RECLAMATION
Managing Water in the West

Draft Appraisal Study Report

Eastern Oregon Water Storage Appraisal Study

for Burnt River, Powder River, and Pine Creek Basins

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

April 2011

U. S. DEPARTMENT OF THE INTERIOR

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Summary

Introduction and Background

The Bureau of Reclamation (Reclamation) in cooperation with eastern Oregon stakeholders is studying the potential to improve water supplies in the Burnt River, Powder River, and Pine Creek basins.

About this Report

This appraisal-level report is prepared in compliance with requirements of the *Economic and Environmental Principles and Guidelines for Water and Related Land Resource Implementation Studies* (U.S. Water Resources Council, 1983) (P&Gs). It presents a discussion of the formulation of alternatives, a description of the appraisal level designs and cost estimates for the alternatives considered, and the results of the P&G-specific analyses.

Information in this report is based on a variety of studies. Further background information may be obtained from the *Literature Review of the Powder Basin Oregon, Stream Systems, Water Storage, and Stream Health as they Pertain to the Basin and Water Science* (Reclamation 2008). The following website also contains background information: http://www.usbr.gov/pn/programs/srao_misc/storagestudy/index.html

Project and Authorized Study Area

Eastern Oregon residents have considered and worked toward developing additional storage opportunities for over 50 years. Water is stored in multiple existing reservoirs, but the stored water does not meet late summer water demand for irrigation and instream water rights for fish habitat. Water diversions to roughly 80 percent of irrigated lands are shut down by late summer, which in turn impact stream health, fisheries, and recreation potential.

In January 2005, the Baker County Board of Commissioners established the Powder Basin Water and Stream Health (WASH) Steering Committee to explore and assess potential opportunities for additional instream and out-of-stream projects. The WASH Initiative's mission is to:

> *develop and implement a long-term water management plan that utilizes water conservation, storage and re-use which incorporates beneficial uses such as recreation, agriculture, fish, wildlife, hydropower, flood prevention and instream needs to provide sustainability to the environment, society and the economy.*

The WASH committee requested assistance from Reclamation's Snake River Area Office in Boise, Idaho, and secured additional federal funding in 2007 to pursue further assessment of water supply opportunities in the Powder River basin. The purpose of this appraisal study is to:

- Demonstrate an unsatisfied need, either current or future, within the basins
- Determine if water demand in the Powder River basin is unmet (projected to the year 2050)
- Demonstrate whether that need may be satisfied by structural plans for management and development of available resources
- Determine if there is at least one regional alternative to meet current and future demands
- Determine if there is a Federal objective consistent with Reclamation policies, laws, costs, benefits, and environmental impacts in which there exists at least one regional plan that can be recommended to be carried forward into a Feasibility Study

The funding source for this study was directed toward structural solutions for additional storage facilities. As such, this report does not include nonstructural plans for management and development of existing resources, such as automated water delivery control systems. Water conservation options are being examined by the stakeholders in separate but concurrent activities in partial fulfillment of WASH's stated goals. Preliminary permit applications for consideration of hydropower generation facilities have been tendered by Pacific Rim Energy on Reclamation and other non federal irrigation facilities in Baker County.

The Eastern Oregon Water Storage Appraisal Study area is located in eastern Oregon, bordered to the north by the Wallowa Mountains, to the west by the Blue Mountains, to the south by the Malheur River basin, and to the east by the Snake River. The Burnt River and Powder River water systems are upstream from 10 Snake River and Columbia River dams. The study area is comprised of 3 major basins: Burnt River, Powder River, and Pine Creek, which together encompass approximately 2.7 million acres and are also collectively referred to as the Powder River basin. Stream headwaters originate in the Blue and Wallowa mountain ranges at elevations from 6,000 to nearly 9,000 feet above sea level. They empty into Snake River reservoirs owned and operated by the Idaho Power Company.

Appraisal Study Process

Reclamation's water resource planning process involves three levels of planning, starting with a preliminary assessment. An appraisal study is a preliminary survey of problems and needs that uses existing information to explore conceptual solutions to identified water resources issues. The appraisal study process includes development and screening of alternatives so only viable alternatives that meet project goals are carried forward into the more extensive feasibility analysis step.

Reclamation is authorized by the Burnt, Malheur, Owyhee, and Powder River Basin Water Optimization Feasibility Study Act of 2002 (P.L. 107-237, October 11, 2002), to conduct feasibility studies on water optimization in the Burnt River, Malheur River, Owyhee River, and Powder River basins in Oregon.

Problems and Needs

Irrigation deliveries are the largest water use in the study area. Municipal, domestic, commercial, and industrial uses are estimated to be minimal in comparison.

Approximately one-half of the study area is owned by various Federal agencies. Approximately two-thirds of the area is rangeland, with livestock grazing as the primary land use. One-sixth of the area is forestland where timber harvest and summer livestock grazing are the main uses. Most of the remaining area is cropland and pastureland irrigated by gravity, flood, or sprinkler systems. Irrigated acres produce primarily grain, hay, and pasture (Reclamation 2008; PBWC 1996).

Thirty reservoirs, ranging from 46 acre-feet to 90,500 acre-feet of active storage capacity, supply water primarily for irrigation in the three basins. The hydrology is dominated by snowmelt runoff in the spring, but is also affected by reservoir storage and release. Historic low flows are sometimes less than minimum instream water rights because of low natural runoff or because of upstream diversions by higher priority water rights. Several basin streams have been identified by the Oregon Department of Environmental Quality (Oregon DEQ 2010) as water quality limited. Pollutants of concern include temperature, sedimentation, chlorophyll, dissolved oxygen, and *E. coli*.

The study area lacks anadromous fish. Portions of the study area are occupied by bull trout, listed in 1998 under the Endangered Species Act as “threatened”, and contain bull trout designated critical habitat. The study area supports a diverse resident fish population and an active recreational fishery which includes both native and introduced species.

A limiting factor in this study was the lack of day-to-day measurements of streamflows, diverted flows, and return flows. Substantial efforts were made to develop and improve methods to understand and evaluate existing basin conditions and potential reservoir sites, including natural flows and irrigation demands.

The total irrigation shortage volume is smaller than the difference between the total flow and irrigation demand for each of the three basins within the study area. However, the location and timing of the flow frequently does not align with the location and timing for the demand.

The greatest irrigation demand for water to occurs in July through September, while stream flows are greatest in March through June as a result of the snowmelt and runoff. Water supplies are often not available to meet water demands in most of the irrigated areas by mid- to late August, as natural flows recede and stored supplies diminish, resulting in a lack of flow to meet irrigation water rights and instream rights and needs.

Current system deficiencies or needs were defined in terms of irrigation shortage and currently filed instream water rights. Anticipated municipal future demands were generated based on a "high-growth scenario" of 2 percent growth per year and an average rate of 115 gallons of water per person per day, projected out to 2050. It is assumed this average municipal rate also includes commercial and industrial needs for the purpose of this study. Based on available information, it was anticipated that existing municipal water rights will meet municipal demand through the 2050 planning horizon.

Conjunctive uses of groundwater and surface water are unknown and, therefore, not included in this level of analysis. While water right information exists for industrial uses, most industrial water rights are currently not being used and demand for industrial water use was not expected to increase for the purposes of this analysis.

Climate change may result in changes to the water supply and demand calculated and used as the basis of this report. No analyses were performed in this study to quantitatively estimate possible changes associated with climate change that might affect reservoir operations, irrigation demand or operations, crop types, cropping dates, environmental flow targets, water supplies and shortages, or hydropower production. A qualitative discussion of impacts may be found in Chapter 2.

Resources, Constraints, and Identification of Alternatives

The literature review process and Reclamation recommended 95 storage sites for hydrologic evaluation with potential economic and ecological benefits. A screening process involving stakeholders was performed that reduced the number of sites for further study, based on good potential for water supply and proximity to need. After site aggregation and further hydrologic analysis, four sites were ultimately selected for an appraisal-level evaluation.

The potential storage sites that were evaluated for this study are the following:

- Hardman Dam and Reservoir site on the Burnt River
- Enlargement of the existing Thief Valley Dam on the Powder River with pumpback; two alternatives were considered but only one carried forward for economic analysis
- North Powder Dam and Reservoir site on the Powder River
- East Pine Dam and Reservoir site on Pine Creek

The proposed Thief Valley reservoir involves enlargement of an existing dam. The other three sites involve new dam and reservoir facilities. Hydropower facilities were evaluated in conjunction with storage. These sites were evaluated individually, not operating in parallel with each other.

Alternative Designs and Cost Estimates

Reclamation completed an appraisal-level evaluation of the four selected sites that included conceptual-level engineering and economic investigations to evaluate site suitability for construction, preparing appraisal-level construction cost estimates, characterizing water supply and hydropower benefits, and identifying permitting constraints and applicable environmental benefits. The team also conducted a qualitative assessment of potential environmental issues and other considerations such as the presence of protected species and their habitats, water quality and recreation impacts, and flood-control potential.

The appraisal-level evaluation of the four potential sites concluded the following:

- Water surpluses are available at each site, and there is need for these storable surpluses.
- Storage facilities could be constructed at each potential site based on field investigations and a review of information.
- Each storage facility has potential for hydroelectric development, although reservoir storage operations could affect existing hydroelectric projects downstream.
- Each storage facility has potential to improve seasonal streamflows and water temperatures to benefit fish and water quality, depending on ability to store relatively cool water in the spring and release it later in the season when river water temperatures normally rise.

The study also indicated the following challenges would need to be addressed if any of the projects are to be analyzed in greater detail:

- Each project must address stream habitat needs for fish species that are listed for protection under the federal Endangered Species Act or species of concern. These issues may be resolvable through a variety of actions ranging from installation of fish-passage facilities to habitat mitigation. The East Pine facility is especially sensitive due to the presence of bull trout and designated bull trout critical habitat in the watershed.
- All projects would require roadway relocations and mitigation for adverse impacts on parks, utilities, and other existing facilities affected by potential inundation by storage water.

- Some projects would require land purchases, transfers, and/or easements to accommodate reservoir facilities.
- Hydropower potential for each site would require further analysis if storage for irrigation is not their primary intended function. The Columbia system would need to be included in all analyses to fully assess impacts to the regional generation of hydroelectric power.
- Flood control, recreation, and other potential benefits were not quantified.

Table 1 summarizes parameters estimated for the proposed storage reservoirs at their 80 percent reliability levels of water supply. The construction cost is the direct and indirect cost for each proposed storage reservoir. The storable volume at 80 percent reliability is essentially the volume of storage proposed to store and release water. The estimated average annual supply is the amount of average annual additional water supply made available by the proposed storage.

Table 1. Summary of Storage Associated with Proposed Storage Reservoirs at 80 Percent Reliability Levels of Water Supply

No.	Proposed Storage Reservoir	Storage Facility Construction Cost	Storable Volume at 80 percent Reliability (acre-feet)	Estimated Average Annual Supply (acre-feet)
83	Hardman Reservoir	$50,000,000	4,800	1,500
30	Thief Valley Reservoir Enlargement with pumping	$183,000,000	43,000	29,000
40	North Powder Reservoir	$113,000,000	5,300	4,500
6	East Pine Reservoir	$133,000,000	21,000	13,700

Table 2 provides comparisons for construction of hydropower generation and transmission facilities.

Table 2. Summary of Hydropower Potential Associated with Proposed Hydropower Facilities at 80 Percent Reliability Levels of Water Supply

No.	Proposed Hydropower Facilities	Hydropower and Transmission Construction Cost	Generation Potential at 80 percent Storage Reliability (MWh/yr)	Preliminary Estimated Impacts on Snake River system (MWh/yr)
83	Hardman Reservoir	$3,100,000	721	(110)
30	Thief Valley Reservoir Enlargement	$64,000,000	12,435	(4,440)
40	North Powder Reservoir	$14,700,000	4,919	2,758
6	East Pine Reservoir	$16,300,000	7,399	3,136

The Federal objective is to contribute to national economic development (NED) consistent with protecting the Nation's environment. An NED benefit-cost analysis compares the benefits of a proposed project to its costs. Total costs of the project are subtracted from the total benefits to measure net benefits. Benefits associated with the action alternatives are measured as changes from a No Action alternative. If the net benefits are equal to or greater than one, implying that benefits exceed costs, the project could be considered economically justified. Parameters that are not quantifiable, while important, do not factor into the benefit-cost analysis. No other economic analyses were performed for this appraisal level study.

A benefit-cost analysis was conducted on the proposed alternatives being considered in this study. Benefits and costs associated with each proposed alternative are compared to the No Action (baseline) alternative. Benefit categories evaluated for this analysis include agriculture and hydropower. Other benefit categories such as flood control, recreation, fisheries, etc. were not evaluated. Cost categories include construction of dams, pumping plants and conveyance systems, hydropower plants, power transmission lines and annual operations, maintenance, replacement, and power (OMR&P) costs. Interest during construction (IDC), based on the current FY2011 federal water resource agency planning rate of 4.125 percent, was charged on each construction element annually through the end of the construction period. The construction period was assumed at 3 years for all alternatives (2012-2014). The period of analysis for benefits and OMR&P costs was assumed at 100 years from the end of the construction period (2015-2114).

All benefits and costs are measured in current (2009/2010) dollars. In some cases, costs were initially based on previously developed estimates and therefore had to be indexed up to current dollars. In addition, all benefits and costs were converted to a common point in time (when benefits begin to accrue). It was assumed that IDC provides the conversion of construction costs to the end of the construction period. The 100-year stream of agricultural and hydropower benefits and OMR&P costs were discounted (present valued) back to the end of the construction period using the 4.125 percent planning rate.

Conclusions and Recommendations

None of the alternatives result in positive net benefits or benefit-cost ratios equal to or greater than one (Table 3).

Table 3.Benefit-Cost Analysis Results for each Alternative (Millions $)

Benefit-Cost Components	Hardman Alternative	Thief Valley Alternative	North Powder Alternative	East Pine Alternative
Total Benefits	**43.4**	**185.6**	**59.3**	**41.2**
Agriculture	43.6	193.5	54.4	35.7
Hydropower	-0.2	-7.9	4.9	5.5
Total Costs	**60.6**	**280.3**	**141.2**	**164.1**
Construction & IDC	56.3	262.7	136.1	158.1
OMR&P	4.3	17.6	5.1	6.0
Net Benefits	**-17.2**	**-94.7**	**-81.9**	**-122.9**
Benefit-Cost Ratio	**.72**	**.66**	**.42**	**.25**

Following is a brief summary of key points and recommendations for each of the four potential sites analyzed for additional storage, based on this appraisal-level analysis:

Hardman Reservoir

Reclamation plans to terminate the feasibility evaluation process for this alternative, as it does not meet the stated Federal objectives for this study. Development and implementation of a long-term plan that emphasizes water conservation and improved management practices is recommended for the purposes of satisfying existing and future water user needs of the basin.

The hydropower generation investigated for this study was secondary to irrigation benefit. The benefit/cost ratio of hydropower generation without consumptive use of stored water for irrigation purposes was not investigated as this was outside of the scope of this study. Appraisal level calculations indicate that a storage facility at the proposed Hardman location would have minimal impact on the total annual flow reaching the Snake and Columbia Rivers. However, the impact to the regional hydropower generation systems as a result of the change in flow quantity or flow timing in reaching the Snake and Columbia Rivers was not assessed.

Thief Valley Reservoir Enlargement

Reclamation plans to terminate the feasibility evaluation process for this alternative, as it does not meet the stated Federal objectives for this study. Development and implementation of a long-term plan that emphasizes water conservation and improved management practices is recommended for the purposes of satisfying existing and future water user needs of the basin.

The hydropower generation investigated for this study was secondary to irrigation benefit. The benefit/cost ratio of hydropower generation without consumptive use of stored water for irrigation purposes was not investigated. Appraisal level calculations indicate that an enlarged facility at the Thief Valley location would have a measurable impact on the total annual flow reaching the Snake and Columbia Rivers. However, the impact to the regional hydropower generation systems as a result of the change in flow quantity or flow timing in reaching the Snake and Columbia Rivers was not assessed.

North Powder Reservoir

Reclamation plans to terminate the feasibility evaluation process for this alternative, as it does not meet the stated Federal objectives for this study. Development and implementation of a long-term plan that emphasizes water conservation and improved management practices is recommended for the purposes of satisfying existing and future needs of the basin.

The hydropower generation investigated for this study was secondary to irrigation benefit. The benefit/cost ratio of hydropower generation without consumptive use of stored water for irrigation purposes was not investigated. Appraisal level calculations indicate that a storage facility at the proposed North Powder location would have minimal impact on the total annual flow reaching the Snake and Columbia Rivers. However, the impact to the regional hydropower generation systems as a result of the change in flow quantity or flow timing in reaching the Snake and Columbia Rivers was not assessed.

East Pine Reservoir

Reclamation plans to terminate the feasibility evaluation process for this alternative, as it does not meet the stated Federal objectives for this study. Development and implementation of a long-term plan that emphasizes water conservation and improved management practices is recommended for the purposes of satisfying existing and future water user needs of the basin.

The hydropower generation investigated for this study was secondary to irrigation benefit. The benefit/cost ratio of hydropower generation without consumptive use of stored water for irrigation purposes was not investigated. Appraisal level calculations indicate that a storage facility at the proposed East Pine location would have minimal impact on the total annual flow reaching the Snake and Columbia Rivers. However, the impact to the regional hydropower generation systems as a result of the change in flow quantity or flow timing in reaching the Snake and Columbia Rivers was not assessed.

The following general recommendations are provided by Reclamation to the project stakeholders as a result of the Eastern Oregon Water Storage Appraisal Study:

- None of the alternatives analyzed as water storage projects for irrigation should be considered for further study.

- Stakeholders should pursue water optimization studies and implementation through grant and loan programs supported by Reclamation and others. Non-structural actions would help irrigators close the gap in water users' water delivery needs. Watershed management or water conservation, such as those identified in the WASH objectives, listed under current activities (Section 1.4) should be pursued.

- Stakeholders should consider objectives which further study of hydropower generation optimization.

- To support the above recommendations, stakeholders should pursue means to collect additional long-term hydrologic and water use data within the study area.

Acronyms and Abbreviations

ºC	degrees Celsius
°F	degrees Fahrenheit
AUMS	Animal Unit Months
BLM	U.S. Department of the Interior Bureau of Land Management
cfs	cubic feet per second
cwt	hundredweight
CZ	contributing zone
CZD	Contributing zone diversion
DEQ	Department of Environmental Quality
ERS	Economic Research Service
ESA	Endangered Species Act (Federal)
GWh	gigawatt hour
H	Horizontal
IDC	Interest During Construction
MWh	megawatt hour
Mid C	Mid-Columbia River
NASS	National Agricultural Statistics Service
NEPA	National Environmental Policy Act
NPCC	Northwest Power and Conservation Council
NRCS	U.S. Natural Resources Conservation Service
OAIN	Oregon Agricultural Information Network
ODA	Oregon Department of Agriculture
OMR&P	Operations, Maintenance, Replacement, and Power

OWRD	Oregon Water Resources Department
P&Gs	Principles and Guidelines
PBWC	Powder Basin Watershed Council
P.L.	Public Law
POD	Point of diversion
RCC	Roller compacted concrete
RM	River Mile
TBD	transbasin diversion
U.S.	United States
USBR	U.S. Bureau of Reclamation
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
V	Vertical
WASH	Powder River Water and Stream Health Steering Committee
WC	Watershed Council

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Chapter 1 STUDY PURPOSE AND SCOPE

People's livelihoods in eastern Oregon's Powder River basin, which is comprised of the Burnt River, Powder River, and Pine Creek basins, are directly influenced by water supply availability. Their concerns include instream needs for aquatic ecosystems, recreation, water quality, and out-of-stream needs such as irrigation, power generation, municipal use, and terrestrial ecosystems.

Eastern Oregon residents have considered and worked toward developing additional storage opportunities for over 50 years. Water is stored in multiple existing reservoirs, but the stored water does not meet late summer water demand for irrigation and instream water rights for fish habitat. By August, natural flows recede and stored water supplies diminish. As a result, water diversions to roughly 80 percent of the irrigated lands are shut down, which in turn may impact stream health, fisheries, and recreation potential.

Private parties have developed small dams and storage facilities over the last 50 years. Larger projects had previously been identified and studied by the U.S. Department of the Interior Bureau of Reclamation (Reclamation), the United States Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS), and area soil and water, irrigation and water control districts. In January 2005, the Baker County Board of Commissioners established the Powder Basin Water and Stream Health (WASH) Steering Committee to explore and assess potential opportunities for additional instream and out-of-stream projects. The intent of these projects is to identify benefits to the existing water supply system in concert with enhancing the health and welfare of the basin. The WASH Initiative's mission is to:

> *develop and implement a long-term water management plan that utilizes water conservation, storage and re-use which incorporates beneficial uses such as recreation, agriculture, fish, wildlife, hydropower, flood prevention and instream needs to provide sustainability to the environment, society and the economy*.

The WASH committee's stated goals for this specific study are as follows:

- The WASH Steering Committee has authority granted from Baker County, Union County, and the State of Oregon to proceed with projects as described in the mission statement in cooperation with other affected government entities, special districts, and watershed councils.
- Of the water that leaves the basin as snowmelt runoff, 80 percent will be locally managed by 2030 and 100 percent by 2050.
- Management will occur through conservation practices, storage facilities, re-use, and return flows via surface and subsurface routes.
- 1909 Oregon Water Law will be an integral part of all long-term water planning.

1.1 Reclamation's Authority to Conduct Study

The WASH committee requested assistance from Reclamation's Snake River Area Office in Boise, Idaho, and secured additional federal funding in 2007 to pursue further assessment of water supply opportunities in the Powder River basin. The purpose of this appraisal study is to:

- Demonstrate an unsatisfied need, either current or future, within the basins
- Determine if water demand in the Powder River basin is unmet (projected to the year 2050)
- Demonstrate whether that need may be satisfied by structural plans for management and development of available resources
- Determine if there is at least one regional alternative to meet current and future demands
- Determine if there is a Federal objective consistent with Reclamation policies, laws, costs, benefits, and environmental impacts in which there exists at least one regional plan that can be recommended to be carried forward into a Feasibility Study

The Federal objectives for this study are stated in the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&Gs) (1983), as follows:

a. The Federal objective of water and related land resources planning is to contribute to national economic development (NED) consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements.

b. Contributions to NED are increases in the net value of the national output of goods and services, expressed in monetary units. Contributions to NED are the direct net benefits that accrue in the planning area and the rest of the nation. Contributions to NED include increases in the net value of those goods and services that are marketed, and also of those that may be marketed, and also of those that may not be marketed.

Reclamation desires the following output for this project:

- For existing Reclamation projects - meet water users' contractual obligations for water delivery, needs now and through the study's 40-year planning horizon
- For areas of need outside of existing Reclamation projects - seek opportunities to fulfill needs that meet or exceed 80 percent reliability criteria
- Continue to meet Endangered Species Act (ESA) obligations and identify opportunities to enhance ecological needs
- Meet Indian trust obligations
- Avoid costly litigious processes
- Satisfy the criteria necessary to produce a complete appraisal level report

Any alternative plan recommended to be carried forward to Feasibility Level Evaluation must be capable of meeting the following four tests of viability, as stated in the P&Gs:

- Acceptability to state and local entities and the public, and compatible with existing laws, regulations, and public policies
- Effectiveness in contributing to objectives
- Efficiency as the most cost effective means of meeting objectives
- Completeness in accounting for all necessary investments or other actions, including those by other Federal and non-Federal entities.

