storage. The peak flow is 750 cfs, pumped from Fielding Reservoir; 680 cfs being pumped to Whites Valley Reservoir and 70 cfs diverted to southern delivery points early in the demand season. This scenario represents the peak operational design situation for which the pumps and pipeline to Whites Valley were sized.

Scenario II

This scenario is for the peak demand season when Whites Valley Reservoir is delivering 480 cfs. This scenario could also represent delivering flow to Fielding Reservoir or any combination of flow from Whites Valley Reservoir. Under this scenario, a hydropower system would be functional and generating power. The peak flow from Whites Valley Reservoir could be as high as 700 cfs (based on pipe size), but it is anticipated that only as much as 480 cfs would be necessary. The regulating storage reservoir on the Whites Valley Pipeline (at the hydropower plant) would be situated at an elevation that allows gravity flow to the WHWTP and Cutler Reservoir.

Scenario III

This scenario represents pumping from Fielding Reservoir to the WHWTP. This scenario could also include releases from Whites Valley Reservoir. This scenario would require a different size of pumps in the Fielding Pump Station to pump to southern delivery points at a peak of 480 cfs. These pumps could also provide the required head to deliver to CWD.

11.2.3 Pipeline Reaches and Sizing

Hydraulic calculations were performed for each of the scenarios to determine the pump and pipe sizes for the system conveyance facilities. The basic pipeline hydraulic reaches include:

- Bear River Pipeline:
    - Reach 1: Junction vault (Bear River Pipeline to Whites Valley Pipeline) to Brigham City
    - Reach 2: Brigham City to WHWTP
- Fielding Pump Station Pipelines
    - Suction Pipe
    - Discharge Pipe
- Whites Valley Pipeline
- Cutler Pipeline (deliveries to CWD)

The pipeline reaches were sized according to the delivery point locations, or by peak hydraulic capacity from which the pipelines are sized. A brief description of each reach is provided below.

Bear River Pipeline

The main pipeline from the Junction Vault (with Whites Valley Pipeline) to the WHWTP. It is divided into two reaches, north and south, split by the BRWCD delivery point at Brigham City.

Fielding Pump Station Pipelines

The short section of pipeline from Fielding Dam to Fielding Pump Station (pump suction pipe) to the Junction Vault (pump discharge pipe). These are critical pipelines conveying the highest flow rate (750 cfs).

Whites Valley Pipeline

Connects the Junction Vault near the Fielding Pump Station to Whites Valley Reservoir. This pipeline is bi-directional with a pumped capacity of 680 cfs and gravity peak flow of 480 cfs. This reach is split by the Whites Valley Booster Pump Station with the regulating reservoir (see Section 11.3.2). The flow capacity of the both reaches is the same, but the maximum design head pressures will be different for the two sections of pipe.

Cutler Pipeline

Pipeline from the Junction Vault to Cutler Reservoir for CWD water supply. The peak flow of 180 cfs assumes that there is no available in-stream flow from the Bear River in Cache County.

Figure 11-2 (Volume II) shows the locations of each reach. Table 11-2 provides a summary of flow rates and pipeline diameters.

Table 11-2
Pipeline Reach Summary

Pipeline Reach	Length (feet)	Peak Flow (cfs)	Diameter (inches)
Bear River Pipeline:			
North - Junction Vault to Brigham City	112,960	480	114
South - Brigham City to WHWTP	104,540	318	90
Fielding Pump Station Pipelines			
Suction Pipe	3,580	750	144
Discharge Pipe	1,580	750	120
Whites Valley Pipeline	92,070	680	120
Cutler Pipeline(	46,970	180	78

11.2.4 Pump Stations

The pump stations include the Fielding Pump Station and the Whites Valley Booster Pump Station. See Figures 11-1 and Figure 11-2 (Volume II). The following section provides a brief summary of each pump station, its purpose, sizing criteria, and operational requirements.

Fielding Pump Station

The Fielding Pump Station is located approximately 3,500 feet downstream of Fielding Dam near the Bear River. The pumps elevation is about 4,230 feet MSL. This pump station would need to meet the following criteria:

- Capable of pumping out of Fielding Reservoir (pumping peak flow at the run of the river), minimum reservoir head of 4,240 feet MSL
- Capable of pumping between 50 cfs and 680 cfs to the regulating reservoir at the Whites Valley Booster Pump Station at 4,680 feet MSL
- Capable of a maximum flow of 750 cfs and minimum flow of 50 cfs
- Capable of pumping between 50 cfs and 480 cfs to WHWTP at 4,258 feet MSL with a minimum delivery pressure of 40 psi

- Capable of pumping between 50 cfs and 180 cfs to Cutler Reservoir at 4,395 feet MSL

This pump station will need a wide range of operational heads and flow rates. The pump configuration (number and size of pumps) should allow for a variety of pumping scenarios, including minimum flows, and an 85-foot head range. The pump station should be configured with variable speed drives on many of the pumps for a range of flows.

Pump redundancy for the Fielding Pump Station was estimated to be an additional 30 percent in addition to the calculated brake horsepower, due to the range of pump sizes that will be installed to meet all operational conditions. This generally represents one or two standby pumps for each large pump size, and one standby for the minimum flow pump. The redundancy estimate also included the upsizing (rounding up) of the horsepower values to the next motor size increment.

The peak hydraulics under the various pumping scenarios for the Fielding Pump Station are discussed in Section 11.3.1.

Whites Valley Booster Pump Station

The Whites Valley Booster Pump Station is located about 11.5 pipe miles southwest from Fielding Pump Station. See Figure 11-1 (Volume II). The station elevation is about 4,665 feet MSL. This pump station site would contain the hydropower plant for power recovery when the reservoir is draining. The site would also have a 500 acre-feet regulating reservoir to provide an operational storage buffer for both pumping and hydropower operations.

This pump station would need to meet the following criteria:

- Capable of matching pumped flow rate ranges out of Fielding Reservoir, with the regulating reservoir as an operational buffer
- Capable of pumping between 50 cfs and 680 cfs to Whites Valley Reservoir with a large reservoir head variation of 380 feet (Whites Valley Dam height is approximately 362 feet)

This pump station would need to pump to a variety of delivery heads, as Whites Valley Reservoir has a large elevation variability. The pumps would likely be fitted with variable speed drives to match flows from the Fielding Pump Station.

The estimated pump redundancy for the Whites Valley Booster Pump Station was estimated to be an additional 25 percent in addition to the calculated brake horsepower. The redundancy estimate also included the upsizing (rounding up) of the horsepower values to the next motor size increment. The peak hydraulics under the various pumping scenarios for the Whites Valley Booster Pump Station are discussed in more detail in Section 11.3.2.

11.2.5 Hydraulic Profiles

Hydraulic profiles were developed for each major operational scenario. The hydraulic profiles were based on the general hydraulic criteria and assumptions listed previously. The profiles represent a conceptual basis for the system hydraulics. The following hydraulic profiles provide a more detailed illustration of each operational scenario than those provided in Figure 11-3 (Volume II). The following hydraulic profiles are provided in Volume II:

- **Figure 11-4**: Hydraulic Profile I - Fielding Pump Station Pumped to Whites Valley Reservoir
- **Figure 11-5**: Hydraulic Profile II - Fielding Pump Station Pumped to WHWTP
- **Figure 11-6**: Hydraulic Profile III - Whites Valley Reservoir Gravity Flow to WHWTP
- **Figure 11-7**: Hydraulic Profile IV - Whites Valley Reservoir Gravity Flow to Fielding Pump Station
- **Figure 11-8**: Hydraulic Profile V - Whites Valley Reservoir Gravity Flow to Cutler Reservoir
- **Figure 1-9**: Hydraulic Profile VI - Fielding Pump Station Pumped to Cutler Reservoir

Given the conceptual nature of the system hydraulics, limited discussion will be provided about the hydraulic profiles. The calculations that were performed for the profiles were the basis for the facilities sizing and the overall system cost estimate. The detailed hydraulic calculations for each of these scenarios are provided in the Appendix.

11.3 CONCEPTUAL DESIGN PUMP STATIONS

The scope of this study involves development of a concept layout of pump stations in order to provide a cost estimate. It is not intended to be an optimization or detailed study of pump station layouts and sizing. Further studies should be completed to optimize the sizing, type, and configuration of pumps that would be utilized.

The selection of the pumps for the pump stations was based on the recommendation from the Concept Report to utilize vertical turbine can-type pumps. These types of pumps have a pressurized intake pipe connected to a vertical "can" from which the vertical turbine pumps operate. The vertical turbine style pumps have the ability to pump high flows at high heads. The conceptual design of the pumps was based on manufacturer-supplied (Fairbanks Nijhuis) information on pump sizing, motor sizing, Variable Frequency Drives (VFD), and associated costs.

The pump sizing criteria was utilized to develop a conceptual layout of each pump station (pump size and number, redundancy, space requirements, and power usage). Drawings W-07 and F-06 (Volume II) include conceptual mechanical layouts for both pump stations.

The conceptual layouts for the pump station buildings include pump rooms, electrical and controls room, and a control room. The pump station buildings include features such as roof hatches, overhead cranes, piping and mechanical, large entry doors, concrete encased pump barrels and piping, and building utilities.

The two pump station sites generally include features such as large surge protection facilities, power connections to transmission system, substations, yard piping, metering vaults, pig launch vaults, pump station intake screens, maintenance buildings, storage yards, general utilities, security fencing, and access roads.

Table 11-3 provides a summary of the pump station sizing criteria.

Table 11-3
Pump Station Sizing Summary

Pipeline Reach Name	Peak Flow (cfs)	Total Design Head (feet)	Calculated Brake Horsepower	Upsizing and Redundancy Horsepower
Fielding Pump Station				
Pumping To Whites Valley Booster PS	750	595	61,100	19,500
Pumping To WHWTP	480	400	26,400	8,500
Pumping to Cutler Reservoir *	180	370	9,200	0
		Total Horsepower Fielding PS	**124,700**	
Whites Valley Booster Pump Station	680	800	75,100	18,900
		Total Horsepower Whites Valley Booster PS	**94,000**	

*Horsepower for the pumping to Cutler Reservoir is included with the pumps for pumping to WHWTP, since they have similar total design head (TDH) requirements.

11.3.1 Fielding Pump Station

Drawing F-06 (Volume II) provides a layout of the Fielding Pump Station and includes a basic plan view of the pump station building with pumps, piping, and valves. The drawing also includes the conceptual pump configuration for the initial pump station sizing for 700 cfs used in developing the cost estimate. The drawing does not fully depict the higher flow 750 cfs (higher horsepower) pump station configuration as outlined in this chapter. Figure 7-9 (Volume II) provides a schematic of the Fielding Pump Station and associated facilities.

The Fielding Pump Station site would be located below the dam and would utilize the full head of the reservoir. It must also be able to pump from an almost empty reservoir with little or no head. One of the challenges of this site is to provide adequate screening of the intake to prevent damage to the pumps. The reservoir is on the Bear River, which can carry a large sediment and debris load. Proper screens on the intake (reservoir outlet structure) should be designed to prevent debris damaging or plugging the pumps or downstream facilities.

Another challenge with this site would be operating a large pump station near the river, likely just above river flood stage. High groundwater could make construction difficult and costly. The site will also require measures to address any settlement that may occur.

11.3.2 Whites Valley Booster Pump Station

Drawing W-07 (Volume II) provides a layout for the Whites Valley Booster Pump Station and a basic plan view of the pump station building with pumps, piping, and valves. The drawing also includes the conceptual pump configuration for the initial pump station sizing used in developing the cost estimate. It should be noted that the drawing does not fully depict the higher head (higher horsepower) pump station configuration, as outlined in this chapter. Figure 7-5 (Volume II) provides a schematic of the Whites Valley Booster Pump Station and associated facilities.

The larger Whites Valley Reservoir has a significant amount of head difference from empty to full reservoir. This presents a significant challenge to the design of the Whites Valley Booster Pump Station. The initial design of the pump station in this study was based on a smaller or lower head reservoir. The added reservoir head for the larger reservoir may require that the pump station be configured with an added set of higher head pumps for use when the reservoir is full. Further study and optimization should be performed prior to design of the pump station.

The Whites Valley Booster Pump Station site would also contain a large hydropower plant and a 500 acre-foot regulating reservoir. The pumps would be configured to pump directly out of the regulating reservoir, matching the flows from Fielding Pump Station. The pump station intake will be fitted with intake screens.

11.4 CONCEPTUAL DESIGN PIPELINES

The major pipeline design features include the design diameter and expected maximum pressures, based on the hydraulic calculations used to develop the hydraulic profiles. The anticipated maximum pressures for the pipeline reaches are summarized in Table 11-4. These were based on the maximum pressures listed on the conceptual system configuration and initial assumptions. These should be refined during a preliminary design phase.

Table 11-4
Pipeline Design Summary by Pipeline Reach

Pipeline Reach Name	Diameter (inches)	Maximum Design Pressure (psi)	Maximum Pressure Design Scenario
Bear River Pipelines:			Full Whites Valley Regulating Reservoir; Gravity Flow to WHWTP
North - Junction Vault to Brigham City	114	200	
South - Brigham City to WHWTP	90	200	
Fielding Pump Station Pipelines:			
Suction Pipe	144	30	Full Fielding Reservoir Head
Discharge Pipe	120	240	Fielding PS Pumping to Full Whites Valley Reservoir Regulating Reservoir Head
Whites Valley Pipelines:			
Junction Vault to Booster PS	120	215	Fielding PS Pumping to Full Whites Valley Regulating Reservoir Head

Pipeline Reach Name	Diameter (inches)	Maximum Design Pressure (psi)	Maximum Pressure Design Scenario
Booster PS to Whites Valley Reservoir	120	335	Whites Valley Booster PS Pumping to Full Whites Valley Reservoir Head
Cutler Pipeline	78	190	Full Whites Valley Regulating Reservoir Gravity Flowing to Cutler Res

A significant portion of the conceptual design for the pipeline was performed in detail in the Concept Report. Refer to the Concept Report for detailed information on the conceptual design topics listed below.

1. Pipe Materials and Design
    a. Pipe Materials Evaluation
    b. Pipe Coating and Lining Evaluations
    c. Pipe Joints
    d. Pipe Wall Thickness (not performed as part of this conceptual design)
    e. Pipe Zone Backfill Evaluation
2. Pipeline Plan and Profile Sheets (Concept Report - Volume II)
3. Geotechnical Evaluation and Recommendations
    a. Existing Data Review
        i. Regional Geology
        ii. Site Surficial Geology
        iii. Seismicity and Faults
        iv. Landslides
        v. Groundwater and Liquefaction
    b. Geologic/Geotechnical Reconnaissance
        i. General Surface Topographic Conditions
        ii. Surficial Geologic Conditions
        iii. Shallow Groundwater
        iv. Summary of Identified Potential Geographic Hazards
    c. Geologic and Geotechnical Conditions/Constraints and Construction Considerations
        i. Geologic Materials (Lake Deposits and Alluvium)

ii. Seismicity
iii. Quaternary Faults
iv. Landslides
v. Shallow Groundwater
vi. Liquefaction and Lateral Spreading

11.5 CONCEPTUAL DESIGN DAMS

The following section provides additional details for potential dam and reservoir facilities as part of the overall BRD system.

11.5.1 Fielding Dam and Reservoir

The 70,000 acre-foot Fielding Dam and Reservoir layout and associated facilities configurations are included Drawings F-01 to F-06 (Volume II). The conceptual design details and layouts are summarized in Chapter 7. The reservoir footprint would include some significant challenges. The spillway intake channel and regulating gate structure are a significant portion of the costs. The excavation material taken from the spillway inlet channel could be utilized in the dam embankment. Challenges for overall construction include a river diversion and dewatering during construction of the cutoff and lower portions of the spillway discharge structure. Another significant challenge at this site would be mitigation of settlement and consolidation of foundations materials under the dam embankment.

Future investigations at this site should include additional geotechnical studies at the dam site and the steep sloped areas of the reservoir pool. The potential for landslides and settlement should be determined, as well as determining the materials near the outlet tunnel. New development has been occurring within the floodplain of the Bear River. Real estate acquisition in the near future should be considered to reduce future costs.

11.5.2 Whites Valley Dam and Reservoir

The 540,000 acre-foot Whites Valley Dam and Reservoir and associated facilities are similar to those listed in Chapter 7 for the smaller dam sizes (170,000 acre-feet and 400,000 acre-feet options). See Figure 11-10 (Volume II) for a site plan. The following section provides additional details of the site layout and basic design features.

Dam Embankment

The design of the dam embankment (slopes, zones, and geometry) would be similar to the smaller dam sizes (See Drawings W-1 through W12). The dam embankment would have significantly more earth and rock fill than the smaller reservoir options. The crest elevation would be about 5,402 feet MSL (362 feet high). The site topography and the dam configuration would require a 20-foot high saddle dam directly to the east of the main dam. Since the dam structure sits over the top of bedrock hills and there will be increased hydraulic head, there likely will be more grouting required of the abutment and saddle dam foundations when compared to the smaller dam options.

A comparison of the three potential dam sizes summarized in Table 11-5.

Table 11-5
Whites Valley Dam Size Comparison

Whites Valley Reservoir (acre-feet) Storage	Dam Crest Elevation (feet MSL)	Dam Hydraulic Height (feet)	Dam Crest Length (feet)	Dam Earth/Rock Fill Volume (million cubic yards)
170,000	5,270	230	1,450	4.8
400,000	5,360	320	2,150	10.4
540,000 *	5,402	362	2,875 + 475 (saddle)	16.0 (low range) 18.0 (high range)

* Total earth/rock fill volume is a rough estimate, as no conceptual design was performed for this option. The fill volume for the saddle dam fill is included in total.

Dam Low Level Outlet

The outlet tunnel for a larger dam would be the same size as ae smaller dam. It would potentially have different intake and regulating gate structures due to the higher head. A variable level screened intake, with a regulating structure under the centerline of the dam, may be considered for the larger dam.

Spillway

The spillway would likely be located further west (on the right abutment of the dam) in a local drainage channel. The spillway configuration would essentially have the same configuration the spillway for the smaller dam. There would likely be no required improvements on the down-slope of the spillway as the flow would be contained within the small drainage, away from the right embankment.

Reservoir Area

The larger reservoir footprint would cover approximately 3,550 acres. With the larger reservoir area and higher reservoir operating level, there will likely be more clay lining needed to reduce reservoir seepage losses. Further study of the reservoir basin and abutment geology should be performed to understand and quantify potential reservoir leakage.

Another benefit of the off-stream Whites Valley site would be reduced sedimentation in the reservoir.

CWD Delivery Facilities

In the Concept Report, a conceptual pump and pipeline system was developed to distribute the peak flow of 180 cfs to CWD. Figure 11-11 (Volume II) shows the conceptual pumping and distribution system. The facility sizing, location, and expected delivery flow rates are outlined in the Concept Report, based on input from the CWD. Water would be delivered to the major irrigations systems Cache Valley for water exchanges. Refer to the Appendix of the Concept Report for detailed calculations and assumptions.

11.6 MULTIPURPOSE BRD SYSTEM BENEFITS

Multipurpose projects using reservoir storage may be constructed and for a wide variety of benefits. Some of the benefits of a reservoir include:

- M&I water supply to meet growing needs
- Irrigation water supply
- Water quality improvement
- Flood control protection
- Fish and wildlife habitat enhancement downstream of reservoirs due to minimum flows
- Watershed health
- Hydroelectric power generation
- Recreation

In addition, ROW associated with the pipelines could be used for pedestrian and bicycle trails, motorized transportation corridors, wildlife habitat preservation and migration corridors, other major utility corridors, noise buffers for residential or recreational features, and open space requirements for adjacent developments. The Bear River Development Act specifically recognizes the potential use of the facilities for recreation, fish and wildlife benefits, and flood control.

DWRe has met with agencies and stakeholders responsible for irrigation, transportation, transit, water quality, wildlife, wetlands protection, and trail development. These potential benefits will be considered as planning activities continue.

CHAPTER 12

ENVIRONMENTAL REVIEW

12.0 ENVIRONMENTAL REVIEW

Existing environmental information was collected to identify the major environmental constraints in the study area. This data gathering was supplemented by a brief field reconnaissance of the study area. Data included identification of habitat for wildlife and threatened and endangered species, water resources (including wetlands, floodplains, and other waters), cultural and historic resources, and socioeconomic considerations.

12.1 DESCRIPTION OF PIPELINE ALIGNMENT REVIEW

For the data collection effort, the pipeline alignment was divided into ten sections (Figure 12-0 Volume II). A 200-foot wide corridor centered on the alignment was used as the boundary of the study area for analyzing potential impacts on environmental resources. Each section was then assessed for habitat for wildlife and threatened and endangered species, water resources (including wetlands, floodplains, and other waters), cultural and historic resources, and pertinent socioeconomic considerations.

12.1.1 Land Use

Within the Geographic Information System (GIS) environment, three layers were used to categorize the land types within the study area. First, wetland data was compiled using the US Fish and Wildlife Service's National Wetland Inventory (NWI) (Utah AGRC 2017a). Next, in order to classify land use and cover type beyond wetlands and waters, data from a water usage-related polygon map, published annually by the Utah Division of Water Resources, was utilized (Utah AGRC 2017b). This data depicts the types and extent of irrigated crops, wet/open water areas, dry land agriculture, pasture, and urban (residential/commercial/industrial) areas. In areas where this data was not available (a small portion of the alignment in Section 1), a statewide distribution of dominant vegetation species in Utah was used, provided by the Utah Division of Wildlife Resources (Utah AGRC 2001).

In addition to the GIS analysis, biologists conducted brief field reconnaissance on July 21, 22, and 28, 2010, and on June 30, 2017 by driving the study area, making notes of habitat types on aerial maps, and taking photos along the alignment. Public ROW and canal maintenance roads provided access to the vast majority of the alignment. Where access was restricted, the alignment was observed from a short distance away. Field notes and GIS designated land types were compared for accuracy.

The land cover types were consolidated in six groups according to their capacity to provide wildlife habitat. The habitat groups include agricultural cropland, hayfields, pasture, shrubland, wetlands/waters/floodplains, and urban areas. The following subsections provide brief descriptions of each habitat type.

Agricultural Cropland

An area was categorized as agricultural cropland if it was planted in anything other than alfalfa/hay or plowed (not cleared for development). Croplands are important to the environment because raptors readily forage in them and game birds often forage and nest in croplands.

Hayfields

All areas of perennial hay crops were classified, including grass or alfalfa, with evidence of routine hay cutting as hayfields (as opposed to a pasture, which is not cut uniformly). Hayfields generally provide similar foraging opportunities as pastures and wet meadows, but the routine cutting prevents nesting or breeding by most wildlife. Hayfields along the alignment were generally large, irrigated alfalfa fields adjacent to croplands. Raptors and kit foxes both prey opportunistically on rodents and will readily hunt in hayfields.

Pasture

Pasture habitat type was defined by perennially vegetated areas used primarily to graze livestock. Similarly, pastures were differentiated from grass hayfields based on animal grazing in pastures, versus routine mechanical cutting in hayfields. Pastures provide habitat for many different wildlife species, depending on their size and condition.

Shrubland

Shrubland habitats in the upland study area are limited to hillsides near Whites Valley in Section 1. This habitat contained mostly grasses with some sagebrush (Artemisia tridentata ssp.). The area is primarily undeveloped open space with agriculture/cropland in the valleys.

Wetland/Waters/Floodplains

The wetlands/waters/floodplains category includes wetlands, floodplains, open water, and riparian areas. Wetlands were defined as soils that are saturated seasonally or year-round, and vegetation that is adapted to saturated soils. Wetlands provide valuable habitat for many species of wildlife and plants. Of particular importance is the Bear River Bay, which is downstream of the proposed facilities and provides habitat for millions of migratory birds and a popular recreation area.

Floodplain habitats are valuable because they are somewhat limited in the arid West. Floodplains also provide important migratory corridors through developed and fragmented wildlife habitats. As opposed to an open floodplain, riparian habitat is more structurally complex, with woody overstory vegetation. Riparian corridors provide very high-value habitat for wildlife, and many species use them as migration corridors and for cover while accessing water and food.

The streams and canals are classified as open water. Most of the natural streams in the study area provide poor quality habitat for the native fishes and amphibians due to flow alterations, eutrophication, and sedimentation (Bosworth 2003, USFWS 2001, Sigler and Sigler 1996). Because they do not flow year round, canals usually provide very poor quality habitat for most native fishes and amphibians. Canals can be regulated as jurisdictional waters of the United States, however, because they can provide hydrology to natural streams and other jurisdictional water bodies.

Urban

Developed habitats were defined as spaces in which most of the area is covered in pavement, structures, or imported fill material. Developed habitat provides the lowest habitat value for all wildlife considered in this analysis. Raptors and other migratory birds may be found in developed areas.

12.1.2 Wildlife

The Utah Wildlife Action Plan (Utah Wildlife Action Plan Joint Team 2015) and the Utah Conservation Data Center (UDWR 2015) were used to generate a list of state-sensitive and federally-listed wildlife species that may occur within the study area. The Utah Wildlife Action Plan (Plan) identifies certain state-sensitive species and their habitats. The Plan identifies threats to these species and provides guidance for improving populations and habitats in an effort to reduce and prevent listings under the Endangered Species Act. The Utah Conservation Data Center provides a list report of Utah's sensitive species. Each resource provides lists by county. Table 12-1 provides the list of sensitive species considered and their protection status for Box Elder and Weber counties.

Table 12-1
Sensitive Wildlife Species in Box Elder and Weber Counties, Utah
(Utah Conservation Data Center)

Common Name	Scientific Name	Utah Conservation Data Center	Utah Wildlife Action Plan
Birds			
American White Pelican	*Pelecanus erythrorhynchos*	SPC*	Y
Bald Eagle	*Haliaeetus leucocephalus*	SPC	Y
Bobolink	*Dolichonyx oryzivorus*	SPC	NA
Burrowing Owl	*Athene cunicularia*	SPC	Y
Caspian Tern	*Sterna caspia*	NA	Y
Ferruginous Hawk	*Buteo regalis*	SPC	Y
Flammulated Owl	*Otus flammeolus*	NA	Y
Golden Eagle	*Aquila chrysaetos*	NA	Y
Grasshopper Sparrow	*Ammodramus savannarum*	SPC	NA
Greater Sage-grouse	*Centrocercus urophasianus*	SPC	Y
Lewis's Woodpecker	*Melanerpes lewis*	SPC	Y
Long-billed Curlew	*Numenius americanus*	SPC	NA
Mountain Plover	*Charadrius montanus*	SPC	NA
Northern Goshawk	*Accipiter gentilis*	CS**	NA
Peregrine Falcon	*Falco peregrinus*	NA	Y

Common Name	Scientific Name	Utah Conservation Data Center	Utah Wildlife Action Plan
Sharp-tailed Grouse	*Tympanuchus phasianellus*	SPC	
Short-eared Owl	*Asio flammeus*	SPC	NA
Snowy Plover	*Charadrius nivosus*	NA	Y
White-faced Ibis	*Plegadis chihi*	NA	Y
Yellow-billed Cuckoo	*Coccyzus americanus*	S-ESA***	Y
Fish			
Bluehead Sucker	*Catostomus discobolus*	CS	Y
Bonneville Cutthroat Trout	*Oncorhynchus clarkii utah*	CS	Y
Lahontan Cutthroat Trout	*Oncorhynchus clarkii henshawi*	S-ESA	NA
Least Chub	*Iotichthys phlegethontis*	CS	Y
Northern Leatherside Chub	*Lepidomeda copei*	SPC	Y
Yellowstone Cutthroat Trout	*Oncorhynchus clarkii bouvieri*	SPC	Y
Invertebrates			
California Floater	*Anodonta californiensis*	SPC	Y
Desert Mountainsnail	*Oreohelix peripherica*	SPC	NA
Fat-whorled Pondsnail	*Stagnicola bonnevillensis*	NA	Y
Lyrate Mountainsnail	*Oreohelix haydeni*	SPC	NA
Northwest Bonneville Pyrg	*Pyrgulopsis variegata*	SPC	Y
Utah Physa	*Physella utahensis*	SPC	Y
Western Pearlsell	*Margaritifera falcata*	SPC	NA
Amphibians			
Columbia Spotted Frog	*Rana luteiventris*	NA	Y
Great Plains Toad	*Bufo cognatus*	SPC	NA
Northern Leopard Frog	*Rana pipiens*	NA	Y
Western Toad	*Bufo boreas*	SPC	Y
Mammals			
Kit Fox	*Vulpes macrotis*	SPC	Y
Preble's Shrew	*Sorex preblei*	SPC	Y
Pygmy Rabbit	*Brachylagus idahoensis*	SPC	Y
Townsend's Big-eared Bat	*Corynorhinus townsendii*	SPC	NA
Reptiles			
Smooth Greensnake	*Opheodrys vernalis*	SPC	NA

Common Name	Scientific Name	Utah Conservation Data Center	Utah Wildlife Action Plan
Plants			
Ute Ladies' Tresses	*Spiranthes diluvialis*	LT****	NA

*SPC Wildlife species of concern.
**CS Species receiving special management under a Conservation Agreement in order to preclude the need for Federal listing
***S-ESA Federally-listed or candidate species under the Endangered Species Act.
****LT-Listed threatened.
Y-Yes, NA-Not Applicable

12.1.3 Cultural And Historic Resources

The National Register of Historic Places (nationalregisterofhistoricplaces.com) was researched for a list of known historical sites and districts within the study area in order to identify any potential sites that could be impacted by the BRD.

12.1.4 Socioeconomic Considerations

Socioeconomic considerations were identified and defined by locating parks, schools, trails, churches, and gathering places within the study area. The alignment crosses the United States Fish and Wildlife Service's Bear River Migratory Bird Refuge (BRMBR), which has designated public hunting areas and is a popular recreational bird watching area. The Block B hunting unit in the BRMBR is crossed by the alignment. Since the alignment crosses the hunting area near the edge (near I-15 and a dirt access road) direct hunting impacts would most likely be from restricted access to hunting areas during construction and indirect impacts from construction noise. The alignment will also cross the Weber River Parkway Trail in Weber County, which would be disrupted during construction. However, normal activity would resume upon construction completion.

Pipeline construction could temporarily affect parks, schools, and churches near the study area by creating noise, dust, and safety concerns. Construction could also temporarily influence ditches and canals used to irrigate nearby farm fields.

12.2 SUMMARY OF POTENTIAL ENVIRONMENTAL IMPACTS (PIPELINE)

The habitat for wildlife and threatened and endangered species, water resources (waterways, floodplains, and wetlands), cultural and historic resources, and socioeconomic considerations present within each alignment by constructing the pipeline are described for each section of the alignment in the following sections. In addition to the direct impacts of the pipeline and reservoir(s), indirect impacts could be associated with BRD system operations. More studies will be required to better define both construction impacts and operational impacts associated with the pipeline corridor prior to permitting.

12.2.1 Section 1 – Whites Valley to Garland

Section 1 begins in Whites Valley and follows the canyon road south through agricultural/crop fields, shrublands, and an agricultural protection area until reaching Interstate 84. The alignment crosses I-84 and runs adjacent on the south side of the highway through several more agricultural/fields and agricultural protection areas until it approaches Rocky Point Road in Bothwell. It then follows the Highline Canal along 1020 N in Garland until just past I-15, where the Highline Canal merges with the West Canal. The alignment then follows the West Canal running north-northeast until 13600 N in Garland. At 13600 N, it runs east all the way to 4400 West in Garland. Throughout this segment, the alignment crosses numerous urban areas with homes, agricultural/croplands, pasture, and agricultural protection areas. It also crosses the Malad River and associated wetlands and floodplains. Figures 12-1 through 12-4 (Volume II) show Section 1. At 4400 West, there are two potential branches from the alignment that would connect to the Bear River (Section 99, Figure 12-5, Volume II).

12.2.2 Section 2 – Garland to Tremonton

Section 2 begins at 13600 North and about 4400 West in Garland. It runs south adjacent to the Bear River/Corinne Canal until approximately 12000 North in Tremonton. The alignment and canal continue south running adjacent to State Route 13. Section 2 crosses several agricultural/croplands, hayfields, pastures, agricultural protection areas, and wetlands/waters. There are also several homes along this portion of the alignment. Section 2 terminates near 11700 North and State Route 13 where the canal crosses to the west side of State Route 13. Section 2 is shown on Figure 12-4 (Volume II).

12.2.3 Section 3 –Tremonton to Elwood

Section 3 begins at approximately 11700 North and State Route 13 in Tremonton. It follows the Bear River/Corinne Canal south through Elwood where it crosses under I-15. It follows the Bear River/Corinne Canal and State Route 13 until approximately 8000 North. Land cover types indicate that this part of the alignment is mostly urbanized with some water features associated with the canal. Section 3 is shown on Figures 12-4 and 12-5 (Volume II).