This appraisal study process consisted of the following steps:

- Prepare a needs, opportunities, and constraints assessment (Chapter 2)
- Evaluate average annual hydrologic water supply yield in comparison to identified needs for each identified site (Chapter 2)
- Conduct a literature review, document findings and develop a list of potential storage locations for further evaluation (Section 3)
- Identify guidelines and screening criteria to identify potential alternatives (Chapter 3)
- Conduct stakeholder workshop to identify and agree upon alternatives for further study (Chapter 3)
- Evaluate potential storage location alternatives for supply reliability (Chapter 4)
- Conduct appraisal-level cost evaluations of selected alternatives (Chapter 5)
- Perform an economic analysis of selected alternatives (Chapter 6)
- Evaluate and recommend action (Chapter 7)

1.1 Reclamation's Authority to Conduct Study

Reclamation is authorized to conduct this study under the Reclamation Act of 1902 (P.L. 57-161, 32 Stat. 388, June 17, 1902). The Act, as amended and supplemented, authorizes Reclamation to manage and develop innovative water management tools and partnerships to meet the growing demand for water in the American West.

Reclamation's water resource planning process involves three levels of planning, starting with a preliminary assessment. The assessment helps determine the federal role(s) and the desirability of potential partners to proceed to the subsequent appraisal and feasibility analyses.

An appraisal study is a preliminary survey of problems and needs that uses existing information to explore conceptual solutions to identified water resources issues. The appraisal study process includes development and screening of alternatives so only viable alternatives that meet project goals are carried forward into the more extensive feasibility analysis step.

Reclamation is authorized by the Burnt, Malheur, Owyhee, and Powder River Basin Water Optimization Feasibility Study Act of 2002 (P.L. 107-237, October 11, 2002), to conduct feasibility studies on water optimization in the Burnt River, Malheur River, Owyhee River, and Powder River basins in Oregon.

1.2 Stakeholder Work Group Involvement

Reclamation partnered with the WASH committee and other locals to conduct this appraisal study, forming a stakeholder work group to advise Reclamation and provide input on technical work products. A list of the participating membership of the WASH committee is included in Appendix A. Two meetings have been held within the study area to engage the public in this study process. Meeting agendas and minutes are posted on the Reclamation website at www.usbr.gov/pn/programs/srao_misc/storagestudy/index.html (Reclamation 2010). Informal meetings and workshops were also conducted by Reclamation and its contractors with the WASH committee members and other stakeholders during the study process.

1.3 General Description of Study Area

The Eastern Oregon Water Storage Appraisal Study area (see Figure 1-1) is located in eastern Oregon, bordered to the north by the Wallowa Mountains, to the west by the Blue Mountains, to the south by the Malheur River basin, and to the east by the Snake River. The Burnt River and Powder River water systems are upstream from 10 Snake River and Columbia River dams (Nowak 2004a, Nowak 2004b). The study area is comprised of 3 major basins: Burnt River, Powder River, and Pine Creek, which together encompass approximately 2.7 million acres and are also collectively referred to as the Powder River basin.

1.3.1 Environmental Characteristics

The topography in these eastern Oregon basins varies greatly, with relatively high-gradient mountain streams, deep river canyons, and broad shallow valleys. Stream headwaters originate in the Blue and Wallowa Mountain ranges at elevations from 6,000 feet to above 9,000 feet above sea level. They empty into Snake River reservoirs, the Hells Canyon Complex, owned and operated by the Idaho Power Company (Reclamation 2008).

The climate is similar for the Burnt River, Powder River, and Pine Creek basins. The overall climate is temperate, characterized by light precipitation, low relative humidity, rapid evaporation, abundant sunshine, and wide temperature and precipitation fluctuations. The mean annual temperature is about 46°F. Temperature extremes of -28°F (February) and 104°F (August) have been recorded at the Baker City Airport. Precipitation varies widely across the basins. The majority of annual precipitation, which averages about 11 inches in the valleys and nearly 80 inches on the highest elevations, falls as snow during winter. In the summer, hot, dry surface air often mixes with cool, moist upper air masses to produce lightning storms (Nowak 2004a, Nowak 2004b).

1.3.2 Social and Economic Characteristics

The basins have a population of about 17,000 people spread across Baker County and in a small portion of southern Union County. Baker City is the largest city with a population of 10,035 in 2008. The remaining populations are located in very small rural communities. The major employers are agriculture, tourism, and government. Absent industrial growth, the population is expected to continue to grow at its current rate, with no anticipated regional competition for water due to urban development.

Based on factors such as unemployment rates, annual income, and population, the State of Oregon has designated Baker County as a "distressed" area. It is thus eligible for priority assistance from the Economic and Community Development Department (Reclamation 2008, PBWC 1996).

1.3.3 Hydrology and Present Water-Related Development

The amount and timing of runoff in these basins is dependent on the amount of snowpack accumulated during the winter months, and the timing of spring temperature increases and rainfall. Seasonal peak flows generally occur between April and early June. Portions of this area commonly experience rain-on-snow events, which cause brief, localized flooding. Summer flows are influenced by water diversions for irrigation, with rivers reaching their lowest flow levels in late summer (Nowak 2004b).

The agricultural community is the largest water user in Oregon. There are several existing reservoirs whose primary function is to service agricultural demands. These reservoirs range in capacity from 46 acre-feet to 95,500 acre-feet. There are no known facilities that operate strictly for flood control, hydropower, recreation, ecosystem enhancement, or municipal or industrial use.

Domestic, municipal, and industrial water is generally supplied by groundwater resources. Baker City has implemented an aquifer storage and recovery project (Oregon 2010).

Approximately one-half of the study area is owned by various Federal agencies.

Approximately two-thirds of the area is rangeland, with livestock grazing as the primary land use. One-sixth of the area is forestland where timber harvest and summer livestock grazing are the main uses. Most of the remaining area is cropland and pastureland irrigated by gravity, flood, or sprinkler systems. Irrigated acres produce primarily grain, hay, and pasture (Reclamation 2008, PBWC 1996).

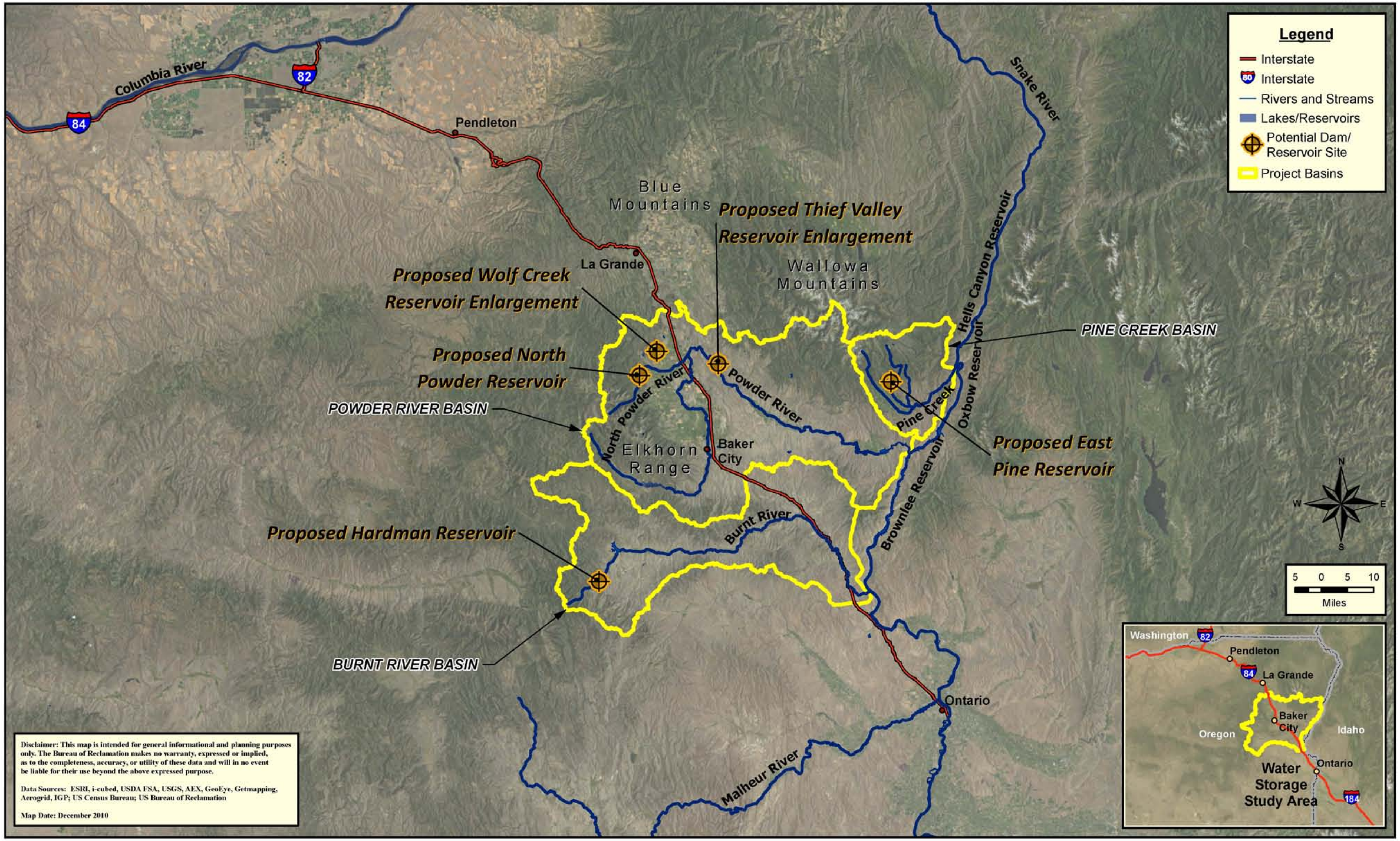

Figure 1-1. Vicinity Map

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1.4 Current Activities and Related Studies

Reclamation owns facilities in three different locations within the study area:

- Unity Dam and Reservoir at the confluence of the North, South, West, and Middle Forks of the Burnt River (25,200 acre-feet, managed by Burnt River Irrigation District).
- Mason Dam and Phillips Reservoir on the Powder River (95,500 acre-feet, managed by Baker Valley Irrigation District).
- Thief Valley Dam and Reservoir on the Powder River (constructed with a capacity of 17,400 acre-feet, capacity estimated to be 13,300 acre-feet in 2001 (Reclamation 2001), managed by Powder River Irrigation District).

The funding source for this study was directed toward structural solutions for additional storage. As such, this report does not include nonstructural plans for management and development of existing resources. Such activities, such as water conservation options, are being addressed in separate but concurrent activities in partial fulfillment of WASH's stated goals. In 2010, WASH applied for WaterSMART grants to address presumed deficiencies in conservation and energy efficiency. Even after the completion of this appraisal study and related work, the basins lack hydrologic data, irrigation demand data, and system inefficiency information. These grant applications were denied funding; WASH is reapplying in 2011 with added focus on ecological needs and ties to existing Reclamation projects in the study area.

Preliminary permit applications have been tendered by Pacific Rim Energy on Reclamation and other non federal irrigation facilities in Baker County. The projects have not been accepted by FERC. It appears that Pacific Rim filed most, if not all, of these preliminary permits without discussion with irrigation facility stakeholders. A preliminary permit only allows the applicant to study and project and to maintain licensing priority. It does not convey any right of entry or similar rights. Before FERC will issue a license or exemption, they will require the applicant to have real property interests either through fee title or easement.

In 2007, WASH prepared a literature review summary of existing studies that had been performed for the Burnt River, Powder River, and Pine Creek basins as the first step in the assessment planning process (Browne 2008). This included a summary of existing information from previous studies and an initial list of previously identified potential reservoir locations, which was later expanded. Reclamation worked in cooperation with the WASH committee and Browne Consulting to complete this review and list, which is described in more detail in Chapter 3.

Previously identified sites that were considered in this appraisal analysis report had been studied in the past by various entities. Some previous studies provided cost estimates and identified development issues and environmental constraints. The available literature provided information that was updated and incorporated into this appraisal study where appropriate, including: 1) topographic and geologic adequacy for potential reservoir locations; 2) potential reservoir sizes and previously developed hydrology for some sites; and 3) costs and benefits of proposed projects.

Chapter 2 PROBLEMS AND NEEDS

2.1 Existing Conditions

Human development and activities have changed the ecology of the study area in many ways, including alterations to the vegetation communities, changes in vegetation structure, manipulation of surface and ground water resources, soil movement, relocation of streams and changes to the composition of fish and wildlife communities. The major activities that have resulted in these changes include logging, fire suppression, grazing, cultivation and other agricultural development, draining of wetlands, ditching and diking of streams, water withdrawal and the introduction, both intentional and unintentional, of exotic plant and animal species.

Water runoff volumes within the study area are greatest during the spring months, primarily associated with snowmelt runoff. Increased flow conditions during winter months can be attributed to either rainstorms or rain-on-snow events. Frozen ground during these events can contribute to the winter flooding events. Summer rainstorms can also initiate an increased flow event, however, they occur infrequently.

Prior to development activities within the study area, some stream reaches most likely experienced low flows during the summer and fall months. Water withdrawals for agricultural irrigation uses have exacerbated this condition and can increase concentrations of water quality pollutants, attributable to agricultural management. These stream reaches also can experience higher water temperatures than under predevelopment conditions, limiting fish distribution, In addition, loss of riparian vegetation as well as habitat diversity has likely increased the severity and extent of these conditions (Nowack 2004).

2.1.1 Overall Basin Characteristics

Eastern Oregon's Burnt River, Powder River, and Pine Creek basins average between approximately 10 and 60 inches of mean annual precipitation, with the lowest precipitation in the valleys and the highest in the mountains on the western and northern edges of the basins. Annual precipitation distribution is illustrated in Figure 2-1. The three basins are located in Baker County, except the portion of the Powder River basin north of the North Powder River, which is in Union County. Thirty reservoirs, ranging from 46 acre-feet of active stored capacity to 90,500 acre-feet, supply water primarily for irrigation in the three basins. The hydrology is dominated by snowmelt runoff in the spring, but is also affected by reservoir storage and release.

Natural flow patterns are significantly affected by reservoir storage and release, in addition to water diversions to meet irrigation demands. According to the U.S. Forest Service, portions of many streams are dry during late summer because natural runoff is low and the flow is diverted for irrigation (Wallowa Whitman National Forest 1999). In general, reservoirs typically reach their lowest water volume in late September or early October as a result of low natural inflow and irrigation releases. They fill gradually through late fall and winter, then reach their peak or full content in late April or early May. Smaller reservoirs (relative to basin size and runoff) may fill earlier. At the onset of irrigation season, the reservoirs begin to release storage water, reaching minimum volumes in September or October.

Historic low flows are sometimes less than minimum instream water rights because of low natural runoff or because of upstream diversions by higher priority water rights. A summary of non-agricultural water rights information is provided in Appendix B.

Streamflow measurements are the data choice for hydrologic analyses. Data from a gaging station provide a time-series of flow at a specific location, creating a period of record. For the studied basins, data that were available were analyzed and summarized in the following sections.

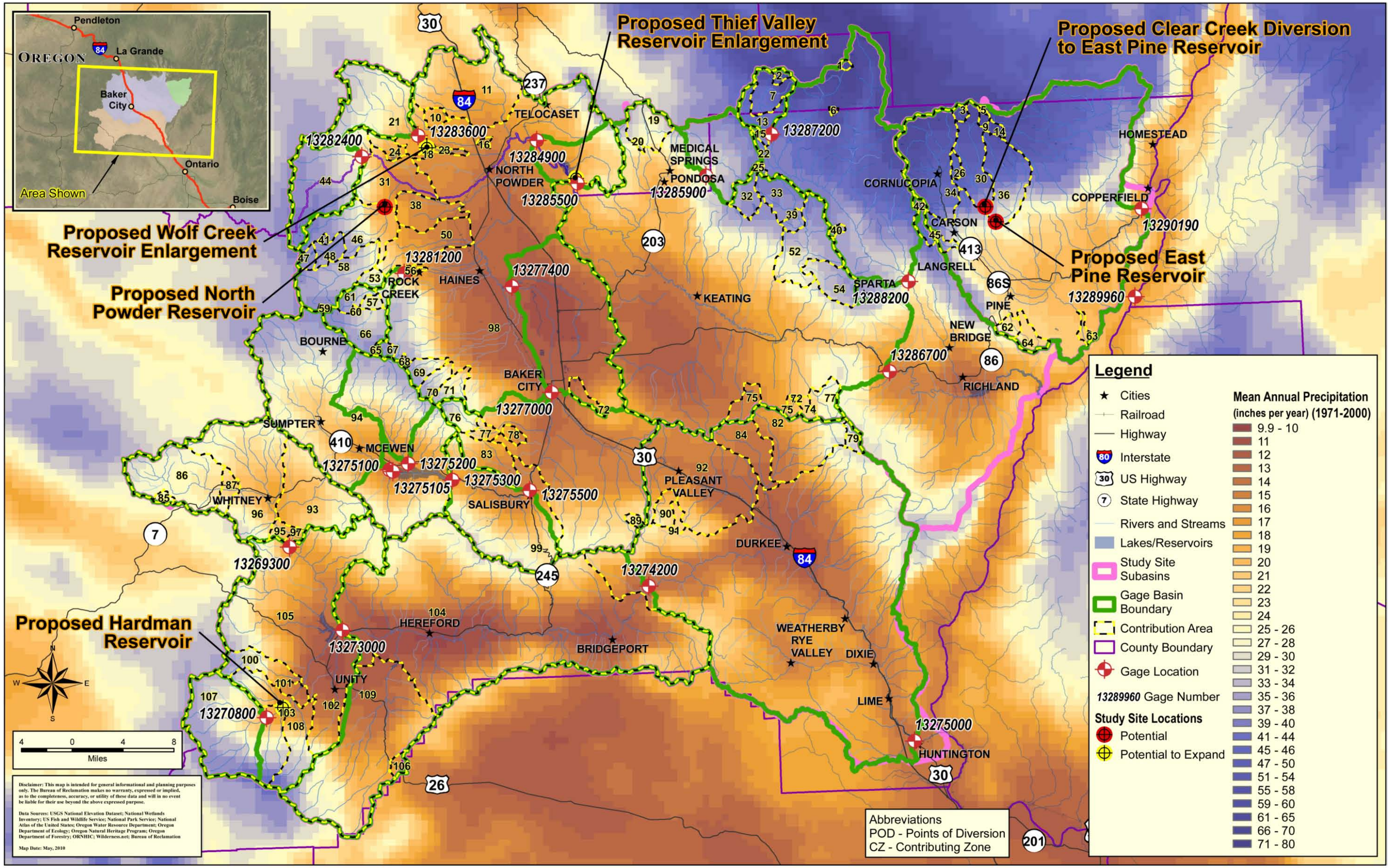

Figure 2-1. Mean Annual Precipitation on the Burnt, Powder, and Pine Creek Basins

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2.1.2 Burnt River Basin

The following subsections describe the current basin conditions including location, size, topography, hydrology, existing reservoirs, water use, instream flows, water quality, land use, fish resources, and ESA-listed species of the basin.

Location and Size

The Burnt River basin makes up the southern portion of the Eastern Oregon Water Storage Appraisal Study area (see Figure 2-2). The Burnt River basin is defined by the Blue Mountains to the west, the Snake River to the east, the Powder River basin to the north, and the Malheur River Basin to the south. The Burnt River basin is almost entirely in Baker County, except relatively small portions that are in Malheur County along the divide between the Burnt and Malheur rivers. The North, South, West, and Middle Forks of the Burnt River and other smaller tributaries flow from their origins in the Blue Mountains to join at Unity Reservoir at river mile (RM) 77. The river continues in a general easterly direction to enter the Snake River in Brownlee Reservoir near Huntington, Oregon.

The Burnt River basin encompasses about 700,000 acres and includes about 830 miles of major streams (Reclamation 2008). Major Burnt River tributaries below Unity Reservoir include Camp Creek (Burnt RM 71) and Pritchard Creek (Burnt RM 27.5).

Topography

The North, South, West, and Middle Forks of the Burnt River originate in the Blue Mountains near 7,000 feet elevation. Gradients are relatively steep in the headwaters above Unity Reservoir (from 6 to 11 percent), become more gradual (1 to 2 percent) as the tributaries approach Unity Reservoir, and remain relatively flat downstream to the Snake River. The Burnt River joins the Snake River at about elevation 2,080 feet (Nowak 2004a).

Hydrology

As shown on Figure 2-1, mean annual precipitation on the highest elevations averages as much as 42 inches per year. The Burnt River hydrology is characterized by relatively high snowmelt runoff in the spring and relatively low flows in the summer, fall, and winter. The timing and amount of spring runoff is dependent on spring temperatures and precipitation.

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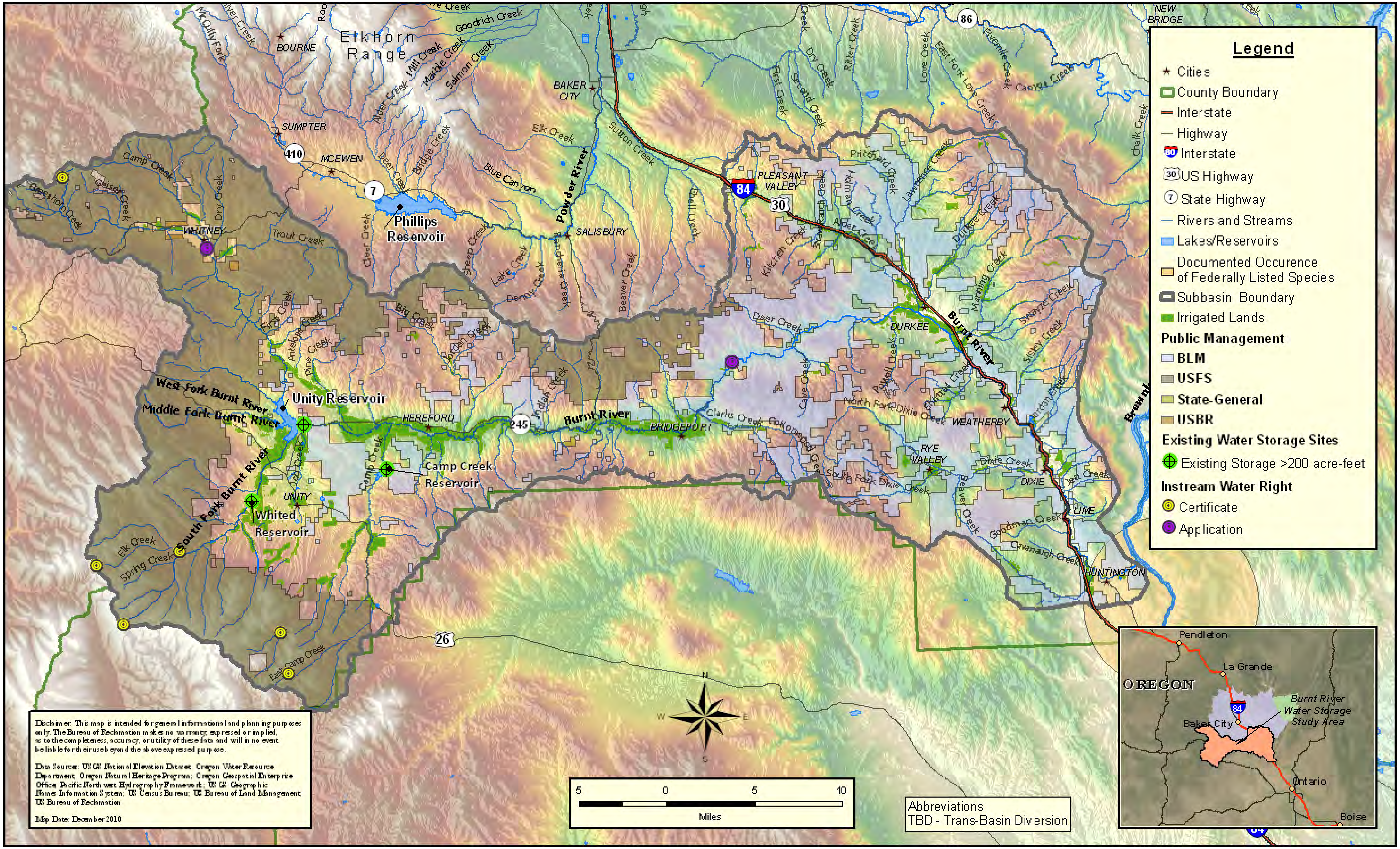

Figure 2-2. Burnt River Basin

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The average annual water year discharge (October to September) from the Burnt River are as follows:

- Hereford gage near the middle of the basin: About 88 cfs (63,500 acre-feet) based on USGS annual statistics from 1929 through 1997 (USGS 2010). Annual discharge flows ranged from 31 cfs in 1934 to 166 cfs in 1965 (22,400 to 119,900 acre-feet) and monthly flows ranged from 0.04 cfs in February 1940 to 618 cfs in April 1943.