12.2.4 Section 4 – Elwood to Bear River City

Section 4 begins at about 8000 North and State Route 13 in Elwood. The alignment runs south following State Route 13 until about 7900 North where it continues south along 5200 West. This section of the alignment runs adjacent to 5200 West, through urban areas, agricultural/croplands, pastures, and hayfields, until 5575 North in Bear River City. Section 4 is shown on Figures 12-5 and 12-6 (Volume II).

12.2.5 Section 5 – Bear River City

Section 5 starts at 5575 North and 5200 West in Bear River City. It runs south along 5200 West through agricultural/croplands, hayfields, and pastures. It also crosses the Malad River and adjacent wetlands and floodplains. Section 5 continues south until 4000 North in Bear River City and ends where the railroad intersects 4000 North. Section 5 is shown on Figures 12-6 and 12-7 (Volume II).

12.2.6 Section 6 – Bear River City to Corinne

Section 6 begins where the railroad intersects 4000 North in Bear River City. From here, it heads southeast through hayfields and urbanized areas following the railroad alignment, eventually running parallel with State Route 13. It follows the railroad and State Route 13 through Corinne, crossing the Bear River, and ends at 2600 West. Much of this section is urbanized with some agricultural/croplands. Section 6 is shown on Figures 12-6 and 12-7 (Volume II).

12.2.7 Section 7 – Corinne, Brigham City, and Perry

Section 7 starts at State Route 13 and 2600 West in Corinne where it turns south. It follows 2600 West for a short distance, and then heads southeast, adjacent to an unnamed dirt road. The alignment crosses multiple agricultural croplands, the Black Slough, and a portion of the BRMBR. The alignment continues southeast until approximately the junction of I-15 and Highway 91 in Brigham City. From this point, the alignment runs adjacent to the I-15 Frontage Road on the west side of the freeway through agricultural/croplands and urbanized areas. Section 7 ends at the junction of the I-15 Frontage Road and 2700 South in Perry. Section 7 is shown on Figures 12-8 and 12-9 (Volume II).

12.2.8 Section 8 – Union Pacific Railroad (Perry to Farr West)

Section 8 begins at the junction of the I- 15 Frontage Road and 2700 South in Perry. From here, the alignment heads east, adjacent to 2700 South, until the railroad crossing. The alignment then heads south paralleling the east side of the rail line. The alignment continues adjacent to the railroad while crossing multiple croplands and hayfields and some urban areas, as well as a number of potential wetlands and other waters of the US, including Willard Creek. Section 8 then diverges from the railroad line and turns east at Center Street in Willard. The alignment continues along Center Street until 400 West, where it turns south. It runs adjacent to the west side of 400 West through hayfields until it veers southeast at approximately 100 South. The alignment then travels southeast through multiple hayfields, pastures, and other agricultural/croplands until approximately 900 South in Willard. At this point, the alignment runs south adjacent to the west side of the railroad through more agricultural/crops areas, hayfields, wetlands/waters, and urban areas until 7800 South in Willard. At this point the alignment turns west and follows 7800 South over to the west side I-15 ROW. Section 8 then follows the west side of I-15 until approximately the junction of State Route 126 and 4000 North in Farr West. Section 8 is shown on Figures 12-9 and 12-10 (Volume II).

12.2.9 Section 9 – Farr West to Ogden

Section 9 starts on the west side of State Route 126 at approximately 4000 North in Farr West. It continues south through multiple urban areas until it reaches State Route 134. The alignment then heads south following the east side of State Route 126. This section of the alignment is mostly urban and construction could affect numerous homes, several businesses, a church, a fire station, the Farr West City Park, and a school. It also crosses the Willard Canal, Six Mile Creek, Four Mile Creek, and the North Slaterville Canal. The alignment diverts to the west side of State Route 126 at approximately 300 South in Ogden. From here it continues south through more urban and agricultural/crop lands and crosses Mill Creek, the South Slaterville Canal, Warren Canal, and the Weber River. It also crosses the Weber River Parkway Trail, which runs adjacent to the Weber River. Just past the Weber River, the alignment again crosses to the east side of State Route 126. From there, it follows the road south and crosses West Weber Canal, Layton Canal, and Hooper Canal. It also crosses several agricultural/crop fields and numerous businesses. At Wilson Lane, the alignment veers to the southwest across croplands. It continues south and then southwest adjacent to the Layton Canal through pastures, hayfields, and several urban areas. The alignment heads due west where the Layton Canal crosses 2550 South in Ogden. Section 9 then follows 2550 South until it ends at 2700 West in Ogden. Section 9 is shown on Figures 12-10, 12-11, and 12-12 (Volume II).

Table 12-2 presents acreages of potential impact to each habitat type.

Table 12-2
Habitat Types within the Pipeline Alignment Study Area

Section	Habitat Type (acres)						
	Agricultural/ Cropland	Hayfields	Pasture	Shrubland	Urban	Wetlands/ Water/ Floodplains	Sub-Total
1	169.43	26.32	6.37	51.64	142.67	13.53	409.97
99	10.27	0.20	3.33	0	10.47	0.25	24.52
2	17.65	14.79	7.08	0	9.12	13.51	62.16
3	4.09	3.62	0.08	0	86.05	19.66	113.50
4	26.11	18.12	1.36	0	28.84	1.41	75.83
5	15.07	14.60	1.78	0	12.47	6.38	50.31
6	10.38	13.82	2.16	0	80.94	2.82	110.12
7	43.17	1.90	17.11	0	28.19	40.64	131.00
8	20.77	43.84	53.17	0	88.44	20.04	226.26
9	23.40	10.89	11.06	0	163.57	8.22	217.14
Total	340.34	148.10	103.50	51.64	650.76	126.47	1,420.81

12.3 SUMMARY OF POTENTIAL WETLAND IMPACTS (PIPELINE)

Based on NWI mapping and a 200-foot wide construction corridor, the alignment could affect approximately 126 acres of wetlands, flood plains, riparian corridors, streams, and canals. The affects would typically only be temporary, as the wetlands would recover after construction.

Indirect impacts to wetlands might also include impacts to the floodplain wetlands along the Bear River and Malad River through the potential loss of hydrology from the diversion of flow. However, the hydrologic sources of these areas will be determined. The indirect impacts of the diversion on floodplain wetlands have not been analyzed. Most of these wetlands likely depend in some way, even if indirectly, on floodplain recharge from the Bear River. The BRMBR and the Bear River Bay wetland complexes receive water from the Bear River and provide highly important habitat for migratory birds. Depending on the timing, diverting water from the Bear River could potentially affect portions of the large wetland complexes downstream. Permitting will require detailed analysis.

12.4 SUMMARY OF POTENTIAL ENVIRONMENTAL IMPACTS OF POTENTIAL RESERVOIR SITES

The six potential reservoir sites were studied as part of this effort: Above Cutler, Cub River, Temple Fork, Fielding, Whites Valley, and South Willard. The Washakie Reservoir site was previously studied by DWRe. Above Cutler, Cub River, and Temple Fork are all located in Cache County. Fielding and Whites Valley are located in Box Elder County. South Willard straddles both Box Elder and Weber Counties. Figure 12-13 (Volume II) provides an overview map of the potential sites.

Publically available information was gathered on wildlife habitat including threatened, endangered, and sensitive species occurrences, wetlands and water resources, soils, prime and unique farmlands, and recreational and historic places. A biologist with HDR conducted site visits on September 5 & 6, 2012 by observing the inundation areas, making notes of wetlands, habitat types, land use, and social/recreational resources on the aerial maps, and taking photos. Consultants mapped wetlands in each reservoir site in 2015 through a combination of desktop review of NWI data, aerial imagery interpretation, and field visits. Public roads provided access to the majority of the inundation areas. Where access was restricted, the area was observed from a short distance away.

Wetlands

NWI data, aerial imagery interpretation, and field visits were used to determine the acres of wetlands within the potential inundation areas of each reservoir site. Data was imported into a Geographic Information System (GIS) along with the inundation boundaries of each reservoir to calculate approximate wetland acreage and wetland type within each reservoir site.

Wildlife

The Utah Wildlife Action Plan (Utah Wildlife Action Plan Joint Team 2015) and the Utah Conservation Data Center (UDWR 2015) were used to generate a list of state-sensitive and federally-listed wildlife species that may occur within the reservoir sites. The Utah Wildlife Action Plan identifies certain state-sensitive species and their habitats. The plan identifies threats to these species and provides guidance for improving populations and habitats in an effort to reduce and prevent listings under the Endangered Species Act. The Utah Conservation Data Center provides a list report of Utah's sensitive species. Each resource provides lists by county. Table 12-2 provides the list of sensitive species considered and their protection status for Box Elder and Weber Counties, Utah. Table 12-3 provides the list of sensitive species for Cache County, Utah.

Table 12-3
Sensitive Wildlife Species in Cache County, Utah
(Utah Conservation Data Center)

Common Name	Scientific Name	Utah Conservation Data Center	Utah Wildlife Action Plan
Birds			
American Three-toed Woodpecker	*Picoides dorsalis*	SPC	NA
American White Pelican	*Pelecanus erythrorhynchos*	SPC	Y
Bald Eagle	*Haliaeetus leucocephalus*	SPC	Y
Black Swift	*Cypseloides niger*	SPC	NA
Bobolink	*Dolichonyx oryzivorus*	SPC	NA
Boreal Owl	*Aegolius funereus*	NA	Y
Burrowing Owl	*Athene cunicularia*	SPC	Y
Caspian Tern	*Sterna caspia*	NA	Y
Ferruginous Hawk	*Buteo regalis*	NA	Y
Flammulated Owl	*Otus flammeolus*	NA	Y
Grasshopper Sparrow	*Ammodramus savannarum*	SPC	NA
Greater Sage-grouse	*Centrocercus urophasianus*	SPC	Y
Lewis's Woodpecker	*Melanerpes lewis*	SPC	Y
Long-billed Curlew	*Numenius americanus*	SPC	NA
Northern Goshawk	*Accipiter gentilis*	CS	NA
Peregrine Falcon	*Falco peregrinus*	NA	Y
Sharp-tailed Grouse	*Tympanuchus phasianellus*	SPC	NA
Short-eared Owl	*Asio flammeus*	SPC	NA
Snowy Plover	*Charadrius nivosus*	NA	Y
Yellow-billed Cuckoo	*Coccyzus americanus*	S-ESA	Y
Fish			
Bluehead Sucker	*Catostomus discobolus*	CS	NA
Bonneville Cutthroat Trout	*Oncorhynchus clarkii utah*	CS	Y
June Sucker	*Chasmistes liorus*	S-ESA	Y
Least Chub	*Iotichthys phlegethontis*	CS	Y
Invertebrates			
California Floater	*Anodonta californiensis*	SPC	Y
Deseret Mountainsnail	*Oreohelix peripherica*	SPC	NA
Green River Pebblesnail	*Fluminicola coloradoensis*	NA	Y
Lyrate Mountainsnail	*Oreohelix haydeni*	SPC	Y
Rocky Mountain Duskysnail	*Colligyrus greggi*	NA	Y
Amphibians			
Great Plains Toad	*Bufo cognatus*	SPC	NA
Northern Leopard Frog	*Rana pipiens*	NA	Y
Western Toad	*Bufo boreas*	SPC	Y
Mammals			

Common Name	Scientific Name	Utah Conservation Data Center	Utah Wildlife Action Plan
Canada Lynx	*Lynx canadensis*	S-ESA	Y
Fringed Myotis	*Myotis thysanodes*	SPC	Y
Pygmy Rabbit	*Brachylagus idahoensis*	SPC	NA
Townsend's Big-eared Bat	*Corynorhinus townsendii*	SPC	NA
Wolverine	*Gulo gulo*	NA	Y
Plants			
Maguire Primrose	*Primula maguirei*	LT	NA
Ute Ladies' Tresses	*Spiranthes diluvialis*	LT	NA

*SPC Wildlife species of concern.
**CS Species receiving special management under a Conservation Agreement in order to preclude the need for Federal listing
***S-ESA Federally-listed or candidate species under the Endangered Species Act.
****LT-Listed threatened.
Y-Yes, NA, Not Applicable

Farmlands and Soils

The Natural Resources Conservation Service (NRCS) soil survey and classification were researched to identify unique and prime farmland soils within each reservoir inundation area (except for the South Willard site).

Social and Recreational Resources

No formal surveys were conducted for social and recreational resources. During the on-line searches and site visits, obvious resources such as parks, trailheads, churches, schools, and historic markers were examined. Publically available maps were utilized to see if additional social and recreational resources were located within or near the inundation boundaries of each reservoir site.

12.4.1 Reservoir Sites Land Type

The following sections describe the general land type of the reservoir sites. See Table 12-4 for a summary of wetland acreage for each site.

Whites Valley

The drainage from the valley generally drains southward and is dry year round except during large storm events. The valley contains mostly seasonal dry farm wheat and grasslands surrounded by wild land sagebrush. There are about 80 acres of prime or unique farmland identified and about 26 acres of emergent marsh wetlands were mapped. The reservoir area is situated entirely on private lands.

Fielding Reservoir

The reservoir basin is mostly comprised of heavily vegetated river floodplain, with occasional farm fields and structures, with the notable exception of a water ski park residential development.

There are roughly 848 acres of prime or unique farmlands. The site is surrounded by mostly agricultural development, with an occasional home and farm structure, with smaller farm roads. There are approximately 298 acres of emergent marsh wetland and 485 acres of open water mapped in the area.

Temple Fork

The drainage from Temple Fork Creek generally drains westward from the surrounding mountains. The reservoir basin area contains mostly sage and grasses, with thick pine and aspen groves on the north facing slopes and in the small drainages. No prime or unique farmlands were identified in the area. There are approximately 5 acres of emergent marsh wetlands and 7 acres of open water identified in the area. The site exists entirely on US Forest Service lands. In a meeting (January 2015) with Utah Division of Wildlife Resources (DWR), DWR aquatics staff indicated that a genetics study has been conducted on Bonneville Cutthroat at Spawn Creek and Temple Fork. Results indicate that these tributaries may contain genetically unique populations and that there is a potential for this population to be classified as a separate sub-species. DWR staff indicated that habitat restoration work has taken place in these streams. Because Bonneville Cutthroats are a conservation species, extensive coordination would be required for permitting (Forest Service Special Use and or 404).

Cub River

The site is mostly comprised of heavily vegetated river floodplain, with occasional farm fields and structures, and a few local roads. There are approximately 246 acres of emergent marsh and 86 acres of open water mapped in the area and 775 acres of prime or unique farmland. The Cub River floodplain channel contains the reservoir boundaries. The site is surrounded by mostly agricultural development, with an occasional home and farm structure, smaller farm roads, with notable exceptions of one large factory, a few dairy farms, and some sewage lagoons.

Above Cutler Dam

The reservoir basin is mostly comprised of heavily vegetated river floodplain, with occasional farm fields and structures, and a few local roads. Within the reservoir footprint, there are approximately 1,898 acres of prime or unique farmland, 653 acres of emergent marsh wetlands, 595 acres of emergent marsh, 64 acres of wet meadow wetlands, and 878 acres of open water. The Bear River floodplain channel contains the reservoir boundaries. The reservoir is surrounded by mostly agricultural development, with an occasional home and farm structure, with smaller farm roads.

Potential issues include the impact to riparian habitat along the river. Part of the site is on lands controlled by PacifiCorp as part of Cutler Reservoir, a hydropower facility under the oversight of the Federal Energy Regulatory Commission (FERC). Cutler Marsh is a mitigation area associated with Cutler Reservoir.

South Willard

The site is located entirely on privately owned lands that have very little development with the exception of a few farmhouses. The area contains agricultural lands in the northern section and approximately 2,311 acres of emergent marsh wetlands and 89 acres of wet meadow wetlands in the southwest portion of the site. There are also approximately 76 acres of open water.

In addition, the reservoir footprint would inundate the Willard Bay Upland Game Management Area (managed by the Utah Division of Wildlife Resources) and the Willard Bay South Marina and Campground. It would also likely to affect the Weber Pathways Rail Trail and associated trailheads. The site is near the Harold S. Crane State Waterfowl Management Area, Willard Bay, Bear River Bay, and the Bear River Migratory Bird Refuge. These sites are important for migratory birds, waterfowl, and upland game.