- Huntington gage at the downstream end of the basin near the Snake River: About 140 cfs (100,500 acre-feet) based on USGS annual statistics from 1963 through 1980 (USGS 2010). Annual discharge flows ranged from 35 cfs in 1977 to 263 cfs in 1974 (25,600 to 190,200 acre-feet) and monthly flows ranged from 9 cfs in July 1977 to 1,069 cfs in April 1974. Figure 2-3 shows mean monthly flows from the Burnt River at Huntington gage.

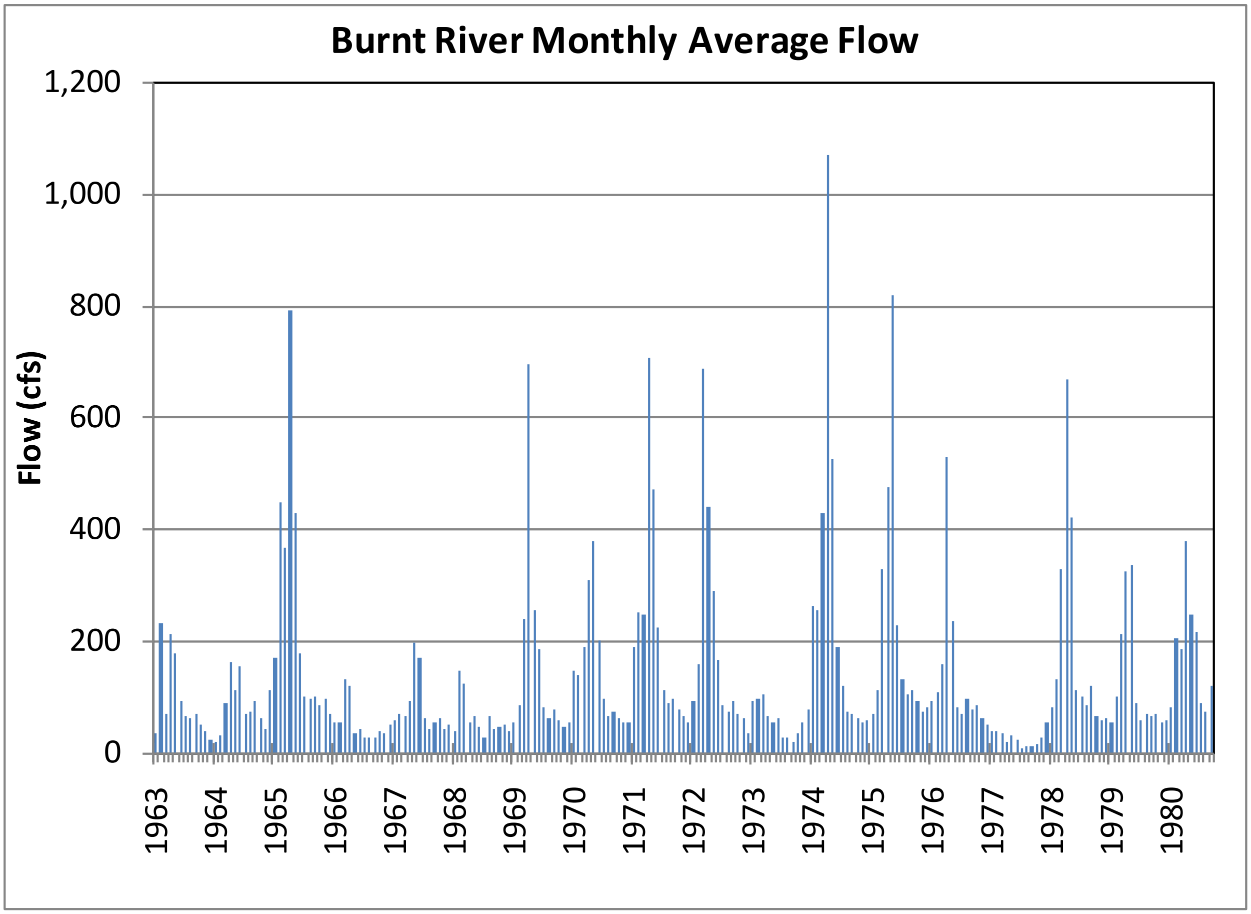

Figure 2-3. Hydrograph of Mean Monthly Flows - Burnt River at Huntington USGS gage (1963-1980)

The North and South Forks of the Burnt River were declared over-appropriated more than 60 years ago by the Oregon State Engineer. The reservoirs in this section of the basin provide supplemental irrigation water previously depended entirely on the natural flow of the Burnt River (Reclamation 2010). Nearly all of the natural flow is diverted for irrigation during the irrigation season, however, late summer water demand and instream flow designations are not currently met. Natural flow currently provides only 20 to 30 percent of the allocated water rights on the South Fork and 15 to 20 percent of the allocated water rights on the North Fork. The water in the Burnt River basin is fully appropriated for irrigation and there is no remaining unappropriated water (Nowak 2004a).

Existing Reservoirs

The Burnt River basin contains several dams and reservoirs that modify the natural hydrograph. Reflected in measured flows are the effects of existing reservoir storage, water use (mostly irrigation diversions and return flows), and instream flows.

Storage reservoirs in the Burnt River basin supply all or a portion of their storage releases to irrigated lands. Water is stored when available and released from the reservoirs as needed based on demand and water right priorities and/or contracts.

Existing reservoirs larger than 200 acre-feet are shown in Figure 2-2. The largest reservoirs in the Burnt River basin are the following:

- Unity Reservoir – 25,200 acre-feet
- Camp Creek Reservoir – 1,700 acre-feet
- Whited Reservoir – 519 acre-feet

The Unity facility is owned by Reclamation. It is managed by the Burnt River Irrigation District.

Water Use

Irrigation deliveries are the largest water use in the basin. Municipal, domestic, commercial, and industrial uses are estimated to be minimal in comparison.

Instream Flows

The Oregon Department of Fish and Wildlife filed for instream water rights on the Burnt River and its tributaries in 1991 for fish habitat purposes. Instream flow rights at specific river reaches on the North and South Forks of the Burnt River range from 3 to 10 cfs. These minimum instream flows currently are not always met because of natural flow fluctuations or more senior water rights using available water supplies.

Water Quality

Several Burnt River basin streams have been identified by the Oregon Department of Environmental Quality (Oregon DEQ 2010) as water quality limited. The parameters of concern are identified in DEQ's 303(d) List of Water Quality Limited Bodies. The following stream segments with listed pollutants were considered in this report:

- North Fork Burnt River – summer temperature (for fish rearing)
- South Fork Burnt River – summer temperature (for redband trout or cutthroat trout)
- Camp Creek – sedimentation (for resident fish and aquatic life, and fish spawning and rearing)
- Burnt River (below Unity Dam) – chlorophyll a (for aesthetics, fishing, stock watering, water contact recreation, and water supply), dissolved oxygen (for resident trout spawning), *E. coli* (for water contact recreation), and summer temperature (for redband trout or cutthroat trout)

Land Use

About half of the Burnt River basin is privately owned and the rest is owned primarily by the U.S. Forest Service and Bureau of Land Management (Reclamation 2008).

The Burnt River basin map (Figure 2-2) shows several features, including existing dams and reservoirs with more than 200 acre-feet of storable volume, irrigated lands, public land ownerships, and the locations of communities, counties, highways, watercourses, and other features.

Fish Resources and ESA-listed Species

The Burnt River basin has no listed threatened or endangered species, and no designated critical habitat, according to the U.S. Fish and Wildlife Service (USFWS 2010). The basin serves as habitat for redband trout, a state-listed species of concern (Reclamation 2010).

Although the Burnt River basin lacks anadromous fish, it does support a diverse resident fish population and an active recreational fishery. The resident fish populations are comprised of both native and introduced species.

2.1.3 Powder River Basin

The following subsections describe current basin conditions including the location, size, topography, hydrology, existing reservoirs, water use, instream flows, water quality, land use, fish resources, and ESA-listed species of the basin.

Location and Size

The Powder River basin makes up the central and northwestern portions of the Eastern Oregon Water Storage Appraisal Study area (Figure 2-4). The Powder River basin is defined by the Blue Mountains to the west, the Snake River to the east, the Wallowa Mountains to the north, and the Burnt River basin to the south. The basin is almost entirely in Baker County, except relatively small northern portions that are in Union and Wallowa counties. The Powder River begins in the Blue Mountains about 144 miles from its confluence with the Snake River. It flows southeasterly into Phillips Reservoir behind Mason Dam (Powder RM 136). From Mason Dam it flows east, then north, through Baker City. It meanders southeast through the Baker Valley until it is joined by the North Powder River at RM 82. It then flows in a general southeasterly direction through Thief Valley Reservoir and Dam (Powder RM 71) until it enters the Snake River in the Powder Arm of Brownlee Reservoir near Richland, Oregon.

The Powder River basin encompasses about approximately 838,000 acres and includes about 1,668 miles of major streams (Reclamation 2008). Major tributaries include Eagle Creek (Powder RM 10), Wolf Creek (Powder RM 81), North Powder River (Powder RM 82), and Rock Creek (Powder RM 98) (Nowak 2004b).

Topography

The headwaters of the Powder River and its tributaries originate in the Blue and Wallowa Mountains at 6,000 to 9,000 feet elevation. Gradients in the mountains are relatively steep (up to 20 percent), become more gradual (2 to 4 percent) as the tributaries near the valley floors, and remain relatively flat downstream to the Snake River. The Powder River joins the Snake River at about elevation 2,000 feet (Nowak 2004b).

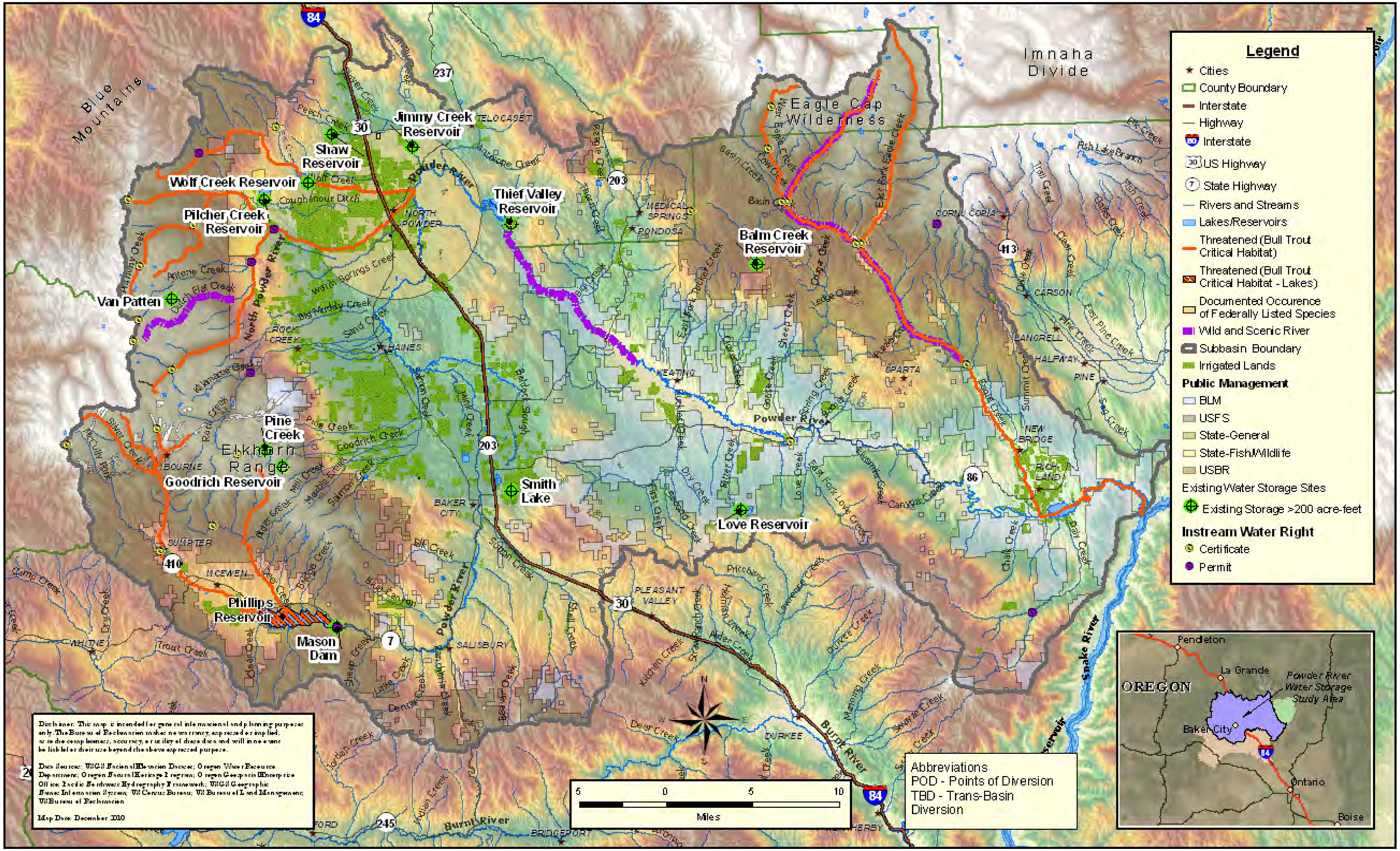

Figure 2-4. Powder River Basin

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Hydrology

As shown on Figure 2-1, mean annual precipitation on the highest elevations averages as much as 38 inches per year. The Powder River hydrology is characterized by relatively high snowmelt runoff in the spring and relatively low flows in the summer, fall, and winter. The timing and amount of spring runoff depend on winter snowpack depth and spring weather factors such as temperature and rainfall. Seasonal peak flows in streams originating in the Blue Mountains generally occur in late April and early May. Peak flows in Eagle Creek, which originates in the Wallowa Mountains, usually occur in mid-May to early June (Nowak 2004b).

The average annual water year discharge (October to September) from the Powder River is as follows:

- Baker City gage near the upper third of the basin: about 104 cfs (75,300 acre-feet) based on USGS annual statistics from 1973 through 1997 (USGS 2010). Annual discharge flows ranged from 49 cfs in 1988 to 203 cfs in 1984 (35,100 to 146,600 acre-feet) and monthly flows ranged from 4.2 cfs in October 1973 to 536 cfs in May 1975.

- Richland gage at the downstream end of the basin near the Snake River: about 250 cfs (180,200 acre-feet) based on USGS annual statistics from 1958 through 1995 (USGS 2010). Annual discharge flows ranged from 50 cfs in 1988 to 675 cfs in 1984 (35,800 to 488,800 acre-feet) and monthly flows ranged from 4.6 cfs in September 1992 to 1,719 cfs in March 1984. Figure 2-5 shows mean monthly flows from the Powder River near the Richland gage.

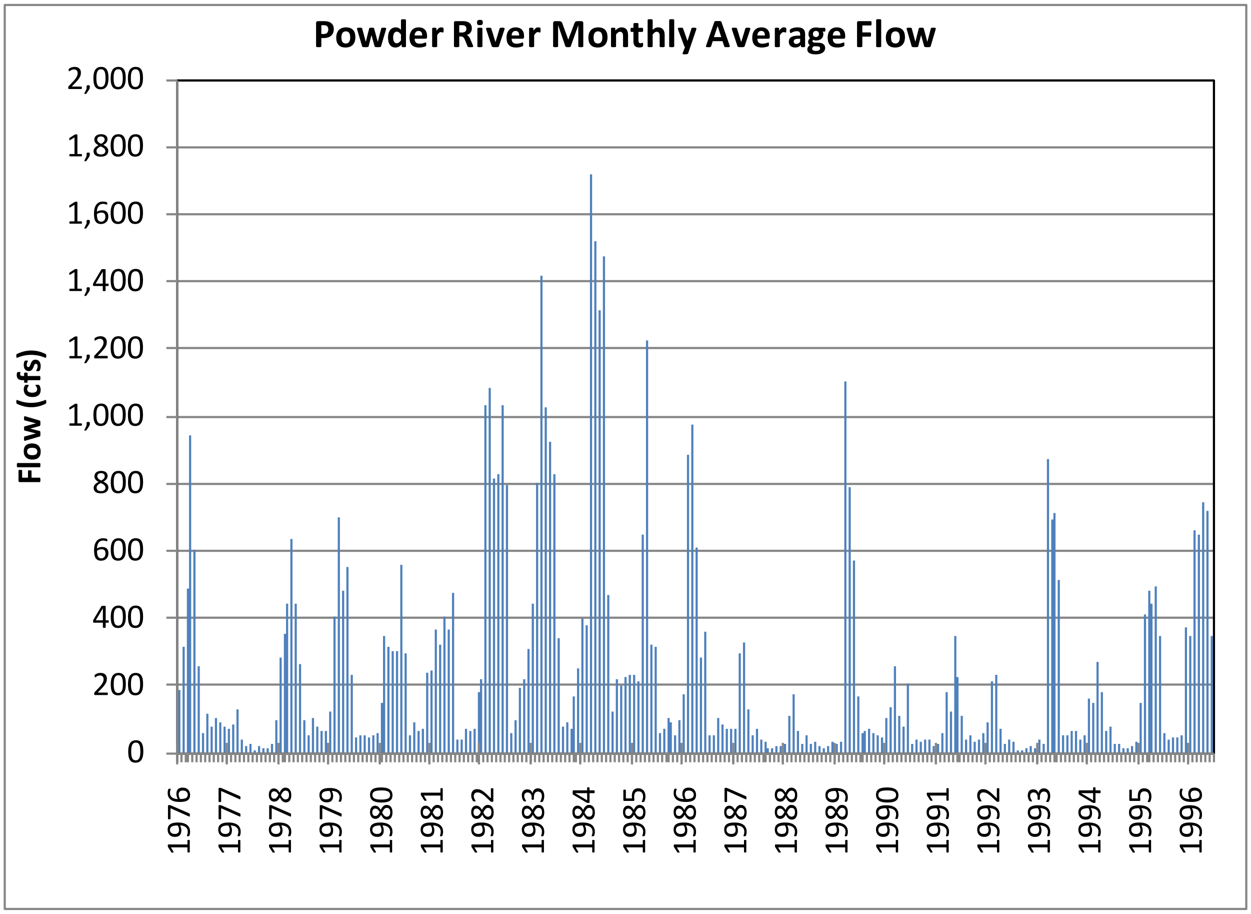

Figure 2-5. Hydrograph of Mean Monthly Flows - Powder River near Richland gage (1976-1996)

Complete information is not available on the numerous water rights in the basin due to transfer and division of rights over the years. However, despite the lack of accurate records, surface water in the Powder River basin is fully appropriated for irrigation and there is no remaining unappropriated water during the irrigation season (Nowak 2004b). Typically in low water years, not enough water is available to meet authorized irrigation delivery to junior water right holders.

Existing Reservoirs

The Powder River basin contains several dams and reservoirs that modify the natural hydrograph. Reflected in measured flows are the effects of existing reservoir storage, water use (mostly irrigation and return flows), and instream flows.

Storage reservoirs in the Powder River basin supply all or a portion of their storage releases to irrigated lands. Water is stored when available and released from the reservoirs as needed based on demand and water right priorities and/or contracts.

Existing reservoirs larger than 200 acre-feet are shown in Figure 2-4. The largest reservoirs in the Powder River basin with their total storage volume are the following:

- Balm Creek Reservoir – 2,926 acre-feet
- Goodrich Reservoir – 603 acre-feet
- Jimmy Creek Reservoir – 675 acre-feet
- Love Reservoir – 920 acre-feet
- Phillips Reservoir (Mason Dam) – 95,500 acre-feet
- Pilcher Creek Reservoir -- 5,910 acre-feet
- Pine Creek Reservoir – 2,100 acre-feet
- Thief Valley Reservoir – 13,300 acre-feet
- Shaw Reservoir – 504 acre-feet
- Smith Lake – 583 acre-feet
- Van Patten Reservoir – 580 acre-feet
- Wolf Creek Reservoir – 11,100 acre-feet

The Thief Valley and Phillips (Mason) facilities are owned by Reclamation; these facilities are managed by local irrigation districts. Thief Valley Dam is managed by the Powder River Irrigaton District whereas Phillips Reservoir and Mason Dam are managed by Baker Valley Irrigation District. Pilcher Creek Water Control District and Wolf Creek Water Control District also manage irrigation water within the basin.

Water Use

Irrigation deliveries are the largest water use in the basin. Municipal, domestic, commercial, and industrial uses are estimated to be minimal in comparison.

Instream Flows

The Oregon Department of Fish and Wildlife filed for instream water rights on the Powder River and its tributaries in 1991 for fish habitat purposes. Instream flow rights at specific river reaches in the river and its tributaries range from 1.8 to 60 cfs. These minimum flows currently are not always met because of natural flow fluctuations or stream depletion by higher-priority water rights. This is particularly true of the larger, 50 cfs instream flow right below Thief Valley Reservoir to Goose Creek.

Water Quality

Several Powder River basin streams have been identified by the DEQ as water quality limited. The parameters of concern are identified in DEQ's 303(d) List of Water Quality Limited Bodies (Oregon DEQ 2010). The following stream segments with listed pollutants were considered in this report:

- Elk Creek – summer temperature (for fish rearing)
- North Powder River – temperature (for fish rearing)
- Powder River – fecal coliform (for recreation water contact) and summer temperature (for fish rearing)

Land Use

More than half of the land in the basin is managed by the U.S. Forest Service and Bureau of Land Management (Nowak 2004b). The Powder River basin map (Figure 2-4) shows several features, including existing dams and reservoirs with more than 200 acre-feet of storable volume, irrigated lands, public land ownerships, and the locations of communities, counties, highways, watercourses, and other features.