Table 12-4
Wetland and Other Waters within Potential Reservoir Sites (acres)

Wetland Category	Potential Reservoir Site					
	Above Cutler	Cub River	Fielding	South Willard	Temple Fork	Whites Valley
Emergent Marsh	652.6	245.6	297.8	2,311.1	4.7	26.0
Emergent Marsh / Wet Meadow	594.7	-	-	-	-	-
Open Water	878.0	86.1	484.9	75.9	6.5	0.1
Wet Meadow	63.6	-	-	89.4	-	-
Totals	**2,253.8**	**331.7**	**782.7**	**2476.4**	**11.2**	**26.1**

Summary

Because each site potentially contains jurisdictional water of the US, Clean Water Act (CWA) Section 404 permitting is likely. Section 328 of Chapter 33 in the Code of Federal Regulations (CFR) describes the objectives of the CWA, which is to maintain and restore the chemical, physical, and biological integrity of the waters of the United States (33 CFR Part 328 Section 328.4). It is administered by the U.S. Environmental Protection Agency (EPA) in coordination with state governments and the U.S. Army Corps of Engineers (USACE). See Chapter 15 for more information on environmental permitting.

CHAPTER 13

POTENTIAL IMPACTS TO GREAT SALT LAKE ELEVATION FROM BEAR RIVER DEVELOPMENT

13.0 POTENTIAL IMPACTS TO GREAT SALT LAKE ELEVATION FROM BEAR RIVER DEVELOPMENT

13.1 BACKGROUND

As indicated in the Bear River Development (BRD) Act (Act), Utah Code 73, Chapter 26, the BRD would divert the "surface waters of the Bear River and its tributaries." The Bear River is the largest tributary to Great Salt Lake (GSL). This chapter examines the potential impact of BRD on the elevation of GSL.

13.2 WATERSHED DESCRIPTION

As indicated in the Great Salt Lake Management Plan (Forestry, Fire & State Lands, 2013), GSL is a remnant of ancient Lake Bonneville and GSL Basin covers approximately 34,000 square miles. It is one of the largest terminal lakes in the world. See Figure 13-1.

13.2.1 Inflows to GSL

The majority of the inflows to GSL occur from precipitation directly on the lake surface, surface flows from the three major tributaries, and groundwater. Precipitation has been estimated to account for a third of the inflow to the GSL and averages about 1.0 million acre-feet annually. Groundwater accounts for just over three percent of the inflow (DWRe, West Desert Basin Planning for the Future, 2001).

The three main surface flows to the GSL are the Bear River, Weber River, and Jordan River. The total inflow from these rivers can vary greatly on an annual basis. In 2011, the total inflow to the GSL from the three rivers was 3.5 million acre-feet, with the Bear River accounting for 47% of the surface inflow. In 2014, the total surface inflow was 826,000 acre-feet, with the Bear River contributing over 60% of the inflow.

Additionally, approximately 180,000 acre-feet come into GSL basin via the Central Utah and Provo River Projects through trans-basin imports from the Uinta Basin (Forestry, Fire, State Lands, Great Salt Lake Comprehensive Management Plan, March 2013).

13.2.2 Outflows from GSL

Since GSL is a terminal lake, there is no natural outlet from the lake. Evaporation is the main natural "outflow" from the lake. On average, nearly 3.0 million acre-feet annually leaves GSL through evaporation. Direct use by the mineral extractors also contributes to outflows from the lake. The natural evaporation leaves behind salts and minerals. GSL is one of the most saline water-bodies in the world. Depending on the area of the lake, the salinity ranges from 5% to as much as 25%. The average salinity of the ocean is about 3.5%.

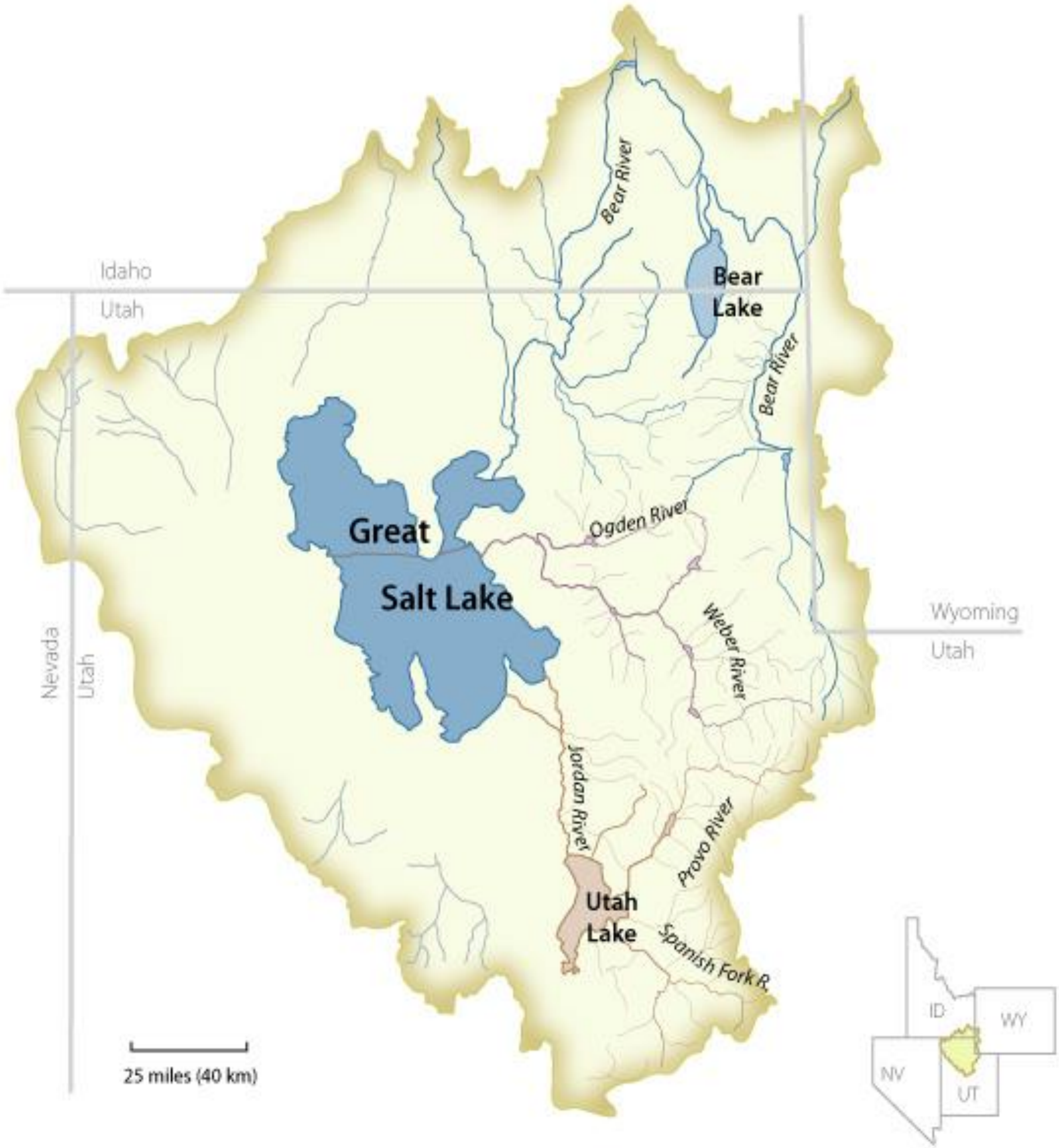


Figure 13-1: Great Salt Lake Watershed

13.2.3 Historic Levels of the Great Salt Lake

The elevation of GSL rises and falls based on inflow to, and evaporation from, the lake. The average elevation since the mid-1800s has been approximately 4,200 feet. The recorded high elevation was nearly 4,212 feet in 1986 and 1987. The previously recorded historic low was about 4,191 in 1963. (FFSL, March 2013) An elevation of approximately 4,189 feet occurred in 2016.

Water leaves the lake primarily through evaporation. The evaporation has a moderating effect on the GSL level. As the GSL becomes higher in elevation it spreads over a much greater surface area, thus increasing evaporation. As the GSL elevation becomes lower, the surface area reduces, thus reducing evaporation. As an example, at elevation 4,213 the GSL has a surface area of approximately 2,920 square miles. At an elevation of 4,200, the surface area is approximately 1,395 square miles. (FFSL, March 2013)

Since the development of land within the GSL watershed, there has been a large diversion of water upstream of the GSL for agricultural, municipal, and industrial uses. This is discussed in more detail in Section 13.7. This is mitigated some by importation of water through the Central Utah and Provo River Projects as indicated in Section 13.2.1.

13.2.4 Geologic Lake Levels

GSL, as discussed above, is a remnant of the much larger lakes that existed in the past. Much research has been done on the lakes that preceded GSL. Lake Bonneville, at its peak, was approximately 800 feet deep and covered a large part of Utah. Historically, GSL has fluctuated based on precipitation in the watershed and evidence suggest it has reached as high as 4,217 feet in elevation. At 4,217 feet, the GSL would expand into the West Desert. This large surface area tends to mitigate additional increase in lake elevation because of the increased evaporation. There is evidence that GSL has reached this level several times in the last 400 years. In addition, recent tree-ring studies in the Bear River Watershed suggest that there have been extended wet periods and severe droughts within the GSL Basin in the last 1,200 years. The droughts could have caused GSL to recede to much lower levels than have been historically measured (Tree-ring Reconstruction of the Level of the Great Salt Lake, Justin DeRose, April 2014). Record high lake levels in the 1980’s led to the construction of the West Desert Pumping Station to remove lake water to the west desert and reduce property damage around the lake.

13.2.5 Circulation and Bays

GSL has several large bays. Farmington Bay is located in the southeast portion of the lake and is bound by the Wasatch Front on the east and Antelope Island on the west. The Jordan River empties into this bay. The Bear River Bay is on the northeast side of the GSL, and receives water from the Bear River. An east-west causeway constructed for a rail line in 1959 splits the lake, and subsequently affected the water level and salinity. This causeway isolated Gunnison Bay on the northwest side of the lake. Because the lake’s main tributaries enter from the south and northeast, the water level south of the causeway was several inches higher than that of Gunnison Bay. The salinity was much higher in Gunnison Bay because of the relatively lower inflows and restricted circulation caused by the causeway. In December of 2016, the causeway was breached allowing for mixing between Gunnison Bay and the south part of the lake.

13.2.6 Great Salt Lake Water Budget Based On Past Research

In 2011, Dr. David Tarboton (Utah State University) examined the overall GSL water budget to estimate historical inflows and outflows. Dr. Tarboton examined data from 1949-2008, and also a smaller data set from 2003-2008. The data included surface inflows, direct precipitation, groundwater, and evaporation, which included mineral extraction withdrawals.

Table 13-1 presents the data sets for the periods of 1949-2008 and 2003-2008. The data shows a reduction in direct precipitation and inflow to the lake from 2003-2008. This reflects the overall dry period that has occurred in the GSL watershed since 2000. The data also shows the magnitude of the effects of evaporation on the lake.

Table 13-1
Great Salt Lake Water Budget Summary
Average Annual Inflows and Evaporation (acre-feet)

Inflow Sources	**Data set 1949-2008**	**Data set 2003-2008**
Bear River	1,347,000	986,000
Jordan River	495,000	425,000
Weber River	338,000	242,000
Davis County Streams	31,000	30,000
Other Streams	105,000	95,000
Total Streamflow	*2,316,000*	*1,778,000*
Direct Precipitation	876,000	781,000
Groundwater	75,000	75,000
Total Inflow	**3,267,000**	**2,634,000**
Outflow Sources		
Evaporation (including mineral extraction)	**3,264,000**	**2,834,000**

Notes: From presentation by David Tarboton, Utah State University, 2011

13.3 BENEFITS OF THE GREAT SALT LAKE

Great Salt Lake contributes to the State of Utah and the counties that surround the lake. The following are some of the benefits of a healthy lake:

- Industry
  - Brine Shrimp Harvesting
  - Mineral Extraction
- Tourism
  - Bird/Wildlife Watching
    - Bear River Migratory Bird Refuge
    - Waterfowl Management Areas
- Recreation
  - Hunting/Duck Clubs
  - State Parks/GSL Marina
  - Boating/Sailing
  - Lake-Effect Snow/Skiing

All of these benefits provide to Utah's quality of life and economy. A study prepared for the Great Salt Lake Advisory Council in 2012 estimated that the lake provides about 7,700 jobs and contributes more than 1.3 billion dollars to the state's economy.

13.4 POTENTIAL DEPLETION

While the BRD System is expected to deliver 220,000 acre-feet annually from the Bear River, not all this water would be depleted from the watershed. Much of the BRD water is expected to return to the watershed in the form of "return flows."

The Act indicates that the BRD water can be used for M&I or agricultural purposes. It is expected that most of the BRD water will be used for M&I purposes due to the demands of a growing population. For the purpose of this study, the assumption was made that the BRD water will be used for M&I purposes.

13.4.1 Municipal and Industrial Use Return Flows

As BRD water is used for indoor uses, it will go to the sewer systems and, once treated, will be reintroduced to the GSL watershed. As BRD water is used for outdoor use, runoff from irrigation will also return through storm water systems that ultimately discharge to the GSL watershed.

13.5 DEPLETION ESTIMATES

Depletion estimates from the full development of 220,000 acre-feet were estimated by using return flow data from existing M&I uses and the estimated depletion from BRD reservoir evaporation. The estimated return flows within each District service area from M&I uses are dependent on different factors.

For example, in WBWCD's service area, about 62% of the current M&I outdoor use is supplied by "secondary" water, rather than culinary (drinking) water. Because of the prevalence of the secondary systems, it is expected that BRD water will be used more for indoor use in WBWCD's service area, rather than for outdoor use. Indoor use typically has a higher return flow than outdoor use. Therefore, return flows of BRD water for WBWCD are expected to be higher than for the other three Districts. The water provided for the other three Districts will be used more for M&I outdoor use, as well as indoor use.

In order to estimate the M&I return flows for BRD water, recent water use data was gathered from several communities within the GSL watershed. The percentage of indoor use versus outdoor use for each community is indicated in Table 13-2. The breakdown varies greatly between the communities. For example, 36.4% of Sandy City's M&I supply is for indoor use while 67.0% of Logan City's M&I supply is for indoor use. For the purposes of this study, the data from these seven communities was averaged into a "composite" return flow percentage to be used to estimate BRD return flows. We also examined several customers of JVWCD. These agencies, while not used in the Table 13-2, have similar indoor and outdoor use percentages.

13.5.1 M&I Indoor Use Return Flows

Indoor use is generally quantified by calculating the volume of the average monthly winter use, when outdoor use is expected to be minimal. The average monthly winter use was then multiplied by twelve (months) to estimate the yearly indoor M&I use. This total volume for indoor use was then divided by the total M&I annual supply volume for the system. For example, for Sandy City, the percentage of the total supply used for indoor uses was calculated to be 36.4%.

Most indoor water use returns to the watershed through sewer systems and wastewater treatment plants, which return treated water to rivers and lakes. For this study, indoor M&I use is assumed to have a return flow percentage of 90%. This means that 90% of the water used indoors is expected to return to the watershed through the sewer systems and treatment plants.

To verify the use of 90% to calculate indoor use return flows, the following publication was referenced: "*Water Use, Chapter 11 of National Handbook of Recommended Methods for Water Data Acquisition*", by William E. Templin, Richard A. Herbert, Claire B. Stainaker, Marilee Horn, and Wayne B. Solley, 1993. The publication references a study done by the California Department of Water Resources in 1983 indicating that "only about 2 percent of the water used inside evaporates" (Chapter 11.D.3a). In other words, as much as 98% of the indoor use is returned to the watershed after being treated. Thus, for this study, the use of 90% as the return flow percentage for indoor use is conservative.

For each community, the percentage of the total water supply that was used indoors was then multiplied by the indoor return flow percentage of 90%. For Sandy City, the indoor use percentage of 36.4% was multiplied by the indoor return flow percentage of 90%. The resulting percentage is 32.8%. Thus, for indoor use, 32.8% of the total M&I supply would be expected to be "return flow". Table 13-2 includes the estimated return flow percentages for M&I Indoor Use for the seven communities.

13.5.2 M&I Outdoor Use Return Flows

To calculate the return flows for M&I outdoor use, the percentage of outdoor use to the total supply was calculated by subtracting the indoor use percentage from 100%. Using Sandy City as an example, the estimated percentage of the total M&I supply used for outdoor uses is 100% minus 36.4%, resulting in a percentage of 63.6% for Sandy's M&I Outdoor Use.

The Utah Division of Water Rights has used a return flow percentage of 35% to estimate return flows to the Jordan River for imported water from the Utah Lake System (ULS). This return flow percentage was used for this study to estimate return flows from outdoor use. For example, for Sandy City, the outdoor use percentage of 63.6% was multiplied by 35%. The resulting return flow percentage is 22.3%. This means that 22.3% of the outdoor use is expected to return to the GSL Watershed. Table 13-2 includes the estimated return flow percentages for M&I Outdoor Use for the seven communities.