Fish Resources and ESA-listed Species

Bull trout, listed as "threatened" in 1998 under the Endangered Species Act (ESA), is present in higher elevations. Critical habitat in the Powder River basin was designated in 2010 (Figure 2-4). Redband trout, a USFWS-listed species of concern, are also present in this basin (USFWS 2010). The Powder River basin lacks anadromous fish, however, it does support a diverse resident fish population and an active recreational fishery. The resident fish populations are comprised of both native and introduced species (Nowak 2004b).

Occurrences of endangered gray wolves and threatened Howell's spectacular thelypody (plant) have been documented in areas immediately west of Thief Valley Reservoir (Figure 2-4).

2.1.4 Pine Creek Basin

The following subsections describe current basin conditions including the location, size, topography, hydrology, existing reservoirs, water use, instream flows, water quality, land use, fish resources, and ESA-listed species.

Location and Size

The Pine Creek basin makes up the northeastern portion of the Eastern Oregon Water Storage Appraisal level Study area (see Figure 2-6). It is located in the northeast corner of Baker

County. Pine Creek originates on the Imnaha divide in the Eagle Cap Wilderness at Pine Lakes. Pine Creek generally flows southeast to agricultural land surrounding the city of Halfway. The creek then generally flows east and northeast for about 20 miles into Hells Canyon Reservoir on the Snake River (PBWC 2000) near Oxbow, Oregon, just downstream of Oxbow Dam.

The Pine Creek drainage covers approximately 195,800 acres and is about 36 miles long (PBWC 2000). Major tributaries include Clear Creek, East Pine Creek, Fish Creek, and North Pine Creek.

Topography

This basin includes numerous high lakes in sub-alpine forests, beginning as high as 9,500 feet. Gradients are initially steep. The creek and its East Pine and Clear Creek tributaries drop to a relatively flat area around elevation 2600 feet near Halfway, Oregon. It then meanders at a relatively flat gradient before entering the Snake River at about elevation 1680 feet (PBWC 2000).

Hydrology

As shown on Figure 2-1, mean annual precipitation on these highest elevations averages as much as 80 inches per year. The basin has numerous high lakes. Pine Creek hydrology is characterized by relatively high snowmelt runoff in the spring and relatively low flows in the summer, fall, and winter. The timing and amount of the spring runoff is dependent on spring temperatures and precipitation.

The average annual water year discharge (October to September) from Pine Creek are as follows:

- Oxbow gage near the Snake River: about 350 cfs (253,500 acre-feet) based on USGS annual statistics from 1968 through 1995 (USGS 2010). Annual discharge flows ranged from 55 cfs in 1977 to 674 cfs in 1974 (40,000 to 488,000 acre-feet) and monthly flows ranged from 14 cfs in August 1977 to 1,929 cfs in June 1974. Figure 2-7 shows mean monthly flows from Pine Creek near Oxbow gage. The USGS does not have a gage in middle part of the basin.

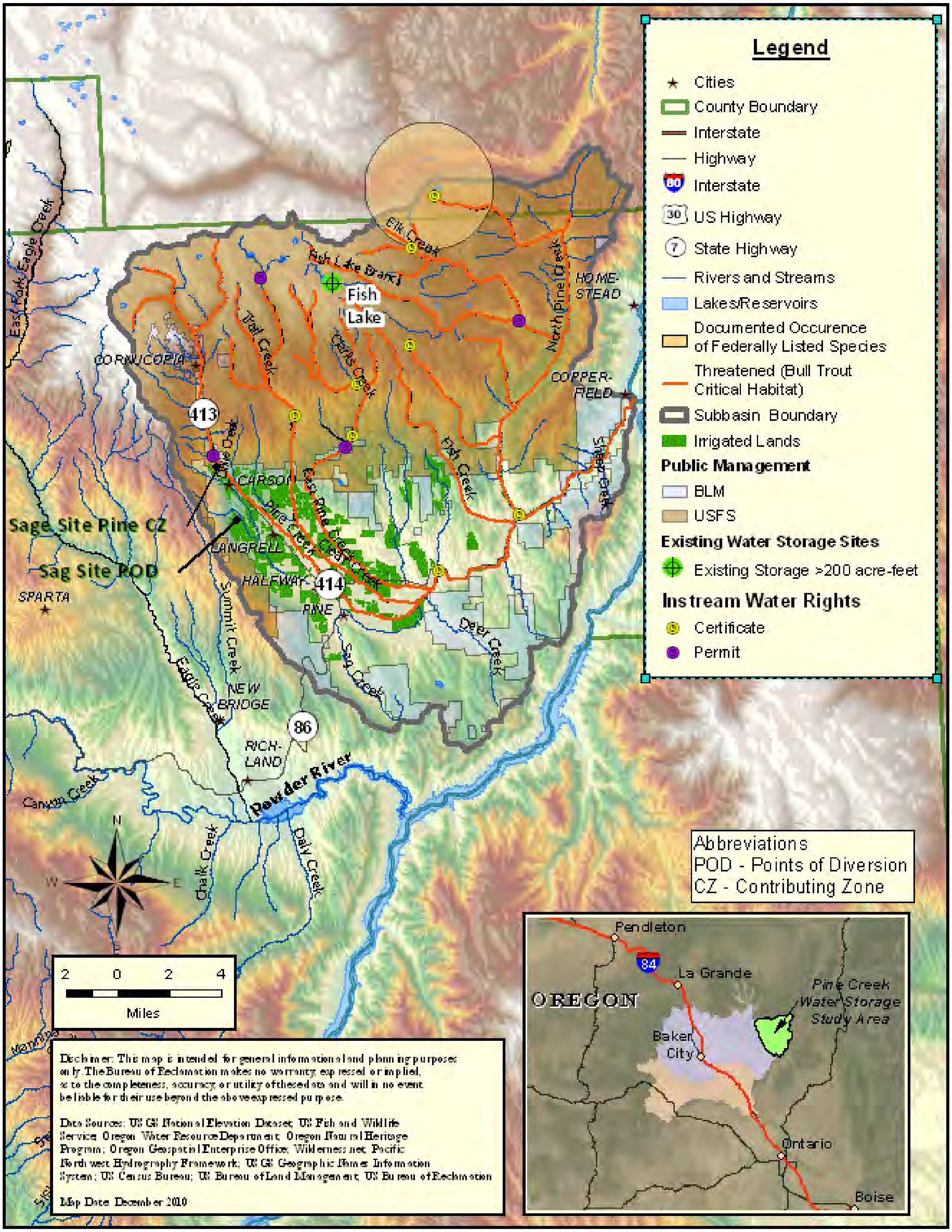

Figure 2-6. Pine Creek Basin

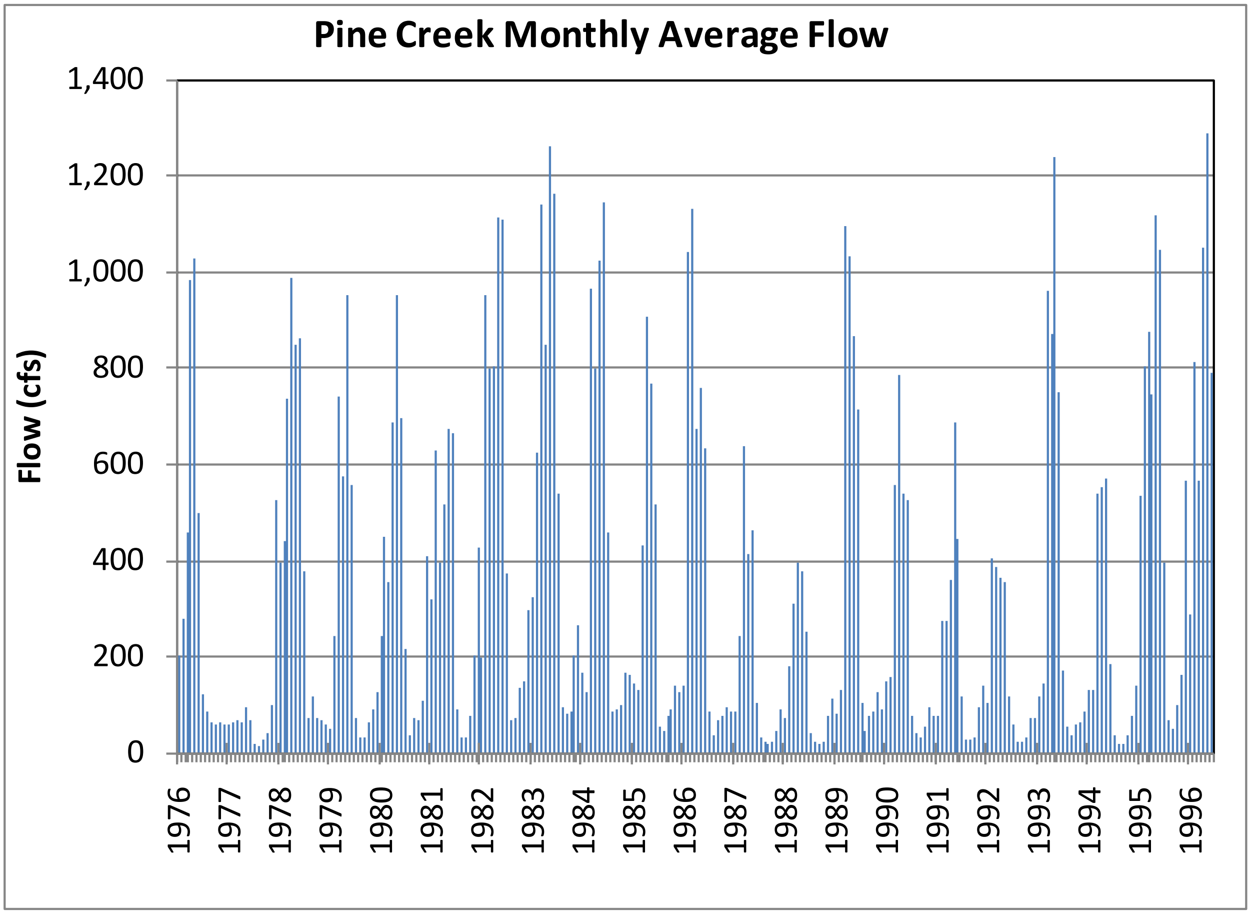

Figure 2-7. Hydrograph of Mean Monthly Flows - Pine Creek near Oxbow gage (1976-1996)

Existing Reservoirs

Storage reservoirs in the Pine Creek basin supply nearly all of their storage releases to irrigated lands. Water is stored when available and released from the reservoirs as needed based on water right priorities and contracts. The only identified reservoir in the Pine Creek basin with a capacity greater than 500 acre-feet is Fish Lake, which holds 825 acre-feet of water. This facility is neither owned nor operated by Reclamation.

Water Use

Irrigation deliveries are the largest water use in the basin. Municipal, domestic, commercial, and industrial uses are estimated to be minimal in comparison.

Instream Flows

Instream flow rights at specific reaches on Pine Creek and its tributaries range from 0.6 to 60.0 cfs. The Oregon Department of Fish and Wildlife filed for instream water rights on Pine Creek and its tributaries in 1991 for fish habitat purposes. These minimum instream flows currently are not always met because natural runoff may not be available and more senior water rights are using available water supplies.

Water Quality

The Clear Creek and East Pine Creek basins have been identified by the Oregon DEQ as water quality limited. The parameters of concern, related to beneficial use for fish, are identified in DEQ's 303(d) List of Water Quality Limited Bodies (Oregon DEQ 2010). The following stream segments with listed pollutants were considered in this report:

- Clear Creek – summer temperature (for fish rearing)
- East Pine Creek – summer temperature (for fish spawning and rearing)

Land Use

About 58 percent of the land is managed by the U.S. Forest Service; 11 percent by the Bureau of Land Management, State of Oregon, and Baker County; and the remaining 31 percent are privately owned (PBWC 2000). The Pine Creek basin map (Figure 2-6) shows several features, including existing dams and reservoirs with more than 200 acre-feet of storable volume, irrigated lands, public land ownerships, and the location of communities, counties, highways, watercourses, and other features.

Fish Resources and ESA-listed Species

The Pine Creek drainage is listed for critical bull trout habitat, and bull trout are present in this basin (USFWS 2010).

2.2 Deficiencies and Current Needs

This section relies on available current water use and projected water needs information developed for a 40-year planning horizon through the year 2050 for the Burnt, Powder, and Pine basins. The water needs in the study area have been articulated to the State of Oregon by eastern Oregon stakeholders, through the Oregon Water Resources Strategy roundtable meeting process. Information used to prepare this study has been shared in support of the state's efforts.

In 1992, the Oregon Department of Agriculture reserved 74,490 acre-feet of water for future economic development in the Burnt River (26,300 acre-feet), Powder River (38,190 acre-feet), and Pine Creek (10,000 acre-feet) basins within Baker and Union Counties (ODWR December 2010). The water was allocated by Oregon Administrative Rules for multiple-benefit reservoirs to maximize economic development of the State and provide water for future anticipated needs. Current and future water needs include irrigation, municipal demands, and instream water uses for fish and wildlife habitat and recreation. In addition, benefits to hydropower, livestock watering, domestic wells, and mining could be realized from this type of project development. The 1992 water reservations will sunset starting in 2016 if additional storage sites are not developed. A summary list of these reservations is provided in Appendix B.

To reasonably quantify the existing hydrologic conditions of the basin and subsequent water needs, a hydrologic record for the basins must be assessed. However, insufficient records exist to describe historic flow conditions within streams or surface water diversions to irrigated lands. Therefore, to quantify baseline conditions and prospective benefits of proposed projects, a hydrologic analysis of the basin must be performed.

2.2.1 Basin Hydrology Development

As part of this appraisal analysis, it is necessary to develop a complete hydrologic period of record. This data record will rely on historic information, estimates, and computations that will establish the foundation for this study. As stated earlier, insufficient records exist that could be used to characterize historic flow conditions within streams or surface water diversions to irrigated lands.

A spatial inventory of USGS and Reclamation gage locations was performed in addition to the available flow measurements at these sites. The available data coverage would define a period of record that would be analyzed. These records would be considered regulated flow conditions at the gage, and not all of the gage locations are upstream of project reservoirs or irrigation diversions. Therefore, computation of natural flow, or unregulated flow, conditions provided a consistent foundation for creating the additional hydrology data necessary for this study.

To create a natural flow record, modification to the regulated data must be accomplished. This requires the addition of irrigation diversions, return flows and change in reservoir storage to those gages representing regulated flow conditions.

The general equation used to compute natural flow at the gage of interest is:

$$Q_{nat} = Q_{gage} + E + \Delta S + D - R$$

where:

$Qnat$ = computed natural flow for the gauge (acre-feet per month)

$Qgage$ = historic flow observed for the gauge (acre-feet per month)

E = reservoir evaporation (acre-feet per month)

ΔS = change in reservoir storage (acre-feet per month)

(+) positive when filling

(-) negative when releasing

D = irrigations diversions (acre-feet per month)

R = irrigation return flows above the gage (acre-feet per month)

A complete data set of historic observed flows within the three basins was not available. Available historical streamflow records were obtained from USGS and Reclamation. The available data overlap defined a period of record between water years 1971 through 1999 for use in this analysis.

Based on these historical data, correlations were developed to fill in and extend periods of unrecorded data to provide a complete data input record. The gages with the most complete period of record were used for this analysis and are listed in Table 2-1.

Table 2-1. Gages used in basin hydrology development

Gage Identification	Gage Location
5 gages in the Burnt River basin	
13269300	North Fork Burnt River near Whitney, OR
13270800	South Fork Burnt River above Barney Cr, near Unity, OR
13273000	Burnt River near Hereford, OR
13274200	Burnt River near Bridgeport, OR
13275000	Burnt River at Huntington, OR
9 gages in the Powder River basin	
13275100	Powder R above Phillips Lake near Sumpter, OR
13275200	Deer Cr above Phillips Lake near Sumpter, OR
13275300	Powder River near Sumpter, OR
13277000	Powder River at Baker City, OR
13281200	Rock Creek near Haines, OR
13282400	Anthony Creek below North Fork near North Powder, OR
13283600	Wolf Creek above Wolf Creek Reservoir near North Powder, OR
13284900	Powder River above Thief Valley Reservoir near North Powder, OR
13285500	Powder River below Thief Valley Reservoir near North Powder, OR
1 gage in the Pine Creek basin	
13290190	Pine Creek near Oxbow, OR

2.2.2 Reservoir Evaporation

Reservoir evaporation was only included for the three large Reclamation reservoirs: Unity, Phillips, and Thief Valley Reservoirs. Pan evaporation data obtained during the growing season was used to compute the water loss occurring from each reservoir (NCDC, 2008). Evaporative losses for non-growing season months and those with missing pan evaporation data were calculated using the 1985 Hargreaves equation (Hargreaves and Allen, 2003).

2.2.3 Change in Reservoir Storage

Reservoirs located upstream of a gage reregulate the natural flow conditions. As a result, a change in reservoir storage must be included in the computed natural flow data record. Reservoir storage computations were only included for the three large Reclamation reservoirs: Unity, Phillips, and Thief Valley Reservoirs.

2.2.4 Irrigation Diversions

Agricultural irrigation accounts for the large majority of consumptive water use in the Burnt River, Powder River, and Pine Creek basins. To establish meaningful alternative development and screening criteria, quantification of irrigation needs was necessary. Very few irrigation diversions within the study area basins are measured. Therefore, a methodology was developed to quantify total irrigation diversions and consumptive use.

Total irrigation water diverted from the rivers is a function of total irrigated acreages, consumptive use of the crops, and water conveyance and application efficiencies. The computed current level of irrigation diversions were then compared to allocated water rights in an attempt to validate results.

Total Irrigated Acreage

The total annual irrigated crop acreages were estimated utilizing the following three sources.

- Census of Agriculture (Bureau of the Census 1969, 1974, 1978, 1982, 1987; National Agricultural Statistics 1992, 1997, 2002).
- Oregon Agricultural Information Network (OAIN 2008).
- Oregon State University Extension Service (Burt 2008).

The ArcGIS, geographic information system (GIS), was used to ascertain the quantity and the location of irrigated acreages with respect to a particular gage. This was accomplished throughout the three basins to spatially allocate the irrigation diversions with respect to the gages.

Consumptive Use

Consumptive use was calculated for the estimated total annual irrigated acreages. The consumptive use is the amount of water that is removed by the system, the intake of water by plants. In order to quantify consumptive use, crop mix for the irrigated acreages was first determined using available sources (OAIN 2008, Burt 2008, and Bureau of the Census) as different plants have differing water requirements.

Crop irrigation water requirements for 1970 through 1988 are Cuenca's et al. (1992) monthly values by crop (FAO-24 Blaney-Criddle ETc [Doorenbos, 1977] with the Natural Resources Conservation Service [NRCS—formerly SCS] effective rainfall method). Irrigation requirements for 1989 through 1999, utilized Reclamation's Agrimet system. The Agrimet system provided the historical meteorological data that was used to compute consumptive use for the latter half of the period of record.

In reality, a full supply of water for crops is not always available. Therefore, water availability factors were applied to the irrigation diversion computations. These factors were based on water rights, irrigation cut-off dates, and water year type (wet, average, dry). Otherwise, the irrigation diversion requirements would be overstated.

Return Flows

The return flows are defined as the amount of diverted irrigation water that returns to the river in a matter of a few months. These flows are added back to the gage values to compute the natural flow. This parameter is a function of the irrigation diversion and application efficiencies. Efficiency factors were specified for both water conveyance and type of water application. Sprinkler application of water is more efficient that gravity application and results in less water diverted. The following efficiencies were applied:

- Water Conveyance: 90 percent
- Sprinkler Application: 65 percent
- Gravity Application: 40 percent

For each year within the period of record analyzed, acreages were differentiated as being either gravity fed or sprinkled.

Reuse of irrigation water is common. The flow returned to the river upstream becomes available for irrigation diversion downstream. A reuse factor was applied and included in the return flow computations at each gage. The reuse factor prevents overstatement of the natural flow computation at the gage.

2.2.5 Current Basin Hydrologic Conditions

For each gage influenced by irrigation and/or reservoirs, natural flow computations were completed. Linear regression analyses were used to infill the missing or incomplete data. Average annual natural flow volume at each gage was then computed using the completed hydrologic record, water years 1971 through 1999.

In addition to the synthesis of hydrologic data within the basin, irrigation demands and shortages were also computed. A comparison between the total volume of historic stream flow, total volume of irrigation demand, and irrigation shortage for each of the three basins was made (Table 2-2). The difference between water demand and water delivery is referred to as the average annual water shortage. These comparisons indicate that on an annual basis, the total irrigation shortage volume was smaller than the difference between the total flow at the confluence of the Snake River and total irrigation demand for each basin. This is the result of the location and timing of the available flow not aligning with the location and timing of the demand. Available water supply is currently a limiting factor in agricultural applications and is expected to continue to limit agricultural production within the planning horizon. Irrigation shortages for all three basins were estimated to total approximately 161,000 acre-feet.

The following figures (Figure 2-8, Figure 2-9, and Figure 2-10) compare the monthly basin flow volumes to irrigation shortages. The greatest irrigation demand for water to occurs in July through September, while stream flows are greatest in March through June as a result of the snowmelt and runoff.