13.5.3 Overall M&I Depletion

The results for indoor and outdoor return flow percentages were then added together to establish a "composite" return flow percentage for each community. Again as an example, for Sandy City, the return flow percentage of 55.0% was calculated for all M&I use. The composite return flow percentages for all the communities were then averaged. The result is a composite return flow percentage of 62.4% for M&I use. In other words, for these seven communities, on average, 62.4% of M&I uses become "return flows" that are returned to the watershed through outside use runoff and sewer systems through the wastewater treatment plants. Table 13-2 includes the composite return flow percentages for each of the communities.

Table 13-2
Estimated M&I Return Flow Percentages
Typical Communities within the GSL Watershed

Community	Indoor Use[1] (% of M&I supply)	Outdoor Use[1] (% of M&I supply)	Indoor Return Flow[2] (%)	Outdoor Return Flow[3] (%)	Composite Return Flow[4] (%)
Sandy	36.4	63.6	32.8	22.3	55.0
Provo	54.6	45.4	49.1	15.9	65.0
Orem	43.5	56.5	39.2	19.8	58.9
Salt Lake City	54.4	45.6	49.0	16.0	64.9
Layton	43.8	56.2	39.4	19.7	59.1
Clearfield	48.9	51.1	44.0	17.9	61.9
Logan	67.0	33.0	60.3	11.6	71.9
Average Estimated Return Flow Percentage					**62.4**

1 These percentages added together equal 100.0%
2 Multiply Indoor Use % by 90.0%
3 Multiply Outdoor Use % by 35.0%
4 Add Indoor Return and Outdoor Return Flow Percentages

The return flow percentage of 62.4% was then used to determine potential volume of the return flows for the BRD system for three of the Districts (WCD/WD): Bear River WCD, Cache WD, and Jordan Valley WCD as shown in Table 13-4.

As noted previously, WBWCD's service area includes many secondary systems that supply non-culinary/non-drinking water for lawn and garden irrigation. Therefore, BRD water provided by WBWCD is expected to be used more for indoor use, rather than outdoor use. Thus, the return flows for BRD water in the WBWCD service area is expected to be higher than in the service areas for the other Districts. Based on information provided by the various secondary water providers in WBWCD's service area, about 62% of WBWCD's M&I connections use secondary water for outdoor irrigation.

To develop a composite return flow percentage for M&I uses in the WBWCD service area, two calculations were performed. As stated before, about 62% of the M&I connections within the WBWCD service area use secondary water for outdoor irrigation. Thus, it would be expected that BRD water supplied to those connections would be used primarily for indoor use. As such, the indoor use return flow percentage of 90% was multiplied by 62%.

For the other WBWCD connections (38% of total connections) that do not have secondary water and use culinary water for outdoor use, a return flow percentage of 62.4% was multiplied by 38.0%. These two results were added together for a composite return flow percentage of 79.5% for the WBWCD service area. In other words, it is estimated that 79.5% of water use in the WBWCD service area would be "return flows." Table 13-3 includes this information.

Table 13-3
Estimated M&I Return Flow Percentages
Weber Basin Water Conservancy District (WBWCD)

Water District	Connections with secondary water[1] (% of total)	Connections without secondary water[1] (% of total)	Return Flow Percentage[2] (% for Indoor Use)	Return Flow Percentage[3] (% for Indoor /Outdoor Use)	Composite M&I Return Flow Percentage[4] (%)
WBWCD	62.0	38.0	55.8	23.7	79.5

1 These percentages added together equal 100.0%
2 Multiply "Connections with secondary water/culinary use only" by 90.0%
3 Multiply "Connections without secondary water" by 62.4%
4 Add Indoor Use and Indoor/Outdoor Use Return Flow Percentages

There has been a recent effort by those agencies delivering secondary water to meter secondary use. This increased efficiency of secondary use, while not affecting the above analysis, will result in further conservation which should extend the need for additional water supplies to those areas.

13.5.4 Reservoir Evaporation

Recent hydrological data for the Bear River indicates that to develop a reliable annual supply of 220,000 acre-feet, the volume of reservoir storage needed for the BRD system could be as high as 600,000 acre-feet in some years. This additional storage would allow for carry-over in dry years. However, over time, the annual average reservoir volume would be 220,000 acre-feet.

Evaporation will occur from potential BRD reservoir(s) that will result in a depletion from the GSL Watershed. To estimate the potential evaporation losses for the BRD, data from existing reservoirs in Utah was researched.

As an example, Deer Creek Reservoir has an average annual evaporation loss of about 7,000 acre-feet with a total reservoir capacity of nearly 153,500 acre-feet, resulting in an evaporation loss of 4.6%. This reservoir would reflect the potential evaporation losses in potential reservoirs that would be higher in elevation or have a deeper storage pool. As an example of a shallow reservoir, Willard Bay has an average annual evaporation loss of about 20,000-25,000 acre-feet annually with a total reservoir capacity of about 227,000 acre-feet. This results in an estimated evaporation loss of about 10.0%.

For this study, the potential reservoir evaporation loss was estimated to be 5.2%. This percentage was calculated with the assumption that the majority of the potential reservoir storage would be in reservoirs with a deeper pool and at a higher elevation. Thus, the 220,000 acre-feet of storage was divided between potential reservoir storage (25,000 acre-feet) with an evaporation percentage of 10.0% and the remaining potential reservoir storage (195,000 acre-feet) with an evaporation percentage of 4.6%. For a potential storage of 220,000 acre-feet, the estimated evaporation losses would be about 11,500 acre-feet.

While this reservoir evaporation is considered a depletion due to the BRD system, if the 220,000 acre-feet were not developed and reached GSL, it would also have the effects of evaporation, perhaps with a higher evaporation rate.

13.5.5 Estimated BRD Depletion

By multiplying the return flow percentages for each of the Districts by the BRD allocations and adding the estimated BRD reservoir evaporation loss, an overall BRD depletion was calculated. Using current return flow factors, full development of 220,000 acre-feet for BRD could result in an estimated depletion of 85,670 acre-feet. Thus, an estimated 85,670 acre-feet would not return to the GSL Watershed. See Table 13-4.

Table 13-4
BRD Estimated Depletion

District	Return Flow Percentage (%)	BRD Allocation (acre-feet)	Return Flows[1] (acre-feet)	Depletion M&I Uses[2] (acre-feet)
BRWCD	62.4	60,000	37,440	22,560
CWD	62.4	60,000	37,440	22,560
JVWCD	62.4	50,000	31,200	18,800
WBWCD	79.5	50,000	39,750	10,250
Sub Total M&I		**220,000**	**145,830**	**74,170**
Estimated Reservoir Evaporation				11,500
Estimated BRD Depletion				**85,670**

1 Multiply “Return Flow Percentage” by “BRD Allocation”
2 Subtract “Return Flows” from “BRD Allocation”

This analysis does not include potential future changes in use or return flow patterns. Both indoor and outdoor M&I use may become more efficient through new technology (i.e. low-flow appliances, smart meters/timers) and continued M&I water use education (resulting in increased conservation). The analysis also does not include potential water reuse.

The resulting estimated depletion of 85,670 acre-feet is based on the full development of the 220,000 acre-feet. While current projections indicate the need for water from the BRD in 2050, the full 220,000 acre-feet would be needed at that time. The current projections indicate that the full development of BRD water will not be needed for decades. This means that full depletion from the BRD would also be realized over many decades.

13.6 OTHER DEPLETION FACTORS

While the following factors are also expected to impact return flows, they are difficult to quantify and were not included in estimating the potential depletion resulting from the BRD.

13.6.1 Agricultural Conversion

As the service areas in the BRD convert from agricultural lands to homes and businesses, return flows are expected to increase. Agricultural use has a lower return flow percentage than M&I uses. Thus, when agriculture converts to homes, the return flows are expected to increase.

13.6.2 Development Effects on Return Flows

Impervious or “hardened” surfaces such as roads, parking lots, sidewalks, and rooftops increase runoff, or return flows, compared to undeveloped land. Thus as land is developed in the BRD service areas, return flows are expected to increase.

The Recycled Water Coalition (RWC) is a collaboration of cities, water and wastewater districts. The RWC completed a study in 2005 examining long-term return flows to the Jordan River. In the study, three sets of return flows were compared:

- Return flows that existed in 1945
- Return flows in 2003
- Projected return flows in 2030

The analysis examined inflows to and outflows from the river. The study indicates that there was an increase in return flows to the Jordan River from 1945 to 2003. The study estimated that there would continue to be an increase of the return flows to the river to due to the following:

- Decreased agricultural use
- Increased wastewater treatment plant discharges
- Trans-basin importation of water into the watershed

As the undeveloped service areas of the Districts are developed, it is expected that return flows would increase.

13.7 GREAT SALT LAKE WATER BUDGET MODEL

13.7.1 Background

DWRe has developed several iterations of a GSL water budget model. DWRe uses the model to estimate long-term effects to GSL elevations. An initial model was developed in the 1970s. It was updated in 2008 and was updated again recently in 2016. The latest model was used to determine the potential effects of future BRD diversions on GSL elevations.

13.7.2 Model Results

A white paper titled "Impacts of Water Development on Great Salt Lake and the Wasatch Front" was published on February 24, 2016. The paper was produced through a collaborative effort between Utah State University, Salt Lake Community College, the Utah Divisions of Wildlife Resources and Water Resources.

The white paper discusses how a hydrological model estimates what the GSL lake level would have been prior to the arrival of the Mormon pioneers in the mid-1800s. In other words, what the lake level would have been without the consumptive use of water since the arrival of the pioneers. The white paper indicates that the elevation of GSL would be about 11.1 feet higher today if the diversions since the mid-1800's had not occurred. Table 13-5 shows the data provided in Table 1 from the white paper. The table includes the estimated decrease of the lake level from the various water uses in the watershed.

Table 13-5
Types of Water Consumption (Depletions) and their Influence on Decreasing the Level of the Great Salt Lake

Source	Percent of Water Use	Median Estimated Decrease in Lake Level (feet)
Agricultural	63%	7.0
Mineral Extraction (salt ponds)	13%	1.4
Municipal & Industrial	11%	1.3
Impounded Wetlands	10%	1.1
Reservoir Evaporation	3%	0.3

To estimate the additional potential decrease in the GSL lake level due to the future diversion from the BRD, the estimated BRD depletion amount of 85,670 acre-feet was input into the model. The model results indicated that the lake level would decrease by an average of 8.5 inches and a maximum of 14 inches, depending on the lake level.

This correlates to information in the following documents:

- "Over the last 20 to 30 years, a number of studies have attempted to define the effects of water development and other man-caused water use on the lake level. The studies indicate that, for each additional 100,000 acre-feet of consumptive use, the average level of the lake would be approximately one foot lower." (The Great Salt Lake Planning Project, Statement of Current Condition and Trends (Draft); 1998)

- "Studies of the lake hydrology indicate that 100,000 acre-feet of additional depletions per year would lower the average lake level approximately one foot. (Great Salt Lake Comprehensive Management Plan Resource Document, page 7; May 2000).
- "Figure 3, Lake withdrawals versus lake level" (Preliminary Assessment of the Effects of Withdrawing Water For Mineral Extraction on the Levels of Great Salt Lake at Historic Low Levels; November 2014.

The estimated decrease in the level of the GLS could be partially offset by an increase in storm water runoff resulting from urbanization of the watershed which will accompany the use of BRD supplies. Further studies are needed to quantify the amount of increased storm water discharge and the resulting impact to the GSL.

A comprehensive look at potential impacts of the BRD should be a collaborative effort with stakeholders at all levels. With the current projected need for BRD water expected to be years into the future, the time should be used wisely to engage with stakeholders, including all levels of government agencies and non-government organizations, as well as any other groups that might be impacted.

CHAPTER 14

REAL ESTATE ANALYSIS

14.0 REAL ESTATE ANALYSIS

14.1 BACKGROUND

One of the primary charges of the Bear River Development Act (Act) is to identify the feasibility of a potential corridor for a pipeline from the Bear River to a potential reservoir site(s), and from the reservoir(s) to Weber County. In addition, the Act specifically authorizes DWRe to acquire real property for the development of such a utility corridor. Rapid growth continues in both Weber and Box Elder counties, and undeveloped areas of land are quickly becoming more valuable for residential and commercial development. The need to identify and preserve a corridor for a large-diameter pipeline has increased. Preserving right-of-way now will help to lessen future impacts on the surrounding communities

Review of available reservoir sites indicates that there is limited space available that can provide the storage capacity needed. In particular, the Whites Valley site is the only location identified that can provide sufficient storage capacity to meet the water supply reliability needs of the Bear River Development (BRD) project.

14.2 REAL ESTATE PARCELS ASSOCIATED WITH THE PIPELINE CORRIDOR AND RESERVOIR SITES

DWRe has identified the real estate parcels associated with the potential pipeline routes, along with the property for the potential reservoir sites. The pipeline corridor alignment described in Chapter 9 was used to determine the amount of right-of-way needed. The area within the footprints of the dam and reservoir sites, described in Chapter 7, represent the other primary real estate needs.

The area of study for real estate analysis for a pipeline corridor was determined to be the centerline of the pipeline corridor and expanded based on potential flexibility of pipe placement, land availability, and existing development. The study corridor was widened where potentially beneficial alignment alternatives could be routed, if needed, without significant cost increase or construction difficulty. Other expanded areas were included in the study alignment to allow for construction staging. Once a feasible pipeline corridor was identified, GIS mapping was used to overlay the corridor area onto recorded legal parcel boundaries. All properties within the subject corridor were identified as “impacted parcels”.

The real estate analysis for the dam and reservoir sites was based on the assumption that DWRe would need to acquire the area under the dam site and the reservoir inundation area, plus an additional 25 percent of land area. This additional area could provide for enhanced recreational and wildlife habitat use and serve as a water quality buffer around the dam and reservoir.

The complete real estate analysis identified 1,713 properties as impacted parcels within the pipeline corridor, and another 638 impacted parcels at potential reservoir sites. Table 14-1 shows the areas for the potential corridor alignment, as well as the areas for the potential reservoir sites.

Table 14-1
Potential Impacted Parcels

BRD Facility	Number of Parcels	Total Area (acres)
Pipelines and Associated Facilities	1,713	1,409
Temple Fork	5	391
Cub River	106	1,753
Above Cutler	385	6,040
Fielding (70 kaf)	78	2,040
Whites Valley (540 kaf)	29	4,538
South Willard	35	4,000

14.3 PRIORITY ACQUISITION PARCELS

The Bear River Pipeline Concept Report identified more than 200 parcels as "priority" properties. The report identifies the priority properties as those with public or canal ownership, and private parcels of significant size, near the potential pipeline alignment without significant improvements. The number of priority parcels identified includes 141 publicly- owned parcels and 78 privately-owned parcels. Because of the critical importance of the Whites Valley site (described in Chapters 8 and 10), the 29 parcels associated with that site have been added to the list, for a total of 248 priority parcels.

Preliminary property values were assessed for the priority parcels. For publicly owned-properties, it was determined that it would cost approximately $300/parcel to obtain an access permit on these parcels for construction of a pipeline. As such, estimated costs are $42,300 to acquire permits for the 141 publicly-owned priority parcels. Privately-owned parcels were valued based on three different land types in both Weber and Box Elder Counties. Table 14-2 below identifies the land values per acre for each land type with values as of September 2015.

Table 14-2
Private Property Values – 2015 Dollars

Land type (zoned)	*Value in Weber County ($/acre)	*Value in Box Elder County (2015 $/acre)
Agricultural	6,200	11,013
Commercial/Industrial	119,300	72,575
Residential (vacant)	194,600	158,531

*Values reported are average per acre values in 2015 dollars

Table 14-3 is a similar analysis of real property values based on comparable land sales as of September 2018. The current analysis indicates an average increase in land value of approximately 23% from 2015 to 2018. The large increase in values for agricultural land in Weber County can be attributed to the lack of comparable sales in 2015. The cost of vacant residential land in Box Elder County has decreased slightly over the three-year period.