Table 2-2. Summary of Calculated Water Demand by Basin

Basin	Average Annual Flow Volume near Snake River Confluence (acre-feet/year)	Average Annual Water Demand (acre-feet per year)[1]	Average Annual Water Deliveries (acre-feet per year)[1]	Average Annual Water Shortage (acre-feet per year)[2]	Average Annual Water Shortage (%)
Burnt River	135,000	82,000	77,000	5,000	6
Powder River	459,000	375,000	241,000	134,000	36
Pine Creek	101,000	64,000	41,000	22,000	36
Total	**695,000**	**521,000**	**359,000**	**161,000**	**31**

[1] 29-year period of record (1971-1999), including natural flow and storage water.
[2] Difference between water demand and water delivery

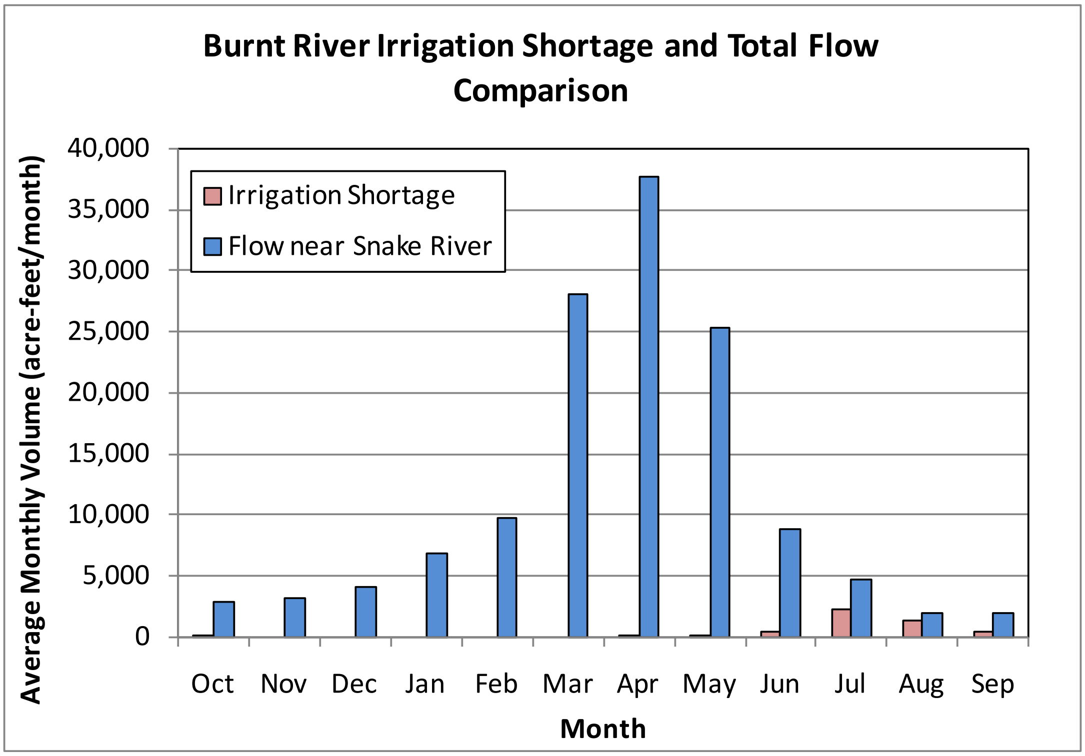

Figure 2-8. Total Calculated shortage and Flow for the Burnt River Basin

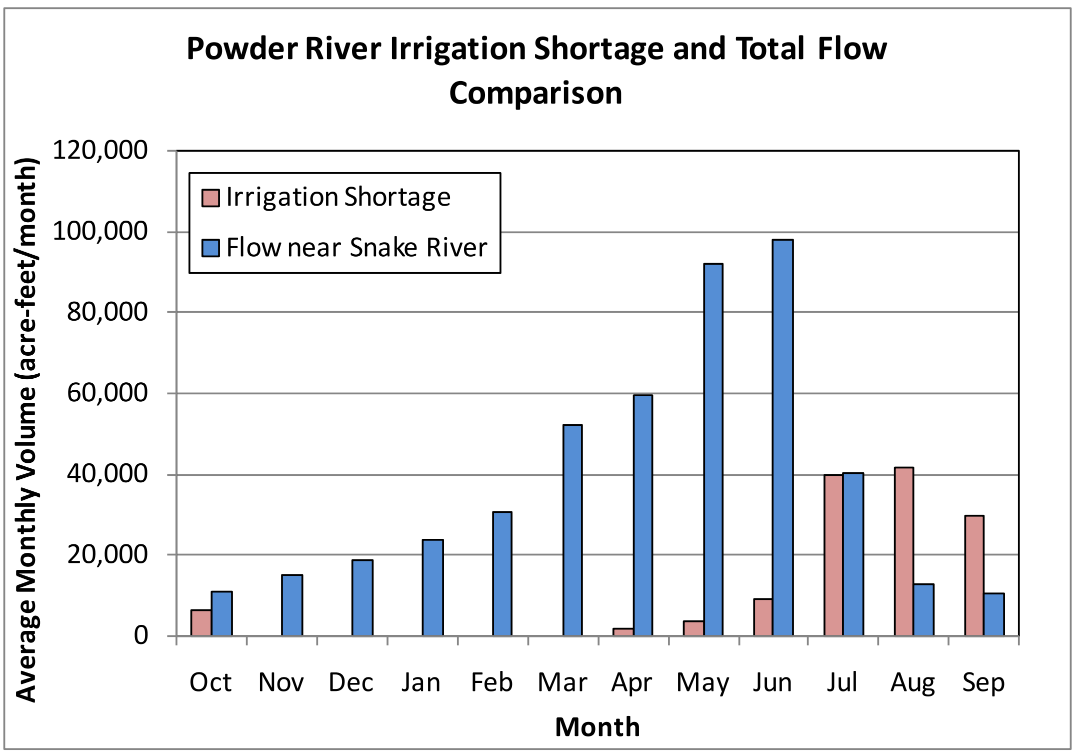

Figure 2-9. Total Calculated Shortage and Flow for the Powder River Basin

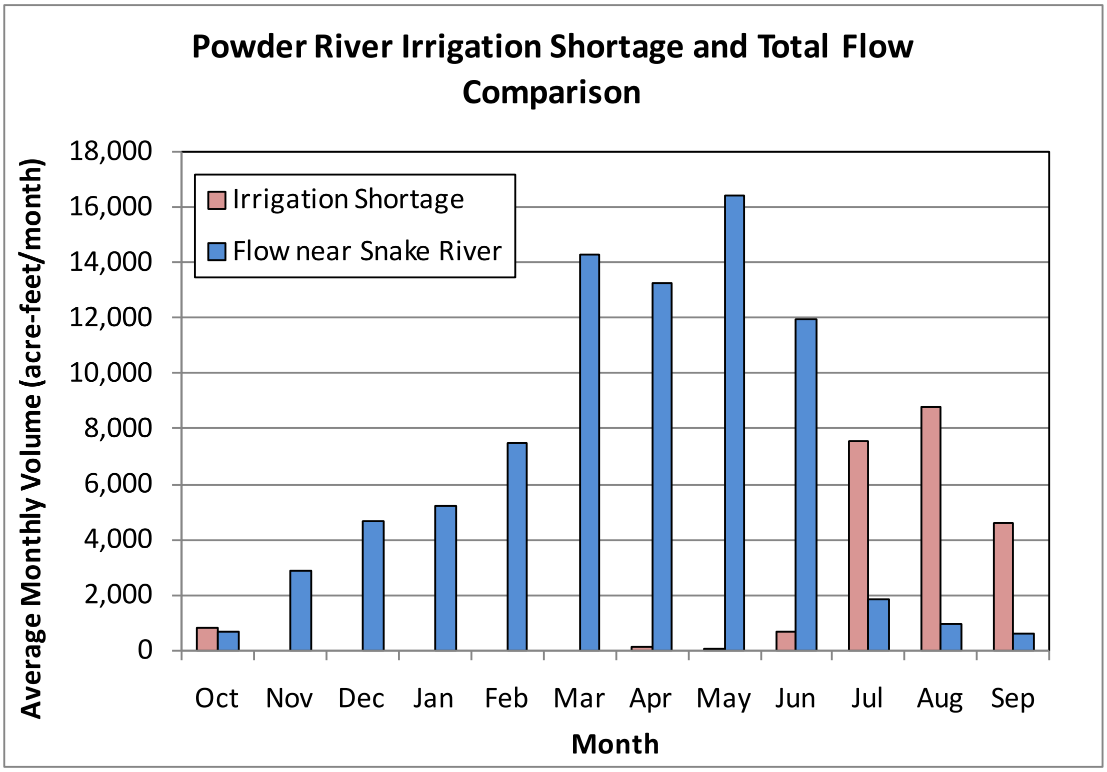

Figure 2-10. Total Calculated Shortage and Flow for the Pine Creek Basin

2.2.6 Municipal Water Needs

Municipal water uses, including domestic, commercial, and industrial, are met through a combination of groundwater and surface-water supplies. Current demand is based on existing water rights and population data for each of the eight incorporated towns in the study area.

Table 2-3 summarizes the current water use supply and demand for municipal water needs, including domestic, commercial, and industrial uses.

Table 2-3. Summary of Municipal Water Demand by Basin

Basin	Available Water Supply (acre-feet per year)[1]	Estimated Current Water Use (acre-feet per year)[2]
Burnt River	876	76
Powder River	12,448	1,447
Pine Creek	180	43

[1]Water supply information was based on existing water rights information from Oregon Department of Water Resources Water Rights Database http://apps2.wrd.state.or.us/apps/wr/wrinfo/. See Appendix B for more water rights information.
[2] Current use is based on population of incorporated communities, multiplied by 115 gallons per person per day, annualized and converted to acre-feet. Population data was obtained from www.city-data.com.

2.3 Future Needs

2.3.1 Assumptions

Overall water needs for the Burnt River, Powder River, and Pine Creek basins are expected to be similar to the current level of demand within the 40-year planning horizon. Available water supply is currently a limiting factor in agricultural applications and is expected to continue to limit agricultural production within the planning horizon. Irrigation shortages for all three basins were estimated to total approximately 161,000 acre-feet.

Future irrigation demand was assumed to be the same as the current demand over the 40-year planning horizon in this study. This assumption was developed as part of the original study scope. System deficiencies or future needs were defined in terms of current irrigation shortage. Therefore, evaluation of potential water supply storage projects will be based on the ability to reduce the estimated irrigation shortages within the existing instream filed water rights.

To estimate future water demand for municipal water uses for each basin, current demand was subtracted from anticipated future demand, using 2050 as the planning horizon. Anticipated future demands were generated based on a “high-growth scenario” of 2 percent growth per year and an average rate of 115 gallons of water per person per day, projected out to 2050. It is assumed this average municipal rate also includes commercial and industrial needs for the purpose of this study.

No significant increase in municipal water demand, including domestic, commercial, and industrial uses was expected, based on population estimates. Based on available information, it was anticipated that existing municipal water rights will meet municipal demand through the 2050 planning horizon. Demand for industrial water could potentially increase if additional irrigation water were available to boost agriculture within the basins. The Powder Basin is strategically located along Interstate 84, the railroad, and near the Columbia River. This strategic location could attract processing facilities, however, was outside the scope of this appraisal level evaluation.

Since irrigation is the predominant water use in the three basins, municipal water uses were not investigated further. In addition, conjunctive uses of groundwater and surface water are unknown and, therefore, not included in this level of analysis. While water right information exists for industrial uses, interviews with county and city officials in the Powder River basin revealed that most industrial water rights are currently not being used and demand for industrial water use is not expected to increase.

Climate change may result in changes to the water supply and demand calculated and used as the basis of this report. No analyses were performed in this study to quantitatively estimate possible changes associated with climate change that might affect reservoir operations, irrigation demand or operations, crop types, cropping dates, environmental flow targets, water supplies and shortages, or hydropower production. The effects of climate change will require further study if these proposed storage sites are studied in more detail. A qualitative discussion is provided in Chapter 2.3.3.

2.3.2 Screening Hydrology

To identify potential water supply resources at locations within the study area identified on the list identified in Chapter 1.4 and described in Chapter 3.0, a relationship was developed estimate annual yield based on site elevation. This methodology afforded a consistent means to quantify potential yield for locations without measured hydrology data. These relationships were then used to generate an initial assessment of the potential yield in an attempt to quantify annual yield for a proposed sites with a significant lack of data. The consistency in methodology allowed for a relative comparison between the projects and respective irrigation demands to determine those worth analyzing further. Chapter 2.2.1 describes the methodology utilized in the development of this screening hydrology.

Figure 2-11 illustrates that relationship for each basin, based on the mean watershed elevation represented by the gage.

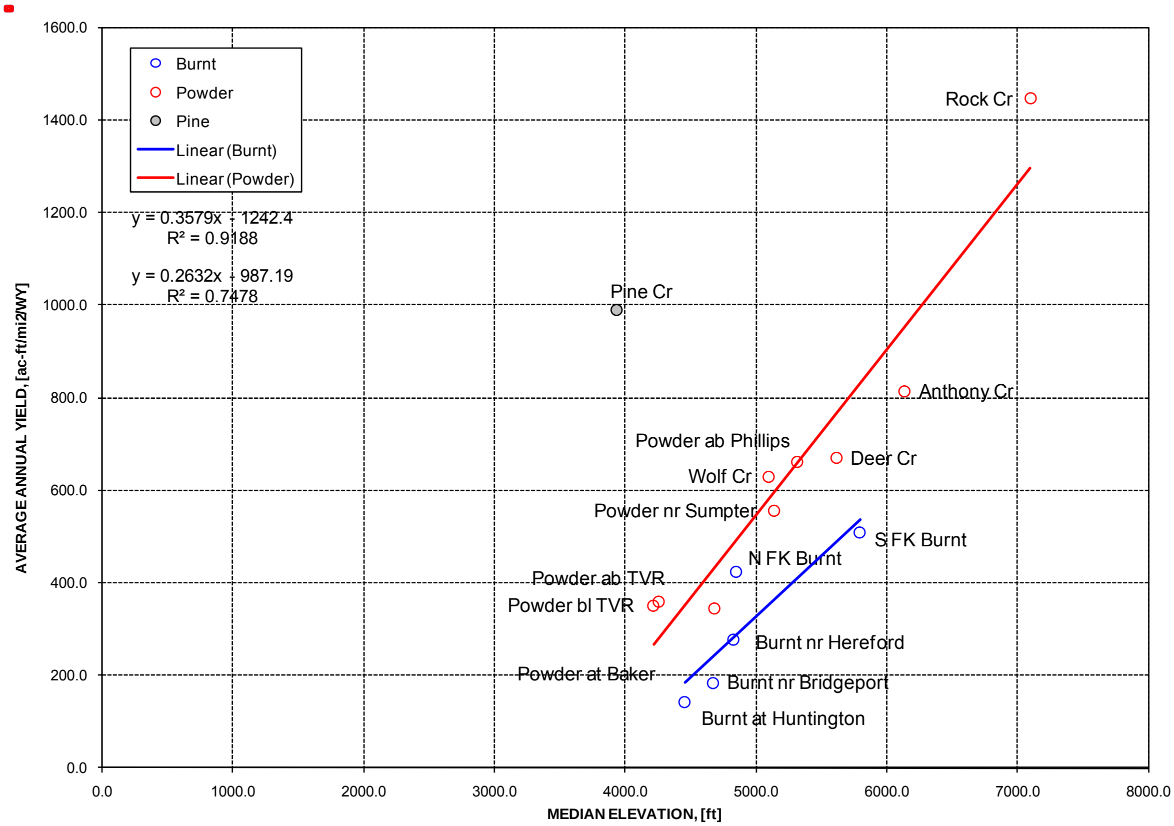

Figure 2-11. Regression to Estimate Average Yield based on Site Elevation

The regression equations for elevation-yield by basin are:

Powder River Basin: $Q_{71\text{-}99} = 0.3579 * EL_{med} - 1242.4;$ $r^2 = 0.919$

Burnt River Basin: $Q_{71\text{-}99} = 0.2632 * EL_{med} - 987.19;$ $r^2 = 0.748$

where: $Q_{71\text{-}99}$ the 1971 to 1999 average annual streamflow, (ac-ft/yr)

EL_{med} is the median watershed elevation, (feet above sea level)

The Powder River equation was adopted for the Pine Creek basin for this screening exercise, due to the existence of only one gage within the watershed.

2.3.3 Future Basin Characteristics

This subsection qualitatively summarizes potential climate change impacts to the water supply and demand. These impacts, as related to various resources areas and operating objectives, might be relevant to the long term planning processes for the water resources in the Snake

River Basin. This discussion of impacts is based on information obtained from the U.S. Climate Change Science Program (CCSP) Synthesis and Assessment Product (SAP) reports and literature reviews as summarized and presented in Reclamation 2009a.

Historical Climate and Hydrology

It appears that all areas of the Pacific Northwest became warmer, and some areas received more winter precipitation, over the course of the 20th century. The Western United States' spring temperatures increased 1–3 degrees Celsius (ºC) between 1970 and 1998. In addition, the Western United States experienced a general decline in spring snowpack, reduced snowfall to winter precipitation ratios, and earlier snowmelt runoff between the mid- and late-20th Century.

These findings are significant for regional water resources management and reservoir operations because snowpack has traditionally played a central role in determining the seasonality of natural runoff. In many headwater basins, the precipitation stored as snow during winter accounts for a significant portion of spring and summer inflow to lower elevation reservoirs. The warmer temperatures in these watersheds can cause reduced snowpack development during winter, more runoff during the winter season, and earlier spring peak flows associated with an earlier snowmelt.

Projected Future Climate and Hydrology

Given observed trends in regional warming and declining snowpack conditions, studies have been conducted to relate potential future climate scenarios to runoff and water resources management impacts. These studies have reported decreased summer streamflows relative to the historic average and may require exploration of operational mitigation measures to balance the needs of the various water users. In addition, the potential for increased winter runoff may necessitate earlier dates of winter flood control drawdown relative to current dates.

Runoff and Surface Water Supplies

The future management of reservoir systems in the Western United States is very likely to become more challenging as runoff patterns continue to change as the result of the climate. Based on recent scenario studies of climate change impacts, it appears that a warming without precipitation change would trigger a seasonal shift toward increased runoff during winter and decreased runoff during summer in basins historically having a significant accumulation of seasonal snowpack. Based on current reservoir operations constraints (e.g., capacity, flood control rules), it appears that such runoff shifts would lead to reduced water supplies.

Based on contemporary climate projections, it appears plausible that the Pacific Northwest could experience precipitation increase with regional warming trends. This could potentially offset some portion of summer runoff decreases associated with warming alone, yet scenarios consistently point to reduced springtime snowpack and substantial reductions in late spring and early summer runoff in snowmelt-driven watersheds of this area.

Projected reductions in spring and summer snowmelt runoff are largely balanced by increases in winter runoff as more precipitation is projected to fall as rain rather than snow. This seasonal timing shift in runoff will present challenges in managing increasing winter streamflow and decreasing late spring and early summer streamflow. It is also projected that precipitation in the future is likely to be highly variable between years and decades, just as it has been in the recent past.

Flood Control

In Western United States reservoir systems currently located in snowmelt-dominated basins with flood control objectives, the anticipated increase in winter runoff volumes must be managed if current flood protection values and objectives are to be preserved. This could motivate the need for adjustments to the current flood control strategies. For example, given existing reservoir capacities and current flood control rules (e.g., winter draft period, spring refill date), a pattern of more winter runoff might suggest an increased flooding risk. Therefore, as an example, flood control rule adjustments, as the climate evolves may in turn result in deeper winter draft requirements, However, this type of winter draft operation may affect dry season water supplies during the summer months if less winter storage volume is carried over in anticipation of the winter runoff events.

Groundwater

Reduced mountain snowpack, earlier snowmelt, and reductions in spring and summer streamflow volumes originating from snowmelt likely would affect surface water supplies and could trigger heavier reliance on groundwater resources. However, warmer wetter winters could increase the amount of water available for groundwater recharge. It has not been demonstrated how much of this additional winter runoff can be captured and utilized without using artificial recharge schemes.

Water Demand

Given that the atmosphere's moisture holding capacity increases when air temperature increases, it would seem intuitive that plant water consumption related to evapotranspiration and surface water potential evaporation would increase in a warming climate. However, several studies report historical trends of decreasing pan evaporation during the past 50 years. This latter result may be related to changes in other factors affecting surface energy balance (e.g., net radiation, wind speed) that are not congruous with the notion of increasing air temperatures. Consequently, there is uncertainty about how physically driven water demands may change under climate change. Further, agricultural water demand could decrease due to crop failures caused by pests and disease exacerbated by climate change. On the other hand, agricultural water demand could increase if growing seasons lengthen. This possibility is based on studies suggesting that the average North American growing season length increased by about 1 week during the 20th century; and it is projected that, by the end of the 21st century, it will be more than 2 weeks longer than typical of the late 20th century. Although changes in water demands associated with natural processes may be difficult to quantify, consumption increases associated with population growth will occur unless water conservation measures are implemented.

As climate change might affect water supplies and reservoir operations, the resultant effects on water allocations in the Snake basin from year to year could trigger changes in water use (e.g., crop types, cropping dates, environmental flow targets, transfers among different uses, hydropower production, and recreation). Such climate-related changes in water use would interact with market influences on agribusiness and energy management, demographic and land use changes, and other nonclimate factors.

Climate change thus may result in changes to the water supply and demand calculated and used as the basis of this report. No analyses were performed in this study to quantitatively estimate possible changes associated with climate change that might affect reservoir operations, irrigation demand or operations, crop types, cropping dates, environmental flow targets, water supplies and shortages, or hydropower production.

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Chapter 3 RESOURCES, CONSTRAINTS, AND IDENTIFICATION OF ALTERNATIVES

This chapter describes the process used to identify the existing resources, opportunities, and constraints which were applicable to the study area's problems and needs defined in Chapter 2. Through application of stakeholder and Reclamation knowledge of the study area, this process resulted in identification of alternatives for further study to address stakeholder goals and Reclamation objectives.

3.1 Literature Review

In 2007, Reclamation prepared a literature review summary of existing studies for the Burnt River, Powder River, and Pine Creek basins as the first step in the assessment planning process (Browne 2008). The comprehensive literature review evaluated and summarized about 90 documents, reports, and other information sources for previous studies addressing characteristics of the Burnt River, Powder River, and Pine Creek basins. Documents in the literature review were prepared by Federal and State agencies, irrigation districts, soil and water conservation districts, universities, counties, and others, including private consulting firms and a local history group. References are categorized by geography and topic (Reclamation 2008). The literature review includes documentation of information sources that address stream systems, land use, land cover, water storage sites, and stream conditions, some dating back to the 1960s.

The initial list developed by WASH identified approximately 50 potential storage locations (enlargement of existing facilities and proposed potential reservoir sites) based on information from previous studies and interviews with stakeholders. The initial list was later expanded to 95 locations by Reclamation.

Some sites on the list that are further considered in this comprehensive report have been studied in past efforts by various entities. Some previous storage feasibility studies and associated technical studies incorporated cost estimates and identified development issues and environmental constraints. The available literature provided information that was incorporated into this appraisal study, including: 1) topographic and geologic adequacy for potential reservoir locations; 2) potential reservoir sizes and previously developed hydrology for some sites; and 3) costs and benefits of proposed projects.

3.2 Resource Opportunity Development

The literature review process and Reclamation recommended 95 sites for evaluation. These sites were identified as potential water storage projects for economic and ecological benefits. This initial pass included selecting sites identified from previous studies, new proposed reservoir locations, and those existing storage facilities with expansion potential. Figure 3-1 shows the numbered locations of all 95 identified preliminary storage study sites in the three river basins.

To determine the average annual yield potential for each site, a mean elevation was estimated for each location. This mean elevation was used in the regression equation to calculate annual yield for the purposes of screening identified sites. Within each of the subbasins, the irrigated demands, consumptive use and shortages near the reservoir locations were aggregated. This was done to assess the relative magnitude of yield benefit to irrigation shortages in relationship to the defined screening criteria.

3.3 Identification of Alternatives

3.3.1 Comparison of Yield to Need (Level 1 Screening)

Screening criteria were developed and applied to each of the 95 potential sites. These criteria were based on the WASH committee's goals and the Federal objectives stated in Chapter 1.0, Study Purpose and Scope. Four criteria were used in this first pass to remove those projects not satisfying the overall study goals (Reclamation 2009b).

Level 1 Screening Criteria

Geographic Overlap

Similar sites in the same geographic area were combined where possible, effectively reducing the number of sites screened. These combined sites were located on the same tributary and within close proximity of each other. Typically the yield characteristics of these sites were similar; however, the annual yield benefit was not additive. Therefore, the downstream site was normally selected as the representative site if proposed for further evaluation in this study. These sites were highlighted in the following Table 3-1, Table 3-2, and Table 3-3 and noted as "Combined" in the Initial Screening Results column, shaded in a green color.

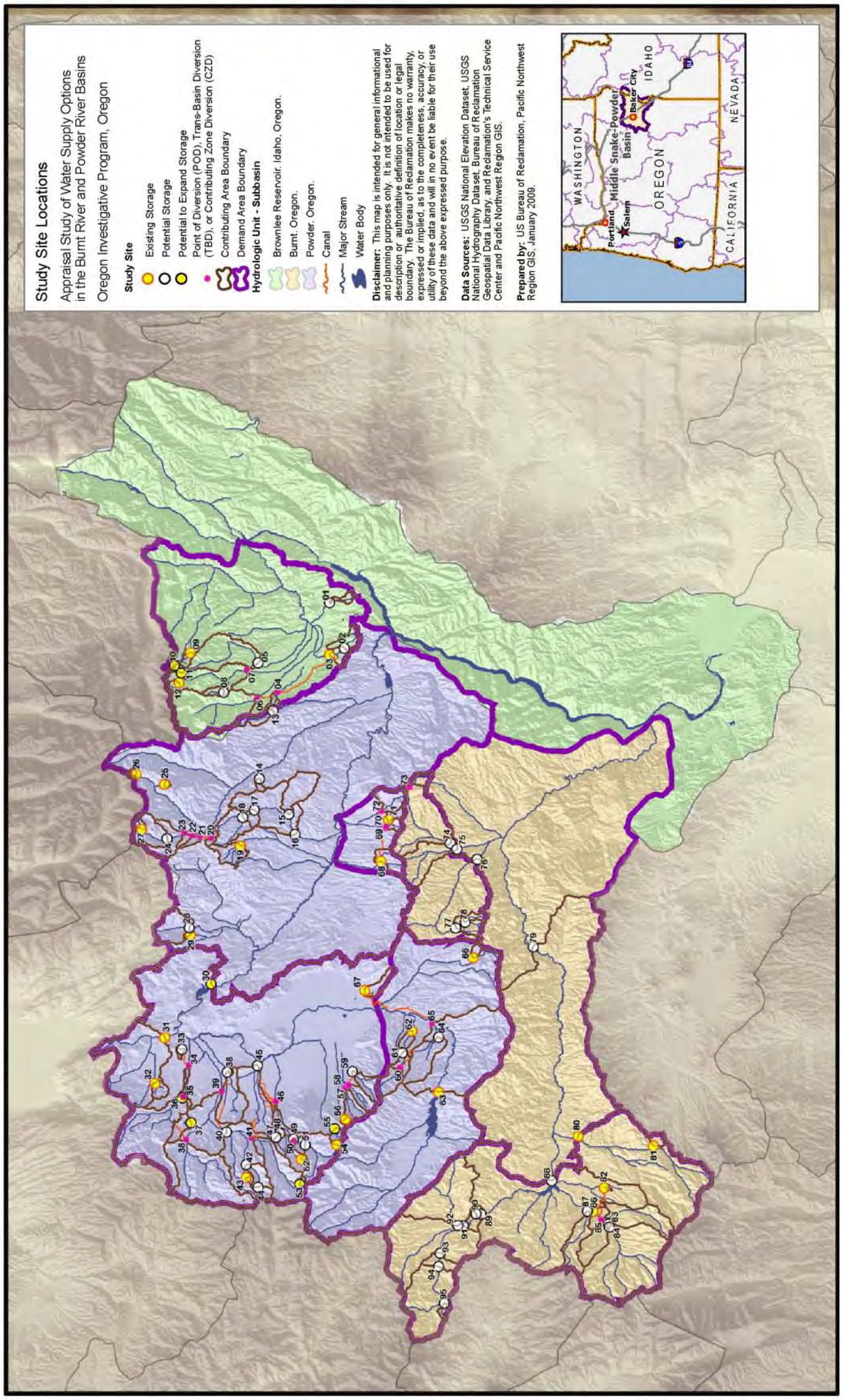

Figure 3-1. Study Site Locations

Ability to Meet Calculated Need

Annual average yields for the proposed sites were calculated and compared to the estimated need in the corresponding aggregated demand areas. This screening step relied entirely on unmet irrigation demand shortages potentially satisfied by a proposed project location. Sites where annual yield was calculated to be much less than the estimated shortage volume (generally a difference of greater than 2,000 acre-feet) are identified as “Not Likely to Meet Estimated Demand.” These are shown in the Initial Screening Results column, shaded in a salmon color, shown in Table 3-1, Table 3-2, and Table 3-3.

No substantive irrigation demand shortages were identified for the Lower Burnt Aggregated Demand Area (Table 3-1). Therefore, proposed sites in this area were eliminated from further study and also highlighted in a salmon color.

Site Proximity to Need

All sites where the potential storage location would be downstream of the irrigation demand and therefore unable to meet upstream needs without pumping were eliminated. The exception to this criterion was Thief Valley Reservoir expansion. Most of the unmet irrigation demand in the Powder River basin is located above Thief Valley Reservoir. The computed average annual yield of a proposed enlargement could result in storage of significantly more water than many other individual potential sites located upstream. It was assumed that the potential yield benefit may justify the addition of a pump station and conveyance system. This site was included for further investigation.

The term “Demand Upstream” is shown in the Initial Screening Results column for those sites where demand was located upstream of the proposed site, shaded in a yellow-gold color (Table 3-1, Table 3-2, and Table 3-3).

Lack of Sufficient Public Benefits Relative to Expected Cost

The appraisal process must demonstrate that potential alternatives are consistent with Federal objectives, policies, laws, costs, benefits, and environmental impacts. Without further analysis, several sites were eliminated based on their potential inability to satisfy the multi-objective goals of this study. The anticipated benefits generated would not be sufficient to justify the cost under Reclamation policies. Therefore, these assumptions were noted in the Initial Screening Results column, and highlighted in a salmon color.

Level 1 Screening Results

A total of 22 potential surface water storage sites met the Level 1 screening criteria. These and the 73 sites that were screened out during the Level 1 screening process are shown in Table 3-1, Table 3-2, and Table 3-3 with labels and color codes as described above.

Table 3-1. Burnt River Basin Initial Site Screening Results by Aggregated Demand Areas

(Green shading indicates a site that was combined. Salmon-colored shading indicates sites that were preliminarily identified as "not likely to meet estimated demand" (Criterion 2), no water shortage was identified (Criterion 3), or indicates the sites were preliminarily identified as being cost-prohibitive (Criterion 4). Yellow-gold indicates a site where demand is upstream.)

Aggregated Demand Area 1 - Upper Burnt						
Average Diversion Demand (acre-feet)	Average Crop Demand (acre-feet)	Average Diversion Demand Shortage (acre-feet)	Site Number	Proposed Dam (Study) Site Name	Average Annual Yield (acre-feet)	Initial Screening Results
31,790	18,438	4,325				
			80	Camp Creek Reservoir	22,769	Demand Upstream
			81	Murray Reservoir	427	Not Likely To Meet Estimated Demand
			82	Morfitt Reservoir	14	Not Likely To Meet Estimated Demand
			83	Hardman Dam	**25,746**	Selected for Further Evaluation
			84	South Fork Burnt River	25,690	Combined with Hardman Dam
			85	Morfitt Reservoir TBD	34,720	Combined with Whited Reservoir
			86	Whited Reservoir	**35,173**	Selected for Further Evaluation
			87	Pole Gulch	3,781	Not Likely To Meet Estimated Demand
			88	Unity Reservoir	87,884	Demand Upstream
			89	Lower North Fork Burnt River	**31,708**	Selected for Further Evaluation
			90	Middle North Fork Burnt River	31,520	Combined with Lower North Fork Burnt River
			91	Upper North Fork Burnt River	31,327	Combined with Lower North Fork Burnt River
			92	Trout Creek	**7,973**	Selected for Further Evaluation
			93	Ricco Dam	**11,866**	Selected for Further Evaluation
			94	North Fork Burnt River	10,779	Combined with Ricco Dam
			95	Tributary North Fork Burnt River	425	Not Likely To Meet Estimated Demand

Aggregated Demand Area 2 - Lower Burnt						
Average Diversion Demand (acre-feet)	Average Crop Demand (acre-feet)	Average Diversion Demand Shortage (acre-feet)	Site Number	Proposed Dam (Study) Site Name	Average Annual Yield (acre-feet)	Initial Screening Results
43,145	25,024	0				
			79	Dark Canyon	154,793	Eliminated due to "no shortage" - however, could be used as an exchange

Aggregated Demand Area 3 – Pritchard (includes Lawrence and Alder)						
Average Diversion Demand (acre-feet)	Average Crop Demand (acre-feet)	Average Diversion Demand Shortage (acre-feet)	Site Number	Proposed Dam (Study) Site Name	Average Annual Yield (acre-feet)	Initial Screening Results
2,500	1,450	382				
			73	Love Reservoir TBD	1,237	May not meet cost/benefit ratio of 1 or greater as 1) federal projects are required to be multi-use reservoirs, 2) projects must be multi-use 3) projects must have several public benefits as opposed to benefitting a small number of water users, 4) benefits of project must be equal to or greater than the cost of the project.
			74	Lookout	3,421	
			75	Lawrence Creek	3,265	
			76	Bert's Reservoir	14,798	
			77	Lower Alder Creek	1,638	
			78	Upper Alder Creek	582	

Table 3-2. Powder River Basin Initial Site Screening Results by Aggregated Demand Areas

(Green shading indicates a site that was combined. Salmon-colored shading indicates sites that were preliminarily identified as "not likely to meet estimated demand" (Criterion 2), no water shortage was identified (Criterion 3), or indicates the sites were preliminarily identified as being cost-prohibitive (Criterion 4). Yellow-gold indicates a site where demand is upstream.)

Aggregated Demand Area 4 - Powder River Above Baker						
Average Diversion Demand (acre-feet)	**Average Crop Demand (acre-feet)**	**Average Diversion Demand Shortage (acre-feet)**	**Site Number**	**Proposed Dam (Study) Site Name**	**Average Annual Yield (acre-feet)**	**Initial Screening Results**
29,644	17,194	1,236				
			60	Blue Canyon Reservoir TBD	4,685	Combined with Blue Canyon – Site #64
			61	Elk Creek	**5,512**	Selected for Further Evaluation
			62	Vahn Reservoir	479	Not Likely To Meet Estimated Demand
			63	Mason Dam	**98,023**	Selected for Further Evaluation
			64	Blue Canyon	3,098	**7,783** acre-feet merged with Blue Canyon Reservoir TBD Selected for Further Evaluation
			65	Smith Lake	122,326	**122,661** acre-feet merged with Smith Lake - Site #67 Selected for Further Evaluation
			66	Bennett Dam	736	Not Likely To Meet Estimated Demand
			67	Smith Lake	335	Combined with Smith Lake - Site #65

Aggregated Demand Area 5 - Powder River Above Thief Valley						
Average Diversion Demand (acre-feet)	Average Crop Demand (acre-feet)	Average Diversion Demand Shortage (acre-feet)	Site Number	Proposed Dam (Study) Site Name	Average Annual Yield (acre-feet)	Initial Screening Results
335,367	194,513	116,248				
			58	Salmon Creek Reservoir POD	4,251	Combined with Salmon Creek Reservoir - Site #59
			57	Salmon Creek Res Marble CZ	3,416	Combined with Salmon Creek Reservoir - Site #59
			55	Pine Creek	2,040	Not Likely To Meet Estimated Demand
			56	Goodrich Reservoir	894	Not Likely To Meet Estimated Demand
			54	Rock Lake	660	Not Likely To Meet Estimated Demand
			52	Killamacue Reservoir	314	Not Likely To Meet Estimated Demand
			51	Rock Creek Dam	**17,489**	Selected for Further Evaluation
			47/1 - 48/2	Big Muddy	2,153	**7,877** acre-feet merged with Big Muddy - Site #50 Selected for Further Evaluation
			50	Big Muddy TBD	5,724	Combined with Big Muddy Sites #47 & #48
			49	Lower Rock Creek Dam	**25,074**	Selected for Further Evaluation
			42	Twin Peak Dam	**8,564**	Selected for Further Evaluation
			45	Lower Muddy Creek	1,427	Demand Upstream - 52,165 acre-feet. merged with Muddy Creek Sites #41 & 46
			41	Muddy Creek Reservoir TBD	22,188	Combined with Lower Muddy Creek - Site #45
			46	Muddy Creek Reservoir POD	28,550	Combined with Lower Muddy Creek - Site #45
			40	North Powder Reservoir	**50,962**	Selected for Further Evaluation
			53	Big Summit	630	Not Likely To Meet Estimated Demand
			44	Dutch Flat Lake	2,804	Not Likely To Meet Estimated Demand
			43	Van Patten	668	Not Likely To Meet Estimated Demand
			36	Wolf Creek Reservoir Complex	18,594	**50,535** acre-feet merged Wolf Creek - Site #38 & Pilcher Creek Reservoir - Site #37 Selected for Further Evaluation
			38	Wolf Creek Reservoir POD	31,105	Combined with Wolf Creek Reservoir Complex -

Aggregated Demand Area 5 - Powder River Above Thief Valley						
Average Diversion Demand (acre-feet)	Average Crop Demand (acre-feet)	Average Diversion Demand Shortage (acre-feet)	Site Number	Proposed Dam (Study) Site Name	Average Annual Yield (acre-feet)	Initial Screening Results
						Site #36
			37	Pilcher Creek Reservoir	836	Combined with Wolf Creek Reservoir Complex - Site #36
			38	Warm Springs	301	Demand Upstream - 84,863 acre-feet, merged w/Warm Springs Reservoir POD - Site #39
			39	Warm Springs Reservoir POD	84,562	Combined with Warm Springs - Site #38
			30	Thief Valley Reservoir	**244,368**	Selected for Further Evaluation
			31	Jimmy Creek Reservoir	3,370	Not Likely To Meet Estimated Demand
			32	Shaw Reservoir	292	**18,872** acre-feet merged Shaw Reservoir POD - Site #35 Selected for Further Evaluation
			33	Sunnyslope Reservoir	16	Demand Upstream - 18,953 acre-feet, merged w/Sunnyslope Reservoir POD - Site #34
			34	Sunnyslope Reservoir POD	18,937	Combined with Sunnyslope Reservoir - Site #33
			35	Shaw Reservoir POD	18,580	Combined with Shaw Reservoir - Site #32
			36	Wolf Creek Reservoir Complex	18,594	**50,535** acre-feet, merged Wolf Creek - Site #38 & Pilcher Creek Reservoir - Site #37 Selected for Further Evaluation
			37	Pilcher Creek Reservoir	836	Combined with Wolf Creek Reservoir Complex - Site #36
			38	Wolf Creek Reservoir POD	31,105	Combined with Wolf Creek Reservoir Complex - Site #36
			38	Warm Springs	301	Demand Upstream - 84,863 acre-feet, merged w/Warm Springs Res POD - Site #39
			39	Warm Springs Reservoir POD	84,562	Combined with Warm Springs - Site #38
			40	North Powder Reservoir	**50,962**	Selected for Further Evaluation
			41	Muddy Creek Reservoir TBD	22,188	Combined with Lower Muddy Creek - Site #45
			42	Twin Peak Dam	**8,564**	Selected for Further Evaluation

Aggregated Demand Area 5 - Powder River Above Thief Valley						
Average Diversion Demand (acre-feet)	Average Crop Demand (acre-feet)	Average Diversion Demand Shortage (acre-feet)	Site Number	Proposed Dam (Study) Site Name	Average Annual Yield (acre-feet)	Initial Screening Results
			43	Van Patten	668	Not Likely To Meet Estimated Demand
			44	Dutch Flat Lake	2,804	Not Likely To Meet Estimated Demand
			45	Lower Muddy Creek	1,427	Demand Upstream - 52,165 acre-feet, merged with Muddy Creek Sites #41 & 46
			46	Muddy Creek Reservoir POD	28,550	Combined with Lower Muddy Creek - Site #45
			47/1 - 48/2	Big Muddy	2,153	**7,877** acre-feet, merged with Big Muddy - Site #50 Selected for Further Evaluation
			49	Lower Rock Creek Dam	**25,074**	Selected for Further Evaluation
			50	Big Muddy TBD	5,724	Combined with Big Muddy - Sites #47 & 48
			51	Rock Creek Dam	**17,489**	Selected for Further Evaluation
			52	Killamacue Reservoir	314	Not Likely To Meet Estimated Demand
			53	Big Summit	630	Not Likely To Meet Estimated Demand
			54	Rock Lake	660	Not Likely To Meet Estimated Demand
			55	Pine Creek	2,040	Not Likely To Meet Estimated Demand
			56	Goodrich Reservoir	894	Not Likely To Meet Estimated Demand
			57	Salmon Creek Res Marble CZ	3,416	Combined with Salmon Creek Reservoir - Site #59
			58	Salmon Creek Reservoir POD	4,251	Combined with Salmon Creek Reservoir - Site #59
			59	Salmon Creek Reservoir	3,626	**11,293** acre-feet, merged with Salmon Creek Sites #58 & #57 Selected for Further Evaluation

Aggregated Demand Area 6 - Eagle Creek						
Average Diversion Demand (acre-feet)	Average Crop Demand (acre-feet)	Average Diversion Demand Shortage (acre-feet)	Site Number	Proposed Dam (Study) Site Name	Average Annual Yield (acre-feet)	Initial Screening Results
75,690	43,901	7,583				
			14	Empire Gulch	286	Not Likely To Meet Estimated Demand
			16	Goose Creek	11,889	**40,124** acre-feet, merged with Goose Creek Sites #21, 22, 23, Phillips - Site #18 & Cougar-Site #17 Selected for Further Evaluation
			17	Cougar Dam	5,070	Combined with Goose Creek - Site #16
			18	Phillips Ingel	4,364	Combined with Goose Creek - Site #16
			19	Balm Creek Reservoir	2,825	Not Likely To Meet Estimated Demand
			21	Goose Creek Glendenning CZ	827	Combined with Goose Creek - Site #16
			22	Goose Creek Cow CZ	813	Combined with Goose Creek - Site #16
			23	Goose Creek Reservoir POD	17,162	Combined with Goose Creek - Site #16
			24	West Eagle Creek	**12,281**	Selected for Further Evaluation
			28	Beagle Creek	2,339	Not Likely To Meet Estimated Demand
			29	Little Park Dam	89	Not Likely To Meet Estimated Demand
			13	Summit Creek	1,878	Not Likely To Meet Estimated Demand
			15	Sawmill Creek	2,131	Not Likely To Meet Estimated Demand
			25	Looking Glass Reservoir	482	Not Likely To Meet Estimated Demand
			26	Eagle Lake Dam	929	Not Likely To Meet Estimated Demand
			27	Echo Lake Reservoir	1,867	Not Likely To Meet Estimated Demand

Aggregated Demand Area 7 - Love Creek						
Average Diversion Demand (acre-feet)	Average Crop Demand (acre-feet)	Average Diversion Demand Shortage (acre-feet)	Site Number	Proposed Dam (Study) Site Name	Average Annual Yield (acre-feet)	Initial Screening Results
794	461	136				
			68	Love Reservoir	602	May not meet cost/benefit ratio of 1 or greater as 1) federal projects are required to be multi-use reservoirs, 2) projects must be multi-use 3) projects must have several public benefits as opposed to benefitting a small number of water users, 4) benefits of project must be equal to or greater than the cost of the project.
			69	Love Reservoir Love CZ	403	
			70	Love Reservoir Widman CZ	604	
			72	Widman Reservoir	572	
			71	Love Reservoir East Fork Love	2,243	

Table 3-3. Pine Creek Basin Initial Site Screening Results by Aggregated Demand Areas

(Green shading indicates a site that was combined. Salmon-colored shading indicates sites that were preliminarily identified as “not likely to meet estimated demand” (Criterion 2), no water shortage was identified (Criterion 3), or indicates the sites were preliminarily identified as being cost-prohibitive (Criterion 4).

Aggregated Demand Area 8 - Pine Creek						
Average Diversion Demand (acre-feet)	Average Crop Demand (acre-feet)	Average Diversion Demand Shortage (acre-feet)	Site Number	Proposed Dam (Study) Site Name	Average Annual Yield (acre-feet)	Initial Screening Results
63,805	37,007	26,739				
			06	Main Stem Pine (Sag Site Pine CZ)	**30,061**	Merged with Sag Sites #04 & #02 and Laird Reservoir - Site #03 Selected for Further Evaluation
			04	Sag Site POD	377	Combined with Main Stem Pine (Sag Site Pine CZ) - Site #06
			03	Laird Reservoir	177	Combined with Main Stem Pine (Sag Site Pine CZ) - Site #06
			02	Sag Site	111	Combined with Main Stem Pine (Sag Site Pine CZ) - Site #06
			07	Main Stem Clear Creek (East Pine Reservoir POD)	16,706	Merged with East Pine Reservoir – Site #05 Selected for Further Evaluation
			05	East Pine Reservoir	8,203	Combined with Main Stem Clear Creek (East Pine Reservoir POD) - Site #07
			10	Sugarloaf Reservoir	261	Not Likely To Meet Estimated Demand
			09	Fish Lake	1,580	Not Likely To Meet Estimated Demand
			11	Mehlhorn & Bassett	1,167	Not Likely To Meet Estimated Demand
			12	Clear Creek Reservoir - West Fork	1,753	Not Likely To Meet Estimated Demand
			08	Meadow Creek	1,229	Not Likely To Meet Estimated Demand
			01	Deer Creek	39	Not Likely To Meet Estimated Demand

3.3.2 Evaluation of Remaining Sites (Level 2 Screening)

The remaining 22 sites identified through the Level 1 screening process were subjected to additional screening criteria. These Level 2 criteria were designed to further reduce the number of potential sites, focusing appraisal level analyses on those projects viewed as fulfilling multiple study goals and objectives.

Level 2 Screening Criteria

The Level 2 screening process included subjective criteria that required stakeholder involvement and discussion to reach consensus. These criteria incorporated issues relating to general permitting constraints such as presence of critical habitat for ESA-listed species, Wild and Scenic River designations, special land-use designations, stipulated instream flow requirements, and proximity to water quality-impaired stream segments. Other conditions that might complicate project permitting or approval were also addressed within this process.

This step was designed to identify as many possible solutions to existing water resource constraints that each screened site could resolve within its subbasin. The Level 2 criteria and methodology used is presented in the following sections.

Refine Hydrologic Reliability

The 22 sites that provided an opportunity to reduce aggregated demand shortages, based on average annual yield computations, were further evaluated for hydrologic reliability. Reservoir volumes were estimated for each site based on filling 80 percent of the time, as stipulated in the study objectives. Based on these volumes, sites were again compared to aggregated irrigation demands within its applicable area.

Computations were made to estimate the storable volume of water for each site using the generated hydrology for water years 1971 through 1999. Annual storable volumes were defined as water that did not need to remain in the stream for downstream diversion. These volumes were sorted for the period of record analyzed to illustrate fill frequency. This storable volume was compared against the identified average annual water shortage. This comparison indicated whether the reliability of the potentially developable new water supply aligned with the irrigation demand.

Identify Constraints

General constraints were identified and mapped where spatial information was available. This included information such as natural, cultural, and manmade resources or other existing conditions associated with the potential storage sites that might make project approval difficult or not possible.