Table 14-3
Private Property Values – 2018 Dollars

Land type (zoned)	Value in Weber County ($/acre)	Value in Box Elder County (2018 $/acre)
Agricultural	28,982	17,601
Commercial/Industrial	144,860	92,758
Residential (vacant)	232,140	154,932

Values reported are average per acre values in 2018 dollars

CHAPTER 15

IMPLEMENTATION

15.0 IMPLEMENTATION

15.1 BEAR RIVER DEVELOPMENT SCHEDULE

As outlined in the Bear River Development Act, the Bear River Development (BRD) includes facilities as described in Chapter 11 to develop 220,000 acre-feet of water. Water demand studies indicate that water will be needed by about 2045-50. This could change as the Districts and DWRe update use and demand forecasts, as discussed in Chapter 5. The enormity of the project in terms of real estate acquisition, environmental requirements, design and construction, and its overall cost make it essential to begin planning in order to guarantee water is available when needed. Figure 15-1 shows a potential schedule for BRD implementation based on a water a delivery date of 2045 and current demand projections. Real estate acquisition would need to begin immediately. Environmental studies and permit processes would need to begin by 2028-2029. The design process would need begin by 2036 to allow three years to complete. Estimating a five-year construction period, that would need to begin in 2040. This schedule will allow BRD water to be delivered for a forecasted need of 2045-2050.

While projections indicated the initial need for BRD water by 2045-2050, the full 220,000 acre-feet is not projected to be needed for decades.

15.1.1 Potential Bear River Development Phasing

DWRe has considered possible ways to phase the development to allow for delivery of water as needed to the Districts without full development and the resulting costs. While it is assumed that the water supplies will be needed in 2045-50, the Districts may need some new water supplies without full implementation of the project sooner. A three-step phasing plan to develop the Bear River water could be as follows.

15.1.2 Phase 1-Interim Supplies for Bear River Water Conservancy District or Cache Water District

DWRe would build facilities to service either BRWCD or CWD as the need arises. These facilities would be constructed to be compatible with the long-term plan for overall BRD system facilities. BRWCD could be served with a pump station on the Bear River in Box Elder County. Water rights could be leased or purchased to provide a reliable water supply during this phase. Deliveries could be made to CWD through exchanges, through direct diversions from the Bear River. No reservoir storage would be needed for this phase.

15.1.3 Phase 2-Initial Project Storage and Pipeline

Initial reservoir storage would be constructed, and water would be released from storage to the Bear River. A pipeline from a diversion on the Bear River would convey water from the Bear River to the WHWTP. Water would be delivered to all the Districts through the BRWCD pump station(s), river diversions for CWD, and deliveries to the WHWTP for WBWCD and JVWCD. The full 220,000 acre-feet water supply would not be developed.

15.1.4 Phase 3-Additional Reservoir Storage

Additional reservoir storage would be constructed. The additional storage would allow for development of the full 220.000 acre-feet. Water would be delivered to BRWCD through the BRWCD pump station(s), river diversions or a pipeline from Fielding or Whites Valley reservoirs for CWD, and deliveries to the WHWTP for WBWCD and JVWCD.

15.2 ADVANCE PLANNING

The Districts are utilizing existing water supplies, increased conservation, and technology to stretch the need for the BRD as far into the future as possible. In the meantime, DWRe needs to begin planning for the BRD in two important areas; environmental compliance and right-of-way acquisition. This chapter describes the approach to developing an environmental compliance plan and right-of-way acquisition plan for the implementation of the BRD. Both plans would need to be addressed well in advance of implementation of the BRD.

15.2.1 Environmental Compliance Plan

The Bear River Development, including necessary storage reservoirs, pump stations, and pipelines, will require environmental and other permitting and agency coordination. This section provides an overview of potential environmental regulations that could be applicable and outlines steps to obtain anticipated state and federal permits and approvals.

Regulatory Background

Compliance with the National Environmental Policy Act (NEPA; 42 U.S.C. §4321 et seq) is anticipated to be required. The purpose of NEPA is to establish a national environmental policy and to ensure that environmental factors are weighted equally when compared to other factors in the decision making process undertaken by federal agencies.

Along with federal and state environmental permitting requirements are administered under state rules that have generally been developed to comply with federal regulations, as described below. Certain regulations would apply depending on the selected reservoir site(s).

Clean Water Act. As described in the Code of Federal Regulations (CFR), the objective of the Clean Water Act (CWA) is to maintain and restore the chemical, physical, and biological integrity of the waters of the United States (33 CFR Part 328 Section 328.4). The CWA is administered by the U.S. Environmental Protection Agency (EPA) in coordination with state governments and the U.S. Army Corps of Engineers (USACE). Under the CWA, every state must establish and maintain water quality standards designed to protect, restore, and preserve the quality of waters in the state. The Utah Department of Environmental Quality (DEQ) oversees these water quality standards in Utah. Utah's water quality regulations broadly consist of three types of standards: an anti-degradation policy, beneficial use designations and their associated numeric water quality criteria, and narrative standards that apply to all waters within Utah.

Under Section 404 of the CWA, any person, firm, or agency planning to alter or work in waters of the United States (WOUS), including discharging dredged or fill material, must first obtain authorization from the USACE. Section 33 CFR 328 defines the term *waters of the United States* (WOUS) as it applies to the jurisdictional limits of the authority of the USACE under the CWA. A summary of this definition of WOUS in 33 CFR 328.3 includes (1) waters used for commerce and subject to tides; (2) interstate waters and wetlands; (3) "other waters" such as intrastate lakes, rivers, streams, and wetlands; (4) impoundments of waters; (5) tributaries of waters; (6) territorial seas; and (7) wetlands adjacent to waters. A given project may qualify for authorization under a general Section 404 permit/s or may require an individual permit. Additionally, Section 73-3-29 of the Utah Code requires any person, governmental agency, or other organization wishing to alter the bed or banks of a natural stream to obtain a stream alteration permit from the State Engineer (Utah Division of Water Rights).

Section 401 of the CWA requires state certification for any permit or license issued by a federal agency for an activity that could result in a discharge of dredged or fill material into WOUS. This requirement allows each state to have input into federally approved projects that could affect its waters (rivers, streams, lakes, and wetlands) and ensures the projects will comply with state water quality standards and any other water quality requirements of state law. In Utah, within DEQ the Division of Water Quality (DWQ) issues Section 401 certifications. Any Section 401 certification in Utah also ensures that the project will not adversely affect impaired waters (waters that do not meet water quality standards and are listed on the 303(d) list) and that the project complies with applicable water quality improvement plans.

Section 402 of the CWA covers the National Pollutant Discharge Elimination System (NPDES), which is a permit system for regulating point sources of pollution. EPA has delegated authority for the National Pollutant Discharge Elimination System (NPDES) program in Utah to DWQ. Construction projects that discharge stormwater to surface water and construction projects that disturb more than one acre of land must obtain a Utah Pollutant Discharge Elimination System (UPDES) permit to minimize impacts to water quality.

National Forest Management Act. The Wasatch-Cache National Forest prepared a Forest Plan in 2003. This Forest Plan guides all natural resource management activities and sets management "direction" for the Wasatch-Cache National Forest areas. Prepared under the National Forest Management Act (NFMA), the "direction" is expressed through goals, objectives, standards, guidelines, management prescriptions, desired future conditions, and monitoring and evaluation requirements for the Forest. Direction is guided by the six primary decisions made in a Forest Plan as follows:

1. Forest-wide goals and objectives
2. Forest-wide standards and guidelines
3. Management area delineations and associated prescriptions
4. Identification of lands not suited for timber production
5. Monitoring and evaluation techniques
6. Recommendation for official designation of Wilderness

The Wasatch-Cache Revised Forest Plans (May 2003) were completed with considerable environmental analysis and public involvement. Major changes to the goals and objectives in certain areas of the Forest will require an amendment to the Forest Plan in association with a required Special Use permit, easement, and/or lease from the Forest Service. All uses of National Forest System lands, improvements, and resources are designated “special uses”. Before conducting a special use, individuals or entities must submit a proposal to the authorized officer and must obtain a special use authorization from the authorized officer (36 CFR 251.50). Plan amendments and Special Use Lease will require NEPA compliance.

National Environmental Policy Act. The purpose of the National Environmental Policy Act (NEPA; 42 U.S.C. §4321 et seq) is to establish a national environmental policy and to ensure that environmental factors are weighted equally when compared to other factors in the decision-making process undertaken by federal agencies. NEPA is a statutory framework that provides supplemental legal authority, disclosure of environmental information, intergovernmental coordination, and an opportunity for public input on any project where a federal agency is connected, whether as a funding agency or other authority (42 United States Code [USC] 4322; 40 CFR 1500.1). Unless a proposed action qualifies as a Categorical Exclusion, an Environmental Assessment (EA) is prepared and then the lead federal agency must prepare either a “Finding of No Significant Impact” or an Environmental Impact Statement (EIS). Alternatively, an agency may undertake drafting of an EIS without first preparing an EA, if the agency believes the action will have significant impact on the human or natural environment, or if the action is considered an environmentally controversial issue.

The lead federal agency for NEPA will also ensure the project complies with other federal environmental programs as described in the following sections.

Clean Air Act. The Clean Air Act (CAA; 40 CFR Parts 50-97 328) is a United States federal law designed to control air pollution on a national level. The CAA requires the EPA to set National Ambient Air Quality Standards (NAAQS; 40 CFR part 50) for pollutants considered harmful to public health and the environment. These standards have been adopted by the Division of Air Quality (DAQ) within DEQ, as the official ambient air quality standards for Utah. In order to meet NAAQS for particulate matter, DAQ regulates fugitive dust rules to minimize of emissions within areas of the state including, all of Cache, Davis, and Salt Lake Counties, all regions of Weber County west of the Wasatch mountain range, and regions of Box Elder County from west of the Wasatch mountain range to the Promontory mountain range. In these regions, any source, including construction projects 0.25-acre or greater in size, is required to submit a Fugitive Dust Control Plan to DAQ and comply with fugitive dust limitations.

National Historic Preservation Act. The National Historic Preservation Act (NHPA; 54 U.S.C. 300101 et seq) is legislation intended to preserve historical and archeological sites. The Act created the National Register of Historic Places, the list of National Historic Landmarks, and the State Historic Preservation Offices (SHPO). Section 106 of the NHPA and USACE’s policies for evaluating permit applications (33 CFR §320.4) require that the applicant analyze impacts to areas that have recognized historic, cultural, or scenic values as well as conservation areas and recreation areas. To provide guidance to Utah agencies and governments, Utah SHPO reviews the projects for their potential effects on archaeological and historical sites.

Endangered Species Act. The Endangered Species Act (ESA; 16 U.S.C. § 1531 et seq) is intended to provide for the conservation of endangered and threatened species of fish, wildlife, and plants. Section 7 of the ESA requires that federal agencies ensure that their actions neither jeopardize the continued existence of species listed as endangered or threatened nor result in destruction or adverse modification of the critical habitat of these species.

Migratory Bird Treaty Act and Bald and Golden Eagle Protection Act. The Migratory Bird Treaty Act (MGTA; 16 U.S.C. 703–712) makes it unlawful at any time, by any means, or in any manner, to pursue, hunt, take, capture, kill, possess, or sell migratory birds. “Take” includes unintentionally killing or injuring birds and can include nest abandonment. The Bald and Golden Eagle Protection Act (16 USC 668a–d) prohibits the take, sale, purchase, possession, barter, or transport, or offer to do any of the above, to either the bald eagle (Haliaeetus leucocephalus) or golden eagle (Aquila chrysaetos) at any time or in any manner. Projects that could affect eagles or other migratory birds are encouraged to incorporate conservation measures, such as conducting preconstruction nest surveys and avoiding habitat disturbance during the nesting season.

Environmental Baseline Studies Baseline environmental studies are needed to characterize the existing environmental resources that might be affected by project construction and operation. Data gathering and field surveys conducted to date provide preliminary information on environmental resources. More studies are needed to complete the required analyses for environmental permits and identify potential effects from the BRD. At a minimum, these baseline studies would include an aquatic resource delineation (wetlands and other WOUS), threatened and endangered species studies, environmental resource surveys, cultural resource surveys, baseline hydrologic and hydraulic modeling of groundwater and surface water, floodplains, and baseline water quality monitoring studies.

Wetland Delineation and Functional Assessment. USACE will require a boundary delineation of the wetlands, and an ordinary high water mark (OHWM) delineation of streams, ditches, and canals and other WOUS in the BRD study area to determine the direct and indirect impacts to wetlands and other WOUS. A required part of this process is developing and performing a wetland functional assessment (33 Code of Federal Regulations [CFR] §332.5), which is a way to determine the ability for a wetland to perform its ecological and hydrological functions. The critical steps for a complete delineation are:

- **Field Delineation and Functional Assessment Methodologies.** The first step is to develop and propose a wetland functional assessment methodology that will be used along with USACE delineation methods. The USACE may invite other state and federal agencies to participate in developing this methodology to ensure their concurrence with the survey methods that will be used.
- **Data Collection, Delineation Field Work, and Functional Assessment.** Wetland delineations of all potential alternative pipeline alignment corridors and reservoir sites will be needed. Data necessary for functional assessment will be determined during interagency coordination, but generally includes an assessment of hydrology, plant communities, and level of disturbance or pollution.
- **Aquatic Resource Delineation Report.** A draft wetland delineation report will be submitted to the USACE for review. USACE comments on the draft would be addressed

and a draft report and a final report will be prepared and submitted. The delineation report should also provide information on whether wetlands and other aquatic features are connected to downstream waters. Isolated wetlands and certain tributaries, along with their associated wetlands, do not qualify as jurisdictional WOUS. The USACE will review the delineation report to make a jurisdictional determination for delineated aquatic resources.

The delineation report and functional assessment will provide the baseline wetlands and waters of the U.S. information to be used in CWA Section 404 permitting to evaluate potential impacts from the BRD alternatives and define appropriate mitigation. Proposed mitigation is defined in terms of both total acreage of wetland impacts for each wetland type and WOUS and wetland functional assessment ratings. See Section 15.2.2 (Mitigation for Wetland Impacts), for more information on mitigation.

Threatened and Endangered Species and Wildlife Habitat Assessment. Assessing impacts from the BRD for NEPA compliance, if required, will require wildlife habitat assessments. In addition, threatened and endangered species studies will be required for compliance with the ESA. The required time-intensive steps are:

- **Development of Wildlife Habitat Methodology.** Because there are no standardized methods, assessment methodology will need to be developed. The assessment methodology should balance the needs of resource agencies (i.e. Utah Division of Wildlife Resources) and the amount of effort required for data collection within a potentially large study area.
- **Collection of Wildlife Habitat Data.** The fieldwork for the wildlife habitat evaluation should begin as soon as possible after the analysis methodology is accepted. Certain threatened and endangered species (TES) have narrow survey windows, many as narrow as one month each year.
- **Production of Wildlife Habitat Technical Report.** The information in the technical report will be used to analyze and compare the expected impacts of the BRD alternatives to wildlife and wildlife habitat. This analysis is required as part of a NEPA process.
- **Biological Assessment.** Given the potential for impacts to TES habitat, consultation under Section 7 of the Endangered Species Act (50 CFR §402) may also be required with the US Fish and Wildlife Service. Because construction of the BRD will be considered a “major construction activity”, a biological assessment (BA) will likely be necessary.

Cultural Resources Assessment. Section 106 of the National Historic Preservation Act (1966) and USACE’s policies for evaluating permit applications (33 CFR §320.4) requires that the applicant analyze impacts to areas that have recognized historic, cultural, or scenic values as well as conservation areas and recreation areas. Therefore, surveys for prehistoric resources, historic properties, cultural resources, and other resources will need to be completed to evaluate the expected impacts. The necessary steps in this process are:

- **Database Search and Tribal Contact.** The first step is to search the Utah Division of State History’s database for information about cultural and historic sites and to coordinate with the State Historic Preservation Office (SHPO), Utah Division of Indian Affairs, and other cultural resource agencies.

- **Collection of Cultural/Historic Properties.** Research that was conducted for the pipeline alternatives evaluation found that few past surveys have been done in the study area. Therefore, intensive "pedestrian" (walk-through) surveys for archaeological sites would likely be needed. Reconnaissance-level surveys would also need to be conducted for historic properties.
- **Report Production.** A cultural resources report would be produced using the results of the database search and the pedestrian or reconnaissance-level surveys.
- **Negotiation of Programmatic Agreement**. A programmatic agreement would be negotiated with SHPO to describe documentation requirements for affected sites.