Special Designations

Maps were used to identify geographic areas or river reaches with special Federal or State designations that might complicate project permitting. Public lands within the study area that have special designations include:

- U.S. Forest Service – Wilderness area, campground facilities, Wild and Scenic River, wildlife management areas, and potentially other designations (urban wildlife interface areas were not included because these designations are related only to fire risk management)
- U.S. Bureau of Land Management – Wilderness Study Area, campground facilities, Wild and Scenic River, and wildlife management areas
- State of Oregon – State parks, wildlife management areas, and potentially other lands
- County- and "Other Local Agency"-owned lands with special designations other than parks were not readily identifiable.

Bull Trout or Other Federal/State Listed Species' and Designated Critical Habitat

Bull trout, which was listed as "threatened" in 1998 under the ESA, have critical habitat present in the Powder and Pine Creek basins. Potential storage sites may impact critical bull trout spawning or rearing habitat and/or resident populations. Migration habitat would not necessarily preclude a project from going forward, but fish passage or other mitigation measures would need to be addressed. Sites would also be removed from the screening process if significant effects on the habitat of listed species or species of concern, such as redband trout, were evident.

All of the screened developments could impact ESA-listed salmon and steelhead in the Columbia and Snake River basins. The operation of reservoir storage projects alters the natural spring runoff hydrograph by reducing available flow for downstream juvenile fish migration. Although the proposed amounts of storable volume would be relatively small when compared to the magnitude of flows within the Snake and Columbia Rivers, this issue would need to be addressed with regional salmon managers and advocates in any subsequent study.

Cultural, Historic, or Locally Significant Sites

Cemeteries, historic buildings, or other historic sites may be affected by a proposed storage location. A cultural resources evaluation would be required in any subsequent study.

Other Considerations

Other considerations identified included EPA 303(d) water quality listings, flood control, hydropower, geologic constraints, and water rights concerns. Additional considerations, such as crop value, recreation, local support, and land ownership, were identified, discussed, and evaluated with the stakeholder work group.

Stakeholder Work Group Workshop

The 22 sites resulting from the Level 1 screening activities were assembled into handouts and maps. This information was presented during a two-day stakeholder workshop in spring 2009, along with the estimated unmet needs and the average annual yield information used to screen the list of 95 sites down to 22 sites. The purpose of this meeting was to engage stakeholders in a prioritization exercise to select at least one site that warranted an appraisal level of study.

Day 1 Workshop Summary

On the first day of the workshop, stakeholders were presented a study overview, the needs assessment, the Level 1 results, and the Level 2 storage hydrology results. Based on the hydrology results, Reclamation identified 7 of the 22 sites that, in the opinion of Reclamation staff, best met the identified needs, and the work group tentatively agreed to this list of potential sites. These sites included:

- Burnt River basin – Hardman Reservoir
- Burnt River basin – North Fork/Ricco Reservoir
- Lower Powder River basin – West Eagle Reservoir
- Powder River basin – Thief Valley Reservoir enlargement
- Powder River basin – North Powder/Wolf Creek Complex Reservoir
- Pine Creek basin – East Pine Reservoir
- Pine Creek basin – Sag Reservoir

The work group received an overview of identified constraints, and identified other potential constraints that would be applicable (e.g., economic considerations, geologic conditions, potential for water right impairment). These constraints were recorded and are characterized in the meeting notes and in the Known Site Issues column in Table 3-4. Constraints included existing conditions and other considerations associated with potential storage sites that might significantly complicate project permitting and make project approvals more unlikely, or in some cases, even prohibit project development. As part of this discussion, the work group characterized the following general constraints, organized geographically:

- Burnt River – Federal land and 303(d) water quality limitations, such as temperature, sedimentation, flow modifications, and chemical content

- Upper Powder River – Listed threatened and endangered species and 303(d) water quality limitations
- Powder River/Thief Valley – Wild and Scenic River designation, bull trout and other listed species, 303(d) water quality limitations
- Pine Creek – Private land ownership, bull trout, 303(d) water quality limitations

Day 2 Workshop Summary

On the second day, the work group revisited the list of seven potential sites being considered. Some stakeholders believed the hydrology at certain sites might be more reliable than the Level 2 results demonstrated, and they felt that some sites needed additional consideration before they were eliminated from further evaluation in this study. Based on work group input, the list of potential storage sites was revised to include the following 14 sites (three in the Burnt River basin, nine in the Powder River basin, and two in the Pine Creek basin):

- Burnt River basin
  - Hardman Reservoir
  - North Fork Reservoir
  - Ricco Reservoir
- Powder River basin
  - Thief Valley Reservoir enlargement
  - Lower Rock Creek Reservoir
  - North Powder Reservoir
  - Wolf Creek Reservoir enlargement
  - Smith Reservoir
  - Twin Peak Reservoir
  - Big Muddy Reservoir
  - Goose Creek Reservoir
  - West Eagle Reservoir
- Pine Creek basin
  - East Pine Reservoir
  - Sag Reservoir

For each of the 14 sites, the work group identified known site issues that might constrain or complicate project development, as discussed above.

Work group members also felt it was important to identify potential benefits for each of the 14 sites. A broad range of benefits were identified for the 14 potential sites. The comprehensive list of site benefits and issues is provided in Table 3-4. Following is a more detailed explanation of the benefits and issues:

- Bull trout habitat – Whether there was potential to impact their survival and impact the permitting process
- Community benefits – Whether a site might substantially increase local recreational opportunities and offer a possible economic boost to the local economy
- Existing dam – Whether a site might have existing structures that might be utilized to reduce project development costs
- Existing power grid – Whether a site might be adjacent to wind power generation and power transmission facilities to potentially take advantage of off-peak, less expensive power to support pumping costs (applies to Thief Valley Reservoir enlargement only)
- Fish passage – Whether a site would be required to provide facilities for fish migration
- Fisheries – Fish habitat benefits were identified if there was potential to improve instream flows, increase range of habitat, and provide minimum reservoir elevation to support fish populations
- Flood control – Whether there was potential to manage a reservoir to improve flood control
- Higher crop values – Whether the improved water supply reliability could support changing to higher-value crops, such as converting from alfalfa to wine grapes
- Hydropower potential – Whether hydropower generation potential existed, or potentially existed, to improve generation capacity of existing hydropower facilities
- Information available – Whether previous studies, designs, and other information were available for the site
- Instream flows – Whether potential existed to improve instream flows from additional stored water
- Irrigation – Whether the site would provide reliable, additional irrigation supply
- Land ownership – Whether land was in an irrigation district or other public entity that might make project development more feasible (Private ownership was viewed as a complicating project development factor)
- Large volume of water – Whether a site would be a able to store a relatively larger amount of water compared to other sites, and serve a larger demand area
- Minimum pool operations – Whether a site would provide minimum reservoir elevation to support fisheries

- Municipal, industrial, or mining potential – Whether a site could potentially serve industrial or municipal supply, in addition to agricultural water supply
- Natural barrier – Whether the site was upstream of a natural fish passage barrier, potentially reducing permitting complexity
- Off-channel – Whether a site was off-channel, and therefore, presumably have a less complicated permitting process relative to other sites
- Operating costs – Whether a site would have lower relative operating costs compared to other potential sites, e.g., gravity distribution versus pumped distribution system (Thief Valley Reservoir enlargement)
- Recreation – Whether a reservoir might be large enough to offer water-related recreation opportunities
- Redband trout – Redband trout habitat benefits were identified if there was potential to improve instream flows, increase range of habitat, and provide minimum reservoir elevation to support fisheries
- Temperature – Whether there was potential to improve temperature from increased flows
- Water right reservation – Whether there was a reserved water right for storable volume for a stream
- Water Quality – Whether there was potential to improve water quality

This information is summarized in Table 3-4 along with other information discussed below.

The work group then voted on these remaining sites with their associated characterizations, as shown in Table 3-4. In addition to presumed benefits and known site issues, the table also includes a summary of estimated minimum and maximum irrigation need, 80 percent storage reliability results, and voting outcome. Each work group member was given four votes, with only one vote allowed per project.

Level 2 Screening Results

After reviewing the voting results, the stakeholder work group agreed by consensus that an appraisal level study should be conducted on the following four potential surface water storage sites, with each affected row highlighted in a gray color in Table 3-4:

- Hardman reservoir site on the South Fork of the Burnt River
- Thief Valley Reservoir enlargement on the Powder River
- North Powder reservoir site on the North Powder River
- East Pine Creek reservoir site on East Pine Creek

Subsequent to the workshop, at stakeholder request, Reclamation agreed to review the Wolf and Pilcher Creek sites on the North Powder River for enlargement potential.

3.4 Alternatives Selected for Further Evaluation

The following sites were selected for further evaluation:

- Hardman Reservoir site on the South Fork of the Burnt River
- Thief Valley Reservoir enlargement on the Powder River
- North Powder Reservoir site on the North Powder River
- Wolf Creek Reservoir enlargement on the North Powder River
- Pilcher Creek Reservoir enlargement on the North Powder River
- East Pine Creek Reservoir site on East Pine Creek

An appraisal level hydrologic evaluation of each of these study areas was conducted, as described in Chapter 4. The analyses were conducted to evaluate the project benefit with respect to the identified goals and objectives defined by the WASH Committee and Reclamation.

This level of analysis did not include the quantification of water management benefits associated with conservation practices, re-use, and return flow. While these are identified as WASH Committee goals, the appraisal level of study detail precludes their analysis at this stage.

Table 3-4. Level 2 Screening and Vote Summary - 14 Potential Sites

(Four sites selected for further study highlighted in gray)

Basin - Site Name (No.)	Minimum Need (acre-ft)	Maximum Need, Low-Flow Water Year (acre-ft)	Estimated 80 Percent Storage Reliability (acre-ft)	Number of Votes	Presumed Site Benefits	Known Site Issues
Burnt – Ricco (93)	600	16,000	2,700	0	• Irrigation • Water right reservation • Recreation • Water quality • Mining/Industrial • Flood control (limited) • Higher crop values • Instream flows	• Temperature • Redband trout • Minimum pool operations • Fish passage • Downstream minimum instream flow needs
Burnt – Hardman (83)	600	16,000	4,800	22	• Water right reservation • Irrigation • Instream flows • Recreation • Land ownership (public) • Natural barrier • Redband Trout • Flood control (limited) • Hydropower potential • Municipal potential • Information available • Higher crop values	• Redband trout • Minimum pool operations • Fish passage • Downstream minimum instream flow needs
Burnt – Lower North Fork Burnt (89)	600	1,600	7,100	0	• Water right reservation • Irrigation • Recreation • Fisheries • Flood control (limited) • Hydropower potential • Large volume of water	• Temperature • Redband trout • Minimum pool operations • Fish passage • Downstream minimum instream flow needs • Some local opposition (water rights)

Basin - Site Name (No.)	Minimum Need (acre-ft)	Maximum Need, Low-Flow Water Year (acre-ft)	Estimated 80 Percent Storage Reliability (acre-ft)	Number of Votes	Presumed Site Benefits	Known Site Issues
Lower Powder – Thief Valley (30)	41,000 (Assumes water is pumped back upstream to water shortage areas above Thief Valley Reservoir)	278,000	56,307	24	• Existing dam • Higher crop values • Existing power grid • Large volume of water • Large project benefit/cost • Sustainable water supply • Hydropower potential • Existing power grid • Minimum pool operations • Recreation • Land ownership (public) • Water right reservation	• Temperature • Redband trout • Minimum pool operations • Fish passage • Downstream minimum instream flow needs • Existing recreation area • Downstream of most demand/need area • Land ownership (private) • Wild/Scenic River (downstream)
Powder – Lower Rock Creek (51)	41,000	278,000	2,200	0	• Irrigation • Instream flows • Low head hydro-power • Recreation • Flood control (limited) • Higher crop values	• Bull trout (ESA) • Redband trout • Minimum pool operations • Fish passage • Downstream minimum instream flow needs • Local opposition-water right impairment; need cooperative agreement • Geologic challenges
Powder – North Powder (40)	41,000	278,000	5,300	20	• Irrigation • Large service area downstream • Recreation • Hydro potential • Information available • Flood control (limited) • Temperature • Higher crop values	• Bull trout (ESA) • Temperature • Water could be supplied by other projects • Fish passage • Existing irrigation infrastructure • Spillway size • Away from need area, therefore higher conveyance cost • Instream flows • Land ownership (private) • Local opposition-water right impairment; need cooperative agreement

Basin - Site Name (No.)	Minimum Need (acre-ft)	Maximum Need, Low-Flow Water Year (acre-ft)	Estimated 80 Percent Storage Reliability (acre-ft)	Number of Votes	Presumed Site Benefits	Known Site Issues
Powder – Wolf Creek Complex (36)	41,000	278,000	0	7	• Existing dam • Can merge with Pilcher off-stream • Recreation • Flood control (limited) • Low head hydro-power • Large service zone • Operation costs • Higher crop values	• Bull trout (ESA) • Temperature • Local opposition-water right impairment; need cooperative agreement
Powder – Smith Lake (65)	41,000	278,000	4,300	0	• Irrigation • Off channel • Recreation	• Fish passage • Downstream minimum instream flow needs • Ditch issues • Land ownership (private) • Local opposition-water right impairment; need cooperative agreement
Powder – Twin Peak (42)	41,000	278,000	1,900	0	• Irrigation • Higher crop values • Recreation • Low head hydro-power	• Redband trout • Minimum pool operations • Fish passage • Downstream minimum instream flow needs • Small storage reliability • Geology • Local opposition-water right impairment; need cooperative agreement
Powder – Big Muddy (47/48)	41,000	278,000	1,100	0	• Irrigation • Off channel • Recreation • Higher crop values • Water quality	• Redband trout • Minimum pool operations • Fish passage • Downstream minimum instream flow needs • Small storage reliability • Requires trans-basin water source • Local opposition-water right impairment; need cooperative agreement

Basin - Site Name (No.)	Minimum Need (acre-ft)	Maximum Need, Low-Flow Water Year (acre-ft)	Estimated 80 Percent Storage Reliability (acre-ft)	Number of Votes	Presumed Site Benefits	Known Site Issues
Powder – Goose Creek (16)	2,300	14,000	10,300	2	• Irrigation • Recreation • Larger storage project	• Redband trout • Minimum pool operations • Fish passage • Downstream minimum instream flow needs • Water could be supplied by another project (Thief Valley) • Down slope from glacial moraine, debris flow over issues • Operational issues
Powder – West Eagle (24)	2,300	14,000	5,700	0	• Irrigation • Recreation • Hydro potential (limited)	• Redband trout • Minimum pool operations • Fish passage • Downstream minimum instream flow needs • Bull trout (presumed) • Wild/Scenic River (downstream)
Pine – East Pine (7)	8,100	49,000	21,200	19	• Water right reservation • Irrigation • Flood control (limited) • Hydro potential (low overhead) • Instream flows • Temperature • Higher crop values • Community benefits (Halfway, Oregon) • Recreation • Designs completed	• Bull trout present throughout basin (ESA) • Minimum pool operations • Fish passage • Downstream minimum instream flow needs • Temperature • Idaho Power Company mitigation area for Hells Canyon projects • Land ownership (private)

Basin - Site Name (No.)	Minimum Need (acre-ft)	Maximum Need, Low-Flow Water Year (acre-ft)	Estimated 80 Percent Storage Reliability (acre-ft)	Number of Votes	Presumed Site Benefits	Known Site Issues
Pine – Sag (6)	8,100	49,000	8,800	0	• No bull trout on Sag Creek • Irrigation • Flood control (limited) • Hydro potential • Off channel • Recreation • Community benefits (Halfway) • Larger project size	• Temperature • Point of diversion • Fish passage • Downstream minimum instream flow needs • Land ownership (private) • Active seismic zone

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Chapter 4 Hydrologic Evaluation of Storage Alternatives

4.1 General

This chapter discusses the model development and alternatives analyses undertaken for the three basins. While the hydrology used in the preliminary screening process provided a basis for quantifying the potential amount of storable water with respect to the irrigation demands, further refinement of basin hydrology was required for these appraisal-level alternatives analyses. Refinements included the spatial distribution of hydrologic flows and irrigation demands in order to preserve mass balance within each basin.

Appraisal studies typically rely on compilation and assessment of existing data. Information used in this study was an assemblage of both measured and calculated data. It should be noted that only a small number of gaged sites exist for these basins, and that these records were incomplete for the period of record analyzed. In addition, water use data were not available from diversion points and required professional judgment and assumptions to quantify irrigation needs and shortages within the basins. Lack of historic diversion data prevented validation of these estimates. However, the assumptions and results are comparable to basins with similar characteristics. Therefore, the mass balance exercise computed local gains and depletions for various reaches of the rivers that lacked adequate information, in an attempt to replicate available historical data and system operations over the 1971 – 1999 period of record. Once this was completed, a model network was configured to represent each basin for the purposes of quantifying the benefits associated with the reservoirs identified in the initial screening processes.

A MODSIM Model network, version 8.1, was created for each basin. MODSIM is a general-purpose river and reservoir operations computer simulation model capable of quantifying changes in system conditions under various operational changes. These surface water distribution models were also structured with a monthly time-step. While the monthly time-step of the model output does not capture the variations of day-to-day circumstances and real-time operational decisions, it does provide a means to quantify changes and make relative comparisons between the alternative scenarios modeled.

Conclusions reached by this study could not have been achieved without existing hydrologic data and water right information, as well as its assimilation into basin water yield and use using methodologies to complete the data sets. The goal of the modeling exercises presented here was to assess the relative changes in model output between the alternatives and the No Action alternative. Thus, for this appraisal level analysis with limited data, this approach provided an acceptable foundation from which to establish alternative benefit computations.

4.2 Basin Hydrologic Development

4.2.1 Agricultural Irrigation

Agricultural irrigation accounts for the large majority of consumptive water use in each basin; however, very few irrigation diversions within these basins are measured. Therefore, a methodology was developed in an attempt to quantify total irrigation diversions and consumptive use. Consumptive use computations quantify the amount of water removed from the system as a result of crop irrigation. Water use by crops in the study area was estimated using available records of crop acreages and type for the study area. These data are most commonly reported on a county-wide basis. Baker County crop acreages and crop types were derived from three sources:

- Census of Agriculture (Bureau of the Census; National Agricultural Statistics)
- Oregon Agricultural Information Network (OAIN 2008)
- Oregon State University Extension Service

The maximum reported crop acreage for the portion of Union County, within the Powder River Basin, was approximately 13,000 acres. Therefore, the annual irrigated acreage was estimated utilizing the same proportions reported for Baker County. Table 4-1 presents the estimated irrigated acreages for the period of record analyzed.

Table 4-1. Baker County and Union County irrigated acreages

Year	Baker County	Union County	Total Acres
1970	121,440	10,900	132,340
1971	119,400	10,720	130,120
1972	113,780	10,220	124,000
1973	115,640	10,380	126,020
1974	121,460	10,910	132,370
1975	121,760	10,930	132,690
1976	126,500	11,360	137,860
1977	126,000	11,310	137,310
1978	135,900	12,200	148,100
1979	129,360	11,610	140,970
1980	130,240	11,690	141,930
1981	127,450	11,440	138,890
1982	130,820	11,750	142,570
1983	131,870	11,840	143,710
1984	142,120	12,760	154,880
1985	139,320	12,510	151,830
1986	136,735	12,280	149,015
1987	115,480	10,370	125,850

Year	Baker County	Union County	Total Acres
1988	104,110	9,350	113,460
1989	108,180	9,710	117,890
1990	105,450	9,470	114,920
1991	110,145	9,890	120,035
1992	103,010	9,250	112,260
1993	109,185	9,800	118,985
1994	111,815	10,040	121,855
1995	116,360	10,450	126,810
1996	144,790	13,000	157,790
1997	127,070	11,410	138,480
1998	113,855	10,220	124,075
1999	116,145	10,430	126,575
Maximum	**144,790**	**13,000**	**157,790**
Average	121,846	10,940	132,786
Average Percent of Total	91.76%	8.24%	100.00%

The Census of Agriculture provided the irrigated cropland and irrigated pastureland estimates. Table 4-2 presents the crop type information available for Baker County. These percentages were then applied to those acreages in Union County and scaled according to Table 4-1.

Table 4-2. Baker County irrigated acreage with Oregon Extension data and estimated pasture

Year	Grass/ grass hay	Alfalfa	Winter grain	Spring grain	Potatoes	Corn	Estimated pasture	Baker County Total Acreage
1970	37,200	41,790	8,740	4,960	450	600	27,700	121,440
1971	32,500	44,850	8,610	4,890	450	700	27,400	119,400
1972	31,800	43,830	6,570	3,730	550	700	26,600	113,780
1973	32,000	41,790	8,100	4,600	550	800	27,800	115,640
1974	33,100	42,810	8,930	5,070	650	800	30,100	121,460
1975	32,000	42,810	9,060	5,140	650	1,000	31,100	121,760
1976	34,200	40,150	10,380	6,920	650	1,000	33,200	126,500
1977	35,000	41,000	8,970	5,980	550	700	33,800	126,000
1978	37,000	41,650	11,580	7,720	250	700	37,000	135,900
1979	36,000	39,650	10,380	6,920	210	600	35,600	129,360
1980	35,000	40,150	11,010	7,340	140	600	36,000	130,240
1981	35,000	37,150	11,550	7,700	350	500	35,200	127,450
1982	37,000	37,150	11,790	7,860	520	500	36,000	130,820
1983	39,000	38,150	10,560	7,040	620	500	36,000	131,870
1984	42,000	40,150	12,360	8,240	470	500	38,400	142,120
1985	40,000	41,150	11,850	7,900	720	500	37,200	139,320
1986	41,000	41,500	10,200	6,800	815	420	36,000	136,735
1987	40,120	34,480	5,940	3,960	480	400	30,100	115,480

Year	Grass/ grass hay	Alfalfa	Winter grain	Spring grain	Potatoes	Corn	Estimated pasture	Baker County Total Acreage
1988	39,740	28,500	4,980	3,320	270	400	26,900	104,110
1989	39,240	28,900	6,600	4,400	740	500	27,800	108,180
1990	38,120	29,700	5,340	3,560	1,030	600	27,100	105,450
1991	41,020	30,600	4,920	3,280	1,325	500	28,500	110,145
1992	34,000	30,600	5,400	3,600	1,810	600	27,000	103,010
1993	38,000	31,600	4,920	3,280	1,685	600	29,100	109,185
1994	39,000	31,500	5,100	3,400	1,765	550	30,500	111,815
1995	40,050	33,550	4,560	3,040	2,210	450	32,500	116,360
1996	38,800	50,300	6,660	4,440	2,620	470	41,500	144,790
1997	40,500	36,900	5,580	3,720	3,070	0	37,300	127,070
1998	36,200	32,500	4,380	2,920	3,755	0	34,100	113,855
1999	34,000	36,200	3,720	2,480	4,245	200	35,300	116,145
2000	47,000	34,400	4,140	2,760	4,550	0	40,700	133,550
2001	40,500	33,000	3,780	2,520	4,300	650	36,600	121,350
2002	41,000	33,000	3,420	2,280	4,900	0	34,900	119,500
Average	**37,487**	**37,317**	**7,578**	**4,902**	**1,434**	**516**	**32,878**	**122,114**
Average as a percent of total	**30.70%**	**30.56%**	**6.21%**	**4.01%**	**1.17%**	**0.42%**	**26.92%**	**100.00%**

Crop irrigation water requirements were calculated using evapotranspiration computations. However, these values are representative of the theoretical water requirement and do not indicate the actual consumptive use. Therefore, in order to prevent over estimation of irrigation requirements, a water use factor was applied to these computations. These water use factors were based on historic irrigation season cut-off dates and were differentiated for wet, dry, and average water years. By applying these factors to irrigation water use, a reasonable estimate to irrigation diversions could be developed.