Hydrologic and Hydraulic Modeling. Constructing the BRD facilities will temporarily affect the movement of water through river channels and wetlands. The operation of the BRD will deplete flow in the lower Bear River, the U.S. Fish and Wildlife Service's Bear River Migratory Bird Refuge (Refuge), and Great Salt Lake. The depletions could affect other resources including water quality, wetlands, sediment transport, fish and wildlife habitat, and recreation. For this reason, hydrologic, hydraulic, and water quality modeling will be necessary. This modeling will include research into, and modeling of, existing conditions and the likely changes within the Bear River and its floodplain, the Refuge, and Great Salt Lake. The results of this modeling will help define the direct and indirect effects of the future BRD operation on riparian areas, wetlands, and wildlife habitat. The primary steps in this modeling are:

- **Data Gathering.** The wetlands delineation data, National Wetlands Inventory (NWI) data, stream gauge data, baseline hydrology models, detailed topographic and bathymetric data, and other data sources will be used to estimate the direct and indirect effects, primarily the effect depletion from the Bear River channel and the associated lake shore areas.
- **Modeling.** The data gathered in the previous step will be used to model both the hydraulic effects on the river channel and the hydrological effects on wetlands in the Bear River delta.
- **Results.** The collection and modeling of water quality data will be used to analyze indirect effects to wetlands and wildlife habitat and to facilitate the CWA Section 401 water quality certification from DWQ.

USACE Permit Application Process

One likely permitting pathway is the Clean Water Act. The USACE authorizes discharge or fill to WOUS through the Clean Water Act Section 404 permitting program. The two main types of permits are Standard (Individual) and General Permits, which are generally defined below.

- **Standard (Individual) Permit**. Are used for activities with more than minimal impacts to WOUS. This requires public notice, review of public interest factors (aquatic, chemical, and human use characteristics), NEPA compliance, and a 404(b)(1) Alternatives Analysis. With this type of permit, the USACE must ensure compliance with other related environmental laws including Endangered Species Act, NHPA, and Section 401, Figure 15-2 depicts this process.
- **General Permits**. The most common form of general permits are nationwide permits,

which are established to cover activities that are similar in nature and cause only minimal environmental effects. These permits are reviewed periodically, NEPA analysis is conducted, and the types of permits are reissued every 5 years. Permit applicants provide a Pre-Construction Notice (PCN) to the USACE seeking coverage; and because NEPA and other laws are addressed, there can be an expedited review process when all PCN conditions are met. It is expected that DWRe can use NWP 12 (Utility Line Activities) for permitting crossing of WOUS. Figure 15-3 depicts this process.

Alternatively, Programmatic General Permit 10 may be applied to stream crossings in Utah that do not affect wetlands. Programmatic General Permit 10 allows an applicant to obtain both state approval, and authorization under CWA 404, through a single application process.

The type of 404 permitting needed for the BRD will depend on the project configuration and the results of the delineation, its associated jurisdictional determination by the USACE, and which reservoir site(s) are selected. Nationwide Permit 12 can be applied to BRD at “separate and distant” locations if the permanent loss of WOUS at each location would be less than 0.5 acre. Based on the environmental review completed to date, construction of the pipeline portion of the BRD system may conform to requirements for authorization under Nationwide Permit 12 (or Programmatic General Permit 10 for stream crossings that do not impact wetlands). However, the USACE may not separate the pipeline portion of the project from the reservoir or diversion sites, because system elements are unlikely to have independent utility from each other.

Programmatic permitting may be feasible if anticipated direct impacts to WOUS from the reservoir site(s) and diversions are within permit limitations. However, nationwide permits are only authorized for projects determined to have minimal adverse effects. These effects include individual direct and indirect effects, and cumulative effects on the aquatic environment and other environmental resources. To qualify for Nationwide Permit 12 authorization, a project must meet all general and regional conditions, and requirements in the Section 401 certification issued for nationwide permits in Utah. Some of the specific aquatic functions considered include current flow patterns and water circulation, water level fluctuations, salinity gradients, aquatic organisms in the food web, and wildlife associated with aquatic ecosystems such as migratory birds. In addition to wetlands, special aquatic sites evaluated include sanctuaries and refuges, and recreational and commercial fisheries. Based on all of these considerations, it is likely that an individual 404 permit will be required for the BRD.

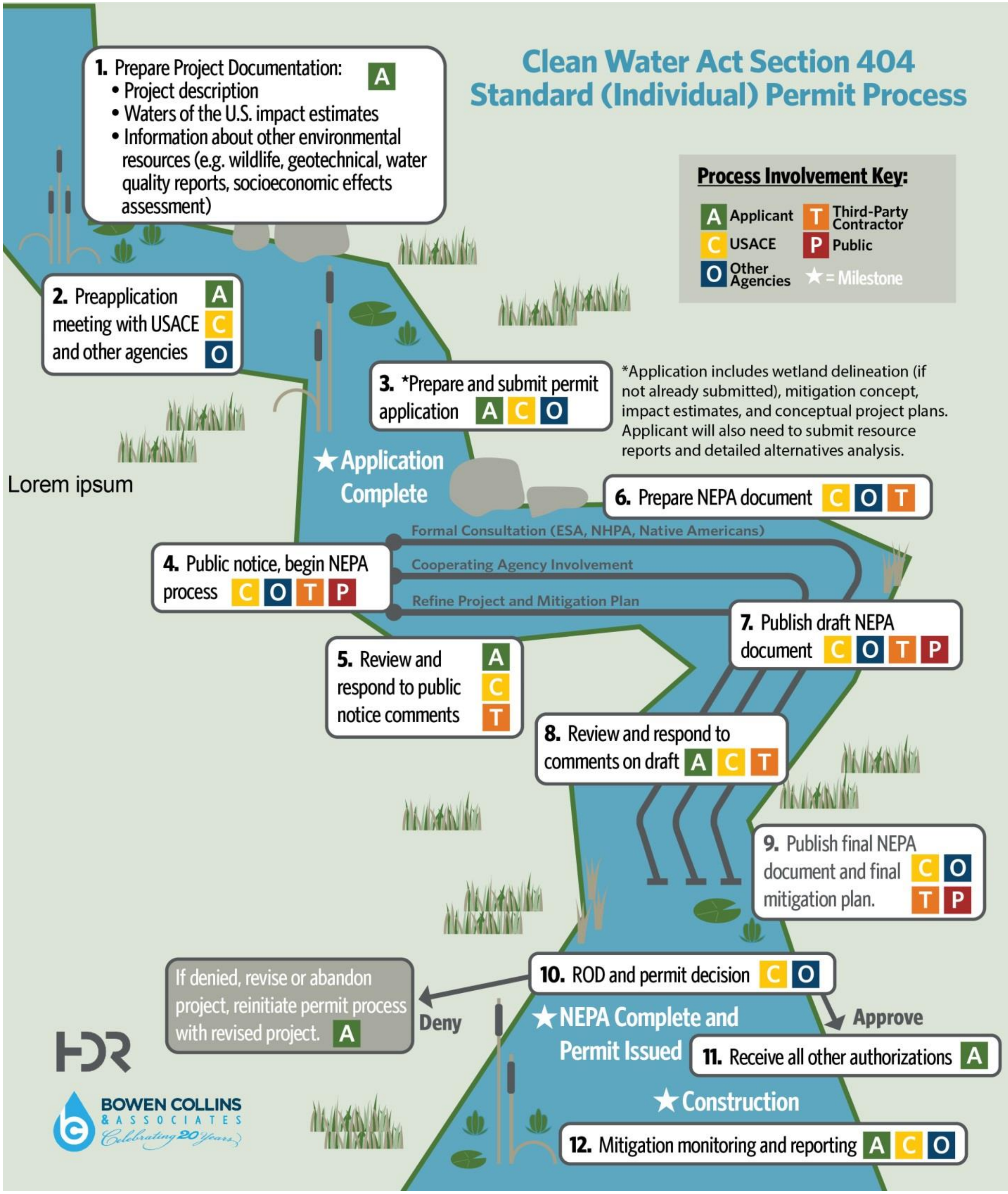


Figure 15-2. Individual Permit Process

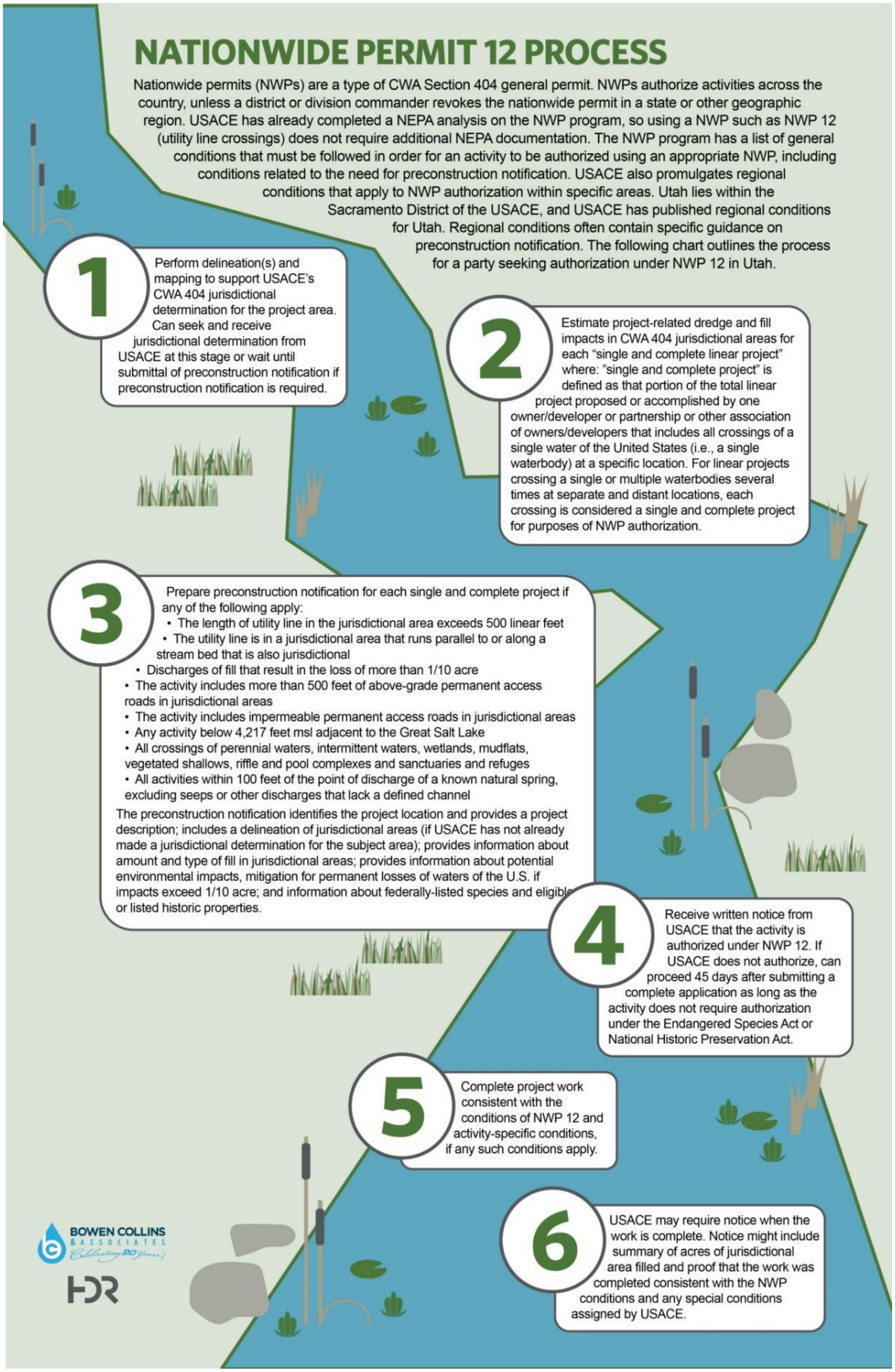


Figure 15-3. Nationwide Permit Process

NEPA Compliance and Integration with Section 404

Unless there is a nexus for a major federal action by another agency, the USACE would likely prepare NEPA documentation in order to issue an individual permit. Alternatively, if the Temple Fork reservoir site were selected, the U.S. Forest Service (USFS) may lead the NEPA process, wherein the USACE could be a cooperating agency and tier their NEPA compliance off the USFS analysis.

Assuming the USACE would lead NEPA implementation, they would determine their scope of analysis for the project. USACE NEPA implementation procedures for its regulatory program state that, for situations in which an applicant proposes a specific activity requiring a Department of the Army permit "that is merely one component of a larger project. The District Engineer should establish the scope of the NEPA document to address the impacts of the specific activity requiring a Department of the Army permit and those portions of the entire project over which the district engineer has sufficient control and responsibility to warrant federal review" (33 CFR 325, Appendix B, Item 7(b)).

Because BRD is publically controversial and there could be significant impacts, the USACE would likely prepare an Environmental Impact Statement (EIS). Major steps in this process are:

- **Notice of Intent and NEPA Scoping.** A Notice of Intent would be published in the *Federal Register* and in local publications. This Notice of Intent would start the public and agency scoping process. The scoping process solicits comments on the important issues that should be addressed in the EIS. Comments will be collected, organized, and published so that USACE and the cooperating agencies can determine the scope of analysis in the EIS.
- **Data on Affected Environment for EIS.** After the scoping period, additional data gathering will likely be needed to more fully define the affected environment and the effects on the resources identified during scoping. A typical approach is to prepare resource-specific technical memoranda with the specific methodologies, data, and analysis.
- **Draft EIS.** The data gathered and captured in technical memoranda would be used to prepare a Draft EIS. The Draft EIS will be published and made available for review and comment by the agencies and the public. While the Draft EIS is out for public review, a public meeting is typically held in which the applicant is available to answer questions and collect formal comments on the Draft EIS.
- **Final EIS.** This step includes collecting, organizing, and responding to agency and public comments on the Draft EIS. USACE will determine the need for additional analysis and revisions that might be necessary before a Final EIS is published. Once a Final EIS is published, the public and agencies will have another opportunity to comment. USACE will prepare a response to any additional substantive comments received that were not addressed in the Final EIS.
- **USACE Decision Document.** Once USACE has reviewed the Final EIS, received public comments, and responded to any substantive comments, it will produce a decision document that will accompany the issuance of the 404 permit.

To appropriately integrate NEPA and CWA 404 requirements, project alternatives developed under NEPA should consider CWA Section 404(b)(1) Guidelines. These guidelines allow the discharge of dredged or fill material into the aquatic system only if there is no practicable alternative, which would have less adverse effects. The environmental document for any project that requires an Individual 404 permit from the USACE, must include an alternatives analysis that identifies the *Least Environmentally Damaging Practicable Alternative*. Additionally, the NEPA document will need to include a conceptual mitigation plan for impacts to wetlands and other WOUS, required buffer areas, and non-aquatic (wildlife) impacts.

Other Permits and Approvals

State-level permits include, but are not limited to, Stream Alteration Permits, Floodplain Development Permits, and, for construction, a Utah Pollutant Discharge Elimination System (UPDES) Permits for stormwater runoff and groundwater discharges, as well as Fugitive Dust Control Plans.

15.2.2 Mitigation for Wetland Impacts

According to 33 C.F.R. § 332, "Compensatory mitigation involves actions taken to offset unavoidable adverse impacts to wetlands, streams and other aquatic resources authorized by Clean Water Act Section 404 permits and other Department of the Army (DA) permits. Three common types of mitigation are project-specific mitigation, mitigation banking, and in-lieu fee mitigation (not currently available in Utah). Current regulatory guidance issued by USACE and EPA suggests that developing a mitigation bank, with funds to back its development, is the preferred method since it provides the greatest opportunity for success as well as being the most ecologically beneficial option.

Project-Specific Mitigation

Potential mitigation concepts should be developed for each project component in advance of the permit application and NEPA processes. During this step, several potential mitigation sites that are feasible to acquire or enhance should be identified and studied to determine which would have the greatest chance of success. Types of wetland mitigation entail preserving existing wetlands, rehabilitating or enhancing existing wetlands, reestablishing former wetlands, or creating new wetlands. These types of activities could occur within existing conservation lands, like those owned by the Nature Conservancy or others.

Once a mitigation approach and site is selected, a formal draft mitigation plan can be prepared if project-specific mitigation is selected. The draft plan is submitted to the USACE for review and coordination, and then a final mitigation plan is prepared. Required elements of a formal mitigation plan include the following:

- Baseline Information
- Objectives and Determination of Credits
- Mitigation Work Plan and Design
- Ecological Performance Standards

- Monitoring Requirements
- Maintenance Plan
- Adaptive Management
- Long-term Management Plan
- Site-protection Instrument and Financial Assurances

The USACE will define the required mitigation ratio, which is the area of impact to area of mitigation. For project-specific mitigation, the USACE will consider variables such as the expected difficulty or uncertainty of success associated with enhancement, restoration, or creation or wetlands, the temporal loss, and the distance from the impact site in setting the ratio. The USACE's Final 2015 Regional Compensatory Mitigation and Monitoring Guidelines (USACE, January 2015) will guide the definition of the required ratio and will typically be greater than 1-acre mitigation for 1-acre of impact (1:1). If mitigation activities were to occur with or after the project impacts occur (temporal losses) and the mitigation activities were limited to existing wetland enhancement, ratios can be as high as 6:1 or 7:1.

Mitigation Banking. If development of a mitigation bank is selected, a mitigation bank prospectus is prepared that describes the mitigation bank objectives, mitigation needs (wetland and wildlife habitat types), site suitability, and other details. In addition to the USACE, coordination on mitigation banking includes an Interagency Review Team (IRT) comprised of resource and regulatory agencies. Once there is consensus on the mitigation prospectus, work will begin to develop a Mitigation Banking Instrument (MBI). During this process, negotiations will occur to determine the proper credit/impact ratios as well as the milestones that must be reached for credits to become available and the process to release the credits.

Wetland banking creates a contiguous wetland complex (and wildlife habitat) in a single location that is easier to develop and monitor, as opposed to several smaller mitigation sites. Similarly, for single projects with a large amount of mitigation required, project-specific mitigation can also create a large contiguous wetland complex. Advanced mitigation occurs when mitigation activities are completed ahead of project construction. An advanced mitigation site may be developed for one or more specific projects.

Subsequent mitigation steps are summarized below for mitigation banking. Project-specific mitigation follows a similar sequence.

- **Mitigation Property Acquisition.** DWRe should identify and secure mitigation property before, or during, the 404 permitting process. Some of the properties must be secured before the DWRe can receive any wetland credits.
- **Final Mitigation Design Plans.** Final mitigation design plans and construction specifications will be developed.
- **Contractor Bidding and Procurement.** Developing contract documents and procuring a contractor will begin once the mitigation planning is complete. Projected operations will likely include grading, construction of diversion structures, and required planting.

- **Site Construction and Planting.** Depending on the site conditions and seasonal considerations, the actual construction is expected to span one construction season. It will be important to finish construction of the site in the fall so that seeds can germinate. Experienced staff should oversee the construction of the mitigation bank to ensure that plans and specifications are followed. Staff should also be available to assess construction progress and make design decisions in the field-specific site conditions.
- **Monitoring and Progress Reporting.** After construction is complete, the mitigation plan and MBI will require site monitoring and annual reporting to USACE. Expected monitoring and maintenance periods can be three to five years, depending on the MBI, monitoring will likely require staff to assess wetlands, habitat suitability, weed-control effectiveness, threatened and endangered species using the area, water quality, and other factors.
- **Release of Mitigation Credits.** After the required establishment periods, and when the success criteria for the site are met, DWRe will begin consultation with USACE so that USACE can release a large part of the mitigation credits related to establishing the mitigation site.
- **Final Monitoring Period.** Once all the MBI conditions are met and the required maintenance periods end, USACE will release all remaining wetland credits. Typically, the banking instrument must include guarantees that the site will be maintained in perpetuity. This long-term maintenance might require a commitment from DWRe, an endowment to provide operating funds, or an agreement with a third party.

Potential Mitigation Strategies. Because of the potential for large direct wetland impacts at potential reservoir sites, and potential for indirect impacts of depletions cost savings can be realized through advanced mitigation activities. Thus, early mitigation planning activities are recommended. In addition to the two approaches described above (project specific or banking), DWRe should explore other options to secure mitigation. Other options include:

- Purchasing credits at an existing mitigation bank(s) like Machine Lake in Box Elder County.
- Develop agreements with other divisions at the Utah Department of Natural Resources and the US Fish and Wildlife Service. This could enhance or expand the conservation efforts on their lands (i.e. Bear River Refuge, Harold Crane, Howard Slough, or Ogden Bay Waterfowl Management Areas).
- Develop partnership agreements with private conservation landowners to expand or enhance habitats with or adjacent to, their holdings. Examples include the Nature Conservancy’s Great Salt Lake Shorelands Preserve, the Bridgerland Audubon Society’s (Amalga) Barren’s Sanctuary, and PacifiCorp’s Cutler Marsh.

As shown in Chapter 12 (Environmental Review), based on preliminary investigations, all reservoir sites have impacts to wetlands and other WOUS. The mitigation approach will vary based on the selected reservoir site(s). For example, for the South Willard or Above Cutler sites, it might be difficult and very costly to identify enough land with wetlands to compensate for nearly 2,500 acres of expected impacts. If the mitigation ratio is ultimately 2:1 or higher, the effort to secure land becomes even more challenging. Mitigation for these sites, therefore, might become a complicated combination of a DWRe-owned mitigation bank, purchasing credits at an existing mitigation bank in advance of project impacts, and some additional project-specific mitigation activities that would be completed concurrently with project construction. These concurrent activities would be undertaken to complete the mitigation requirements, which would only become fully defined through the permitting and NEPA processes. Additionally, the USACE will require contingency measures in mitigation planning. Potential post-construction mitigation activities could be incorporated as contingency measures if monitoring indicates that the mitigation success criteria are not being met and/or if all anticipated credits are not available.

Some of the other reservoir sites have fewer impacts, however, the process of defining feasible mitigation is the same, just at a smaller scale. The benefit of doing as much advanced mitigation as possible is that the mitigation ratios would be closer to 1:1. In addition, there could be cost savings if mitigation land purchases could be minimized, or perhaps avoided, through partnership agreements with existing State and Federal agencies and/or private organizations. At this early stage, DWRe should start to explore all of these options.

It should be noted that the BRD Act, in 73-26-302(2), specifies that "construction of the project and implementation of the environmental mitigation plan shall proceed concurrently". To spend BRD monies for pre-construction mitigation activities, the Act would need to be amended.

The next steps recommended for BRD wetlands mitigation analysis include:

- Refine wetland acreage impact estimates based on potential reservoirs operations and define wetland functions for alternatives.
- Define reservoir operations and determine how the filling and discharge sequence could impact wetlands adjacent to the reservoir site, or if wetlands along the shoreline of the reservoir might be created by the reservoir operations.
- Meet with the USACE to gain insight to its perspective for impact assessment (especially diversion and inundation) to help identify potential mitigation requirements and discuss potential mitigation options.
- Research existing conservation areas and meet with owners to investigate partnering opportunities.
- Identify lands that are conducive to mitigation (size, soil types, water rights).
- Develop updated potential mitigation cost estimates for each reservoir site.

Risk Mitigation Strategies

For large, potentially contentious projects such as this one, a risk-mitigation strategy should be developed to reduce the risk of litigation. Strategies for risk mitigation include:

- **Agency and Public Involvement.** DWRe should involve as many agencies and stakeholders as possible in the planning stages so that they have input early on and are a part of the process.

- **Participate in the NEPA Process.** USACE will select a third party, independent of DWRe, to prepare the actual NEPA document. However, DWRe can conduct all of the preliminary studies and supply existing conditions information to the permitting agency. DWRe can also provide impact analysis conclusions for independent review. DWRe should stay engaged in the NEPA process to help evaluating requests for additional detailed studies of environmental and social resources. DWRe should help define the geographical extents of the analyses.

15.2.3 Right-of-Way Acquisition Plan

Early Acquisition of Real Property

As authorized in the Bear River Development (BRD) Act, DWRe is currently planning and coordinating for the acquisition for the BRD right-of-way (ROW). While the project is not approved or funded for construction, there are many advantages to early acquisition of ROW as opportunities become available. These may include:

1. Avoid greater impacts to wetlands and other important environmental resources by acquiring ROW in current open space of land areas with less environmental significance, before they are developed.
2. Large parcels of undeveloped property have fewer ownership entities. Early acquisition allows for fewer negotiations and conflict. Once development occurs and improvements are built on those open spaces, property acquisitions must be negotiated while considering the effect on people's homes, livelihoods, and communities.
3. Early ROW acquisition can lower the cost of the BRD. The cost of undeveloped property is less. As noted in Section 15.3 of this report, sales comparables indicate an average of 23% increase of land values over the three years between 2015 and 2018. This average may be a little high due to record low-interest rates and low inventory of properties available during this three-year period; however, an increase of 5% to 7% annually for land values is typical. Early acquisition also eliminates the expense of residential and/or business relocations, while allowing more time and resources for the acquisition process.
4. Properties that are purchased by DWRe could be managed in a way to give back to the community until the land is needed for construction. This may include allocation of ROW to open green space for developing communities, lease-back agreements or partnering with local agencies and communities for development of trail and park systems.

Acquiring the priority parcels early in the planning process protects the State's interests, allows more time for further planning and environmental permitting, and lowers overall costs for the BRD.

Right-of-Way Acquisition Manual

In order to guide DWRe staff in the acquisition of real estate for the BRD and to formalize procedures in this important aspect of BRD, DWRe has a Draft ROW Acquisition Manual. DWRe intends for the manual to be a convenient and standard source of real estate acquisition procedures.

The manual outlines practices for DWRe staff and its consultants to provide consistent, fair treatment of landowners, and streamlines the process for acquiring real property.

Opportunities for Early Acquisition

In an effort to acquire priority parcels identified in the potential pipeline alignment, DWRe is identifying “opportunity parcels” for early acquisition. These opportunity parcels may include properties where:

1. Undeveloped land is planned for development. DWRe could coordinate with landowners to preserve a corridor.
2. Sellers contact DWRe about potential purchase.
3. Land purchases by other entities for shared acquisitions.

DWRe has been in discussion for several years with the Utah Transit Authority (UTA) about a potential shared utility corridor along the Union Pacific Railroad east of Willard Bay through Box Elder County. DWRe and UTA signed a Memorandum of Agreement (MOA) in August 2018 to coordinate this effort. This effort includes public outreach, a survey of the corridor area, property valuations of parcels with an opportunity for early acquisition, and negotiation efforts to acquire ROW for a shared corridor. Currently these efforts are based on willing sellers, as both agencies forecast any projects in this area to be well into the future. The following sections provide information regarding approximate land costs and the costs of a real estate services team for negotiations and initial setup.

Estimated ROW Land Value

Land values typically increase 5% to 7% annually and are based on other market conditions such as available inventory and interest rates. The estimated land costs in this study are based on the real estate market conditions of 2018. The specific parcel data was obtained from county tax records. The parcel information (parcel ID, size, owner, and address) for Box Elder County and Weber County was current as of June 21, 2010, and February 21, 2012, respectively.

Land values were estimated based on comparable market sales in each county over six months (April 2018 to October 2018) and current tax assessment values. Table 15-1 indicates the average value (per acre) based on the designated land type: Agricultural, Commercial/Industrial, or Residential. In addition, for the purposes of this study, the area within the Whites Valley footprint was estimated at $1,500/acre.

Table 15-1
Private Property Values (2018 $/acre)

Land Type (zoned)	Box Elder County	Weber County
Agricultural (irrigated)	$17,601	$28,982
Commercial/Industrial	$92,758	$144,860
Residential (vacant)	$154,932	$232,140
Whites Valley site (open land)	$1,500	N/A

Values reported are average per acre values in 2018 dollars

For privately-held priority parcels, it was assumed that DWRe would purchase the entirety of all privately-held priority parcels within the alignment in full “fee”, meaning that all property rights of an entire parcel would be acquired and conveyed by deed.

The average size for the priority private parcels is 100 acres in Box Elder County and 5 acres in Weber County. The average private property value across *all property types* (except within the Whites Valley site) is $29,534/acre in Box Elder County and $116,739/acre in Weber County.

For publicly-held parcels, there may be minimal costs to obtain permits and/or agreements from public agencies. An estimated $300 per parcel was assumed for permit application fees paid for the right to use public lands for the pipeline ROW. This estimated permit fee does not include any associated engineering or legal costs that may be incurred.

For both Box Elder and Weber counties, the estimated cost to acquire privately-held land was calculated by multiplying the average value per acre by the total acreage. The estimated cost for publicly-held land was calculated by multiplying the number of parcels by the cost of the permit fee.

Table 15-2 presents the estimated costs to acquire the 219 priority parcels and the 29 parcels within the Whites Valley site.

Table 15-2
Land Costs for Priority Parcels

County/Land Type	# of Parcels	Area (acres)	Average Value Per Acre	Permit Fee	Estimated Cost*
Box Elder - Private	43	2,791	$29,534	--	$82,430,000
Box Elder - Public	70	1,084	--	$300	$ 21,000
Weber - Private	35	183	$116,739	--	$21,365,000
Weber - Public	71	227	--	$300	$ 21,300
Whites Valley Site	29	4,538	$1,500	--	$6,807,000
Totals	248				$ 110,639,300

*Private Land Cost = Acres x Average Value, Public Land Cost = Number of Parcels x Permit Fee

Estimated ROW Services Costs

This section presents the estimated labor and direct expenses for real estate services staff. These services may include preparing document templates, creating and maintaining a ROW database, developing tracking tools and file management systems, contacting property owners, reviewing title reports and appraisals, securing ROW agreements with public agencies, and conducting property acquisitions.

During the first year of acquisition activities, a real estate team would need to do project setup. Initial project setup may include the following:

- Further define and refine the processes and procedures for property acquisitions and for securing other property interests
- Draft contract templates for property acquisitions and agreements for future property transactions (e.g., easement documents, purchase options, first right of refusal documents, etc.)
- Define the file management system and contents, set up a parcel database, and set up tracking and team collaboration tools
- Prepare subcontractor agreements for ROW Survey and Appraisals.

Table 15-3 indicates an estimate of costs for the ROW acquisition services per parcel.

Table 15-3
Estimated Costs for ROW Acquisition Services ($/parcel)

Acquisition Step	Estimated Cost/Parcel
Project Management	$ 1,000
Survey	$ 2,000
Appraisal	$ 2,700
Appraisal Review	$ 1,000
Preliminary Title Report	$ 300
Acquisition Costs*	$ 5,000
Estimated Cost/Parcel	$ 12,000

* Includes costs for ROW Agent (make offers, contract management, etc.)

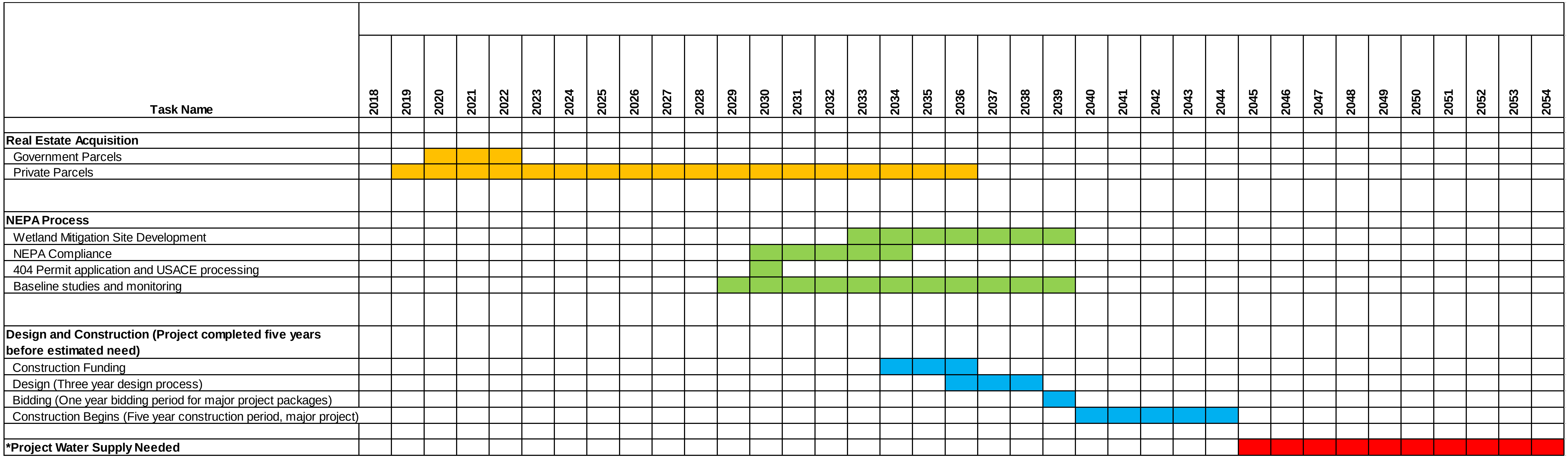
The cost estimate for ROW Acquisition Services to acquire 248 priority parcels is estimated to be approximately $3 Million.

Priority Parcel Acquisition Costs

The total estimated cost of acquiring the 248 priority parcels is estimated as shown in Table 15-4.

Table 15-4
Costs to Acquire Priority Parcels

Acquisition Step	Total Estimated Cost
Land Costs	$ 110,639,300
ROW Acquisition Services Costs	$ 2,976,000
Estimated Cost	$ 113,615,300



*At present 2045 or later

Figure 15-1: Overall Project Schedule

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