The final irrigation demand computations included delivery efficiencies, application efficiencies, and the potential re-use of irrigation water return flows. These additional factors were based on published information or assumptions designed to capture the system dynamics representative of each basin as observed in the available data.

The irrigated acreages were then distributed with respect to gage locations. Water use factors and efficiencies were applied such that the spatial distribution of irrigation diversions, consumptive use, return flows, as well as reach gains and losses, could be computed within the basins.

The followings figures (Figure 4-1, Figure 4-2, and Figure 4-3) illustrate the computed total annual irrigation diversions for each basin. These computations reflect the water use factors and rediversion of return flows used in balancing the hydrology for each basin.

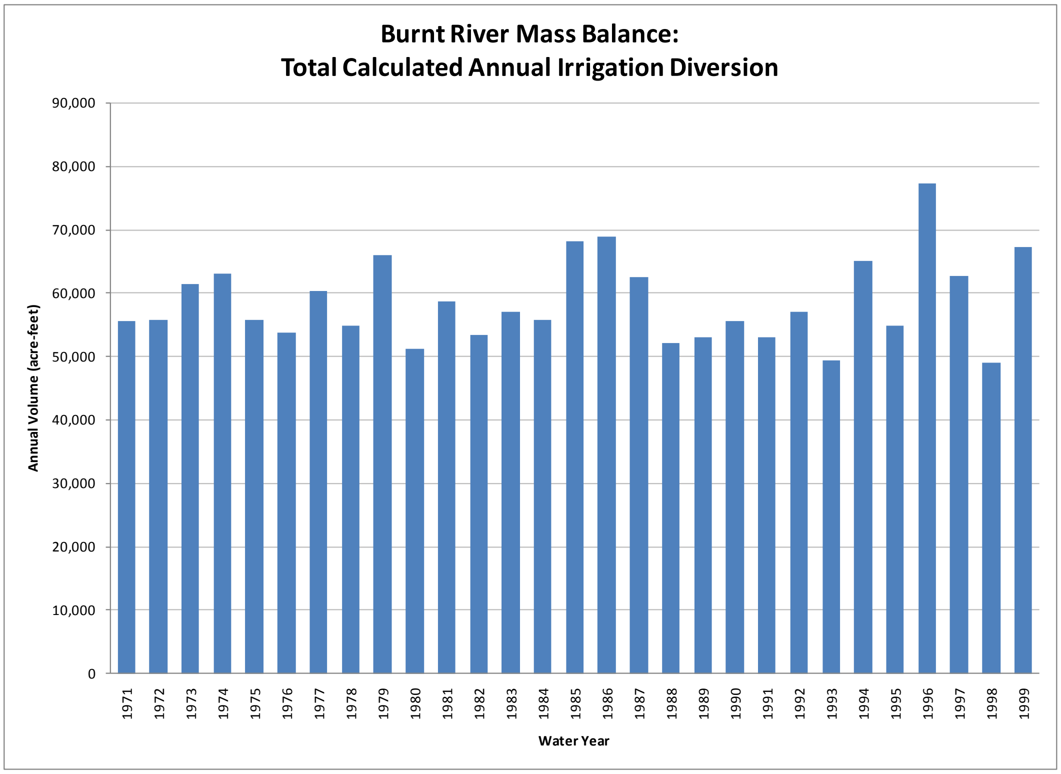

Figure 4-1. Burnt River total calculated irrigation diversion for hydrology mass balance

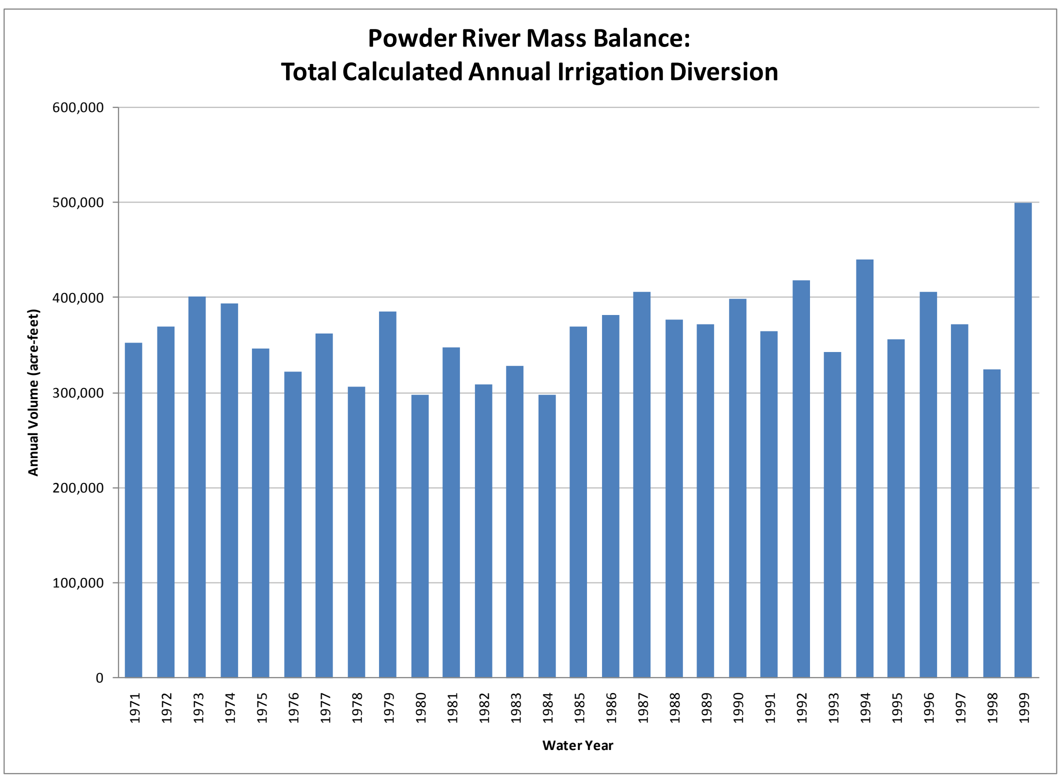

Figure 4-2. Powder River total calculated irrigation diversion for hydrology mass balance

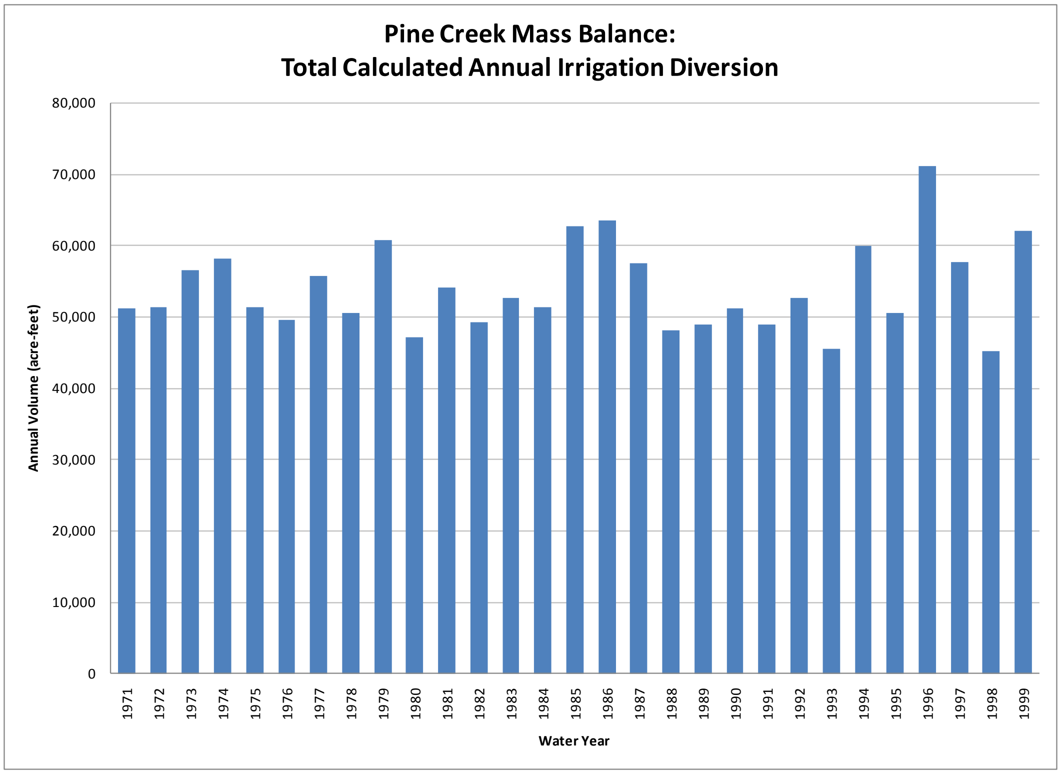

Figure 4-3. Pine Creek total calculated irrigation diversion for hydrology mass balance

It should be noted that these values are a best estimate of historical irrigation diversions for the period of record analyzed. These diversions were then incorporated, along with the hydrology data, to balance the water volumes in the basin for modeling the alternatives identified in the screening process.

4.2.2 Basin Hydrology

Burnt and Powder River Basins

An Excel spreadsheet was used to compute the mass balance within each basin. The initial screening process developed the data for identified gaged sites. These data included available measured data and generated data to complete the period of record. The spatial distribution of the irrigated acreages with respect to each identified gage site was defined in the spreadsheets. The water use factors and efficiencies were used to compute the irrigation diversions, consumptive use, and subsequent return flows, described in the previous section, to calibrate the reach gains and losses between the gages.

Figure 4-4 illustrates the result of the mass balance computations for the Burnt River near Hereford for the USGS gage (No. 13273000) location.

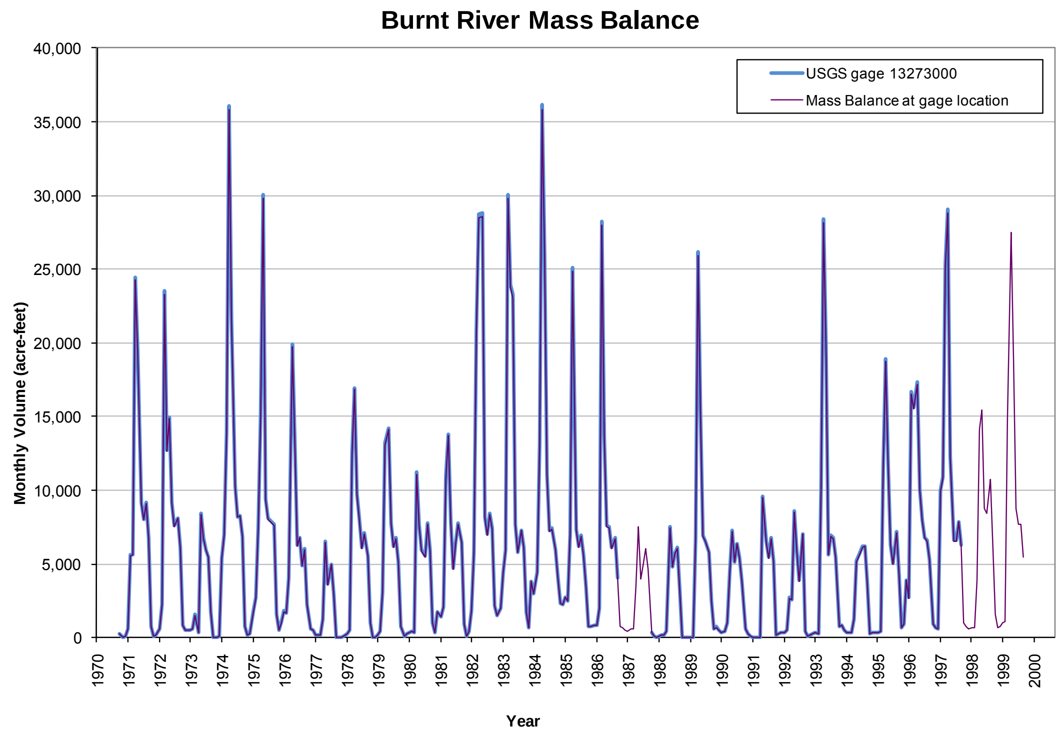

Figure 4-4. Excel spreadsheet mass balance compared to available USGS gage data

Similarly, Figure 4-5 illustrates the mass balance for the Powder River. The balance is shown for the location immediately above Thief Valley Reservoir.

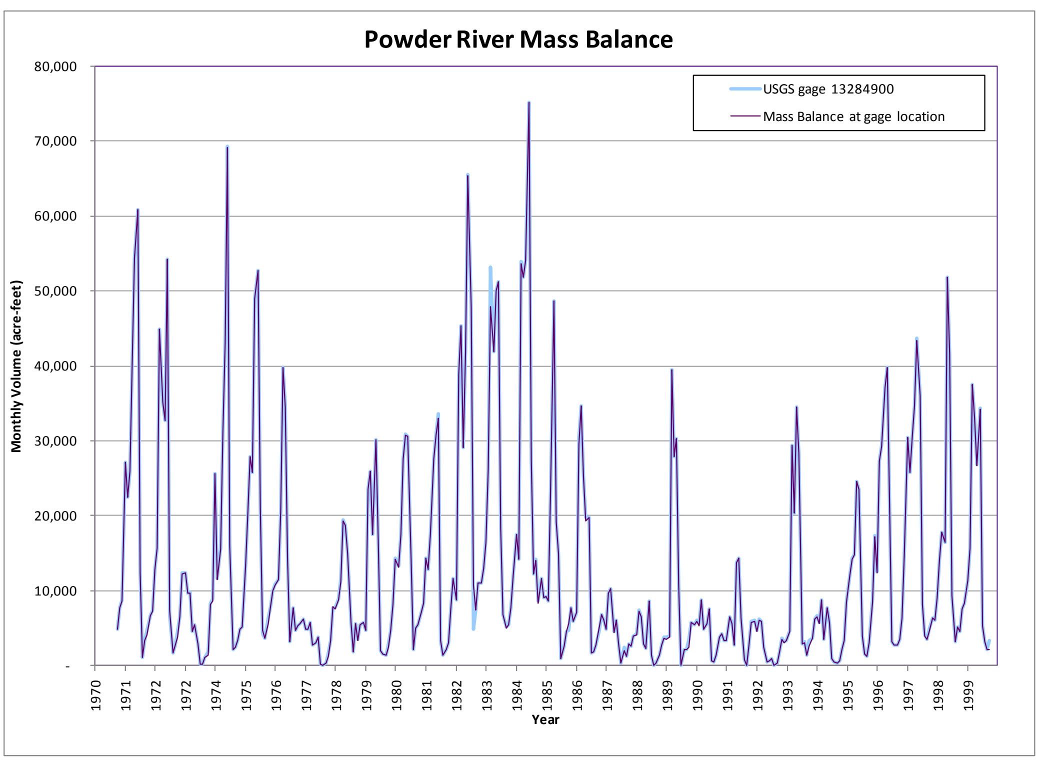

Figure 4-5. Excel spreadsheet mass balance compared to available USGS gage data

Once this mass balance process was completed, the model networks were then configured to include the computed reach gains and losses.

Pine Creek River Basin

One stream gage with a substantial period of record exists within the Pine Creek basin. As a result, a different methodology to develop spatially distributed flows was used instead of the screening process' regression equation. A correlation was developed between the basin's annual unregulated streamflow volume with respect to watershed area and mean annual precipitation. This relationship was applied to each subbasin drainage area located within the Pine Creek basin. The irrigation demands were also distributed between the basins, similar to the methodology used in the Burnt and Powder River basins. Once these computations were complete, the local gains and depletions for the reaches between selected locations were balanced using an excel spreadsheet.

Figure 4-6 illustrates the result of the mass balance computations for Pine Creek at the USGS gage (No. 13290190) location.

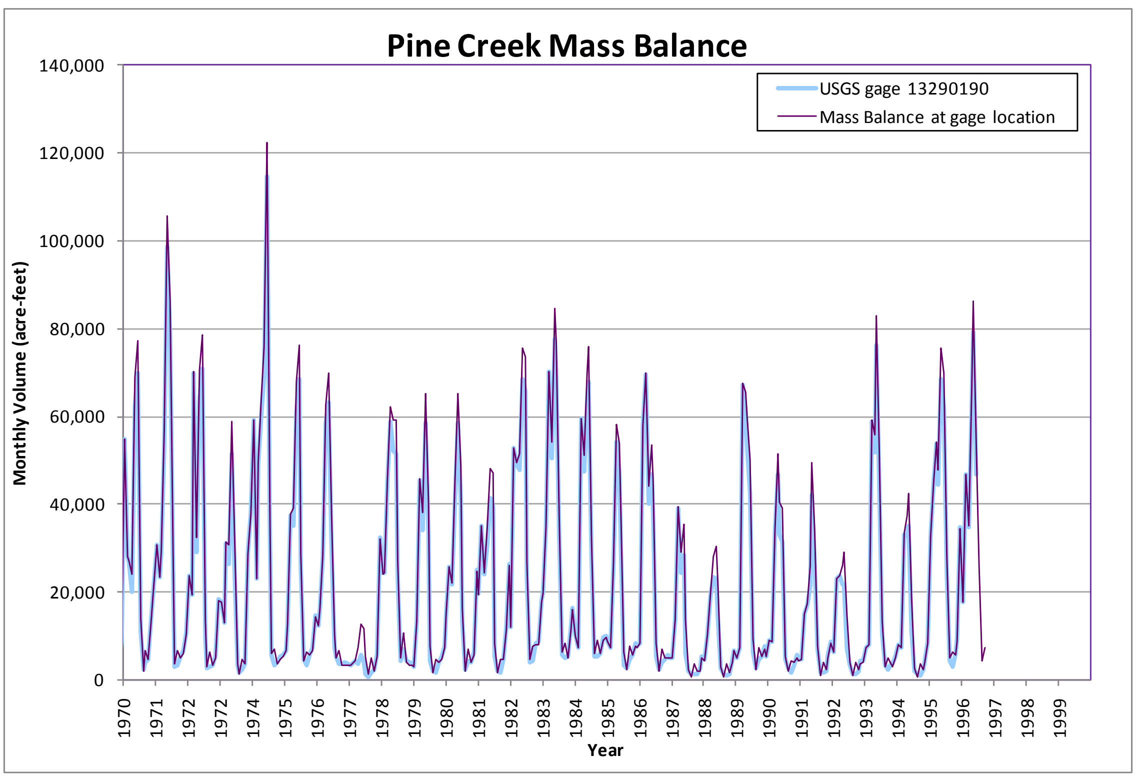

Figure 4-6. Excel spreadsheet mass balance compared to available USGS gage data

Once this mass balance process was completed, a model network was configured to compare the alternatives identified in the screening process.

4.3 Baseline Model Configuration and Calibration

4.3.1 Burnt River Model Development

Network Configuration

The spatial representation of the basin is shown in Figure 4-7. The numbered delineated subbasins were used in balancing the basin hydrology and are used to correspond to model network nodes within the watershed. These nodes are representative of upstream hydrology, reach gains, reach losses, and irrigation diversions. Upstream hydrology and gains were represented as blue circles in the model whereas reach losses or irrigation demands were represented as purple squares. The model network used for the alternatives analysis for the Burnt River basin is shown in Figure 4-8. It should be noted that the model network illustrated in the figure includes the proposed Hardman Reservoir, identified in the screening process.

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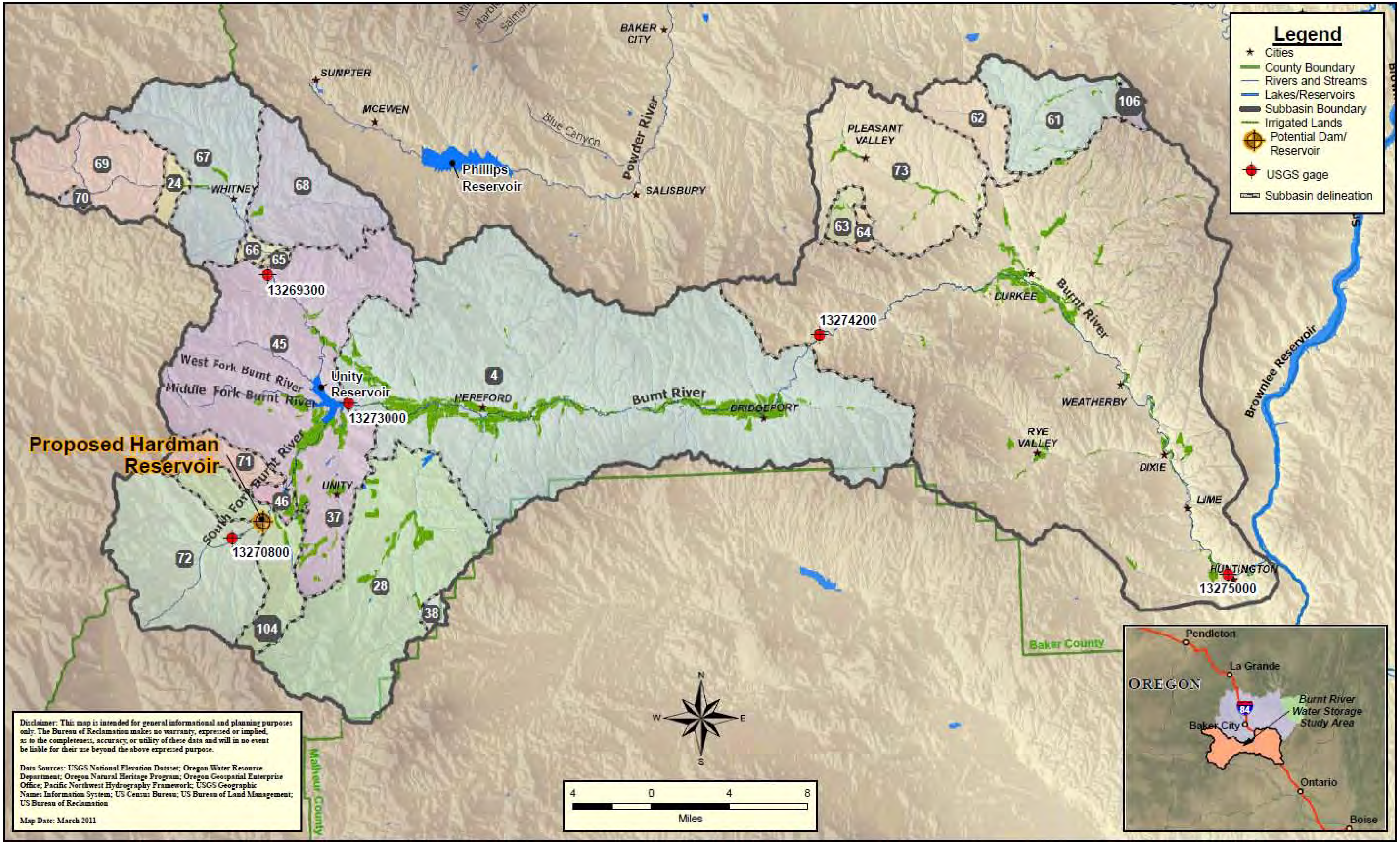

Figure 4-7. Burnt River Basin spatial representation used in model network

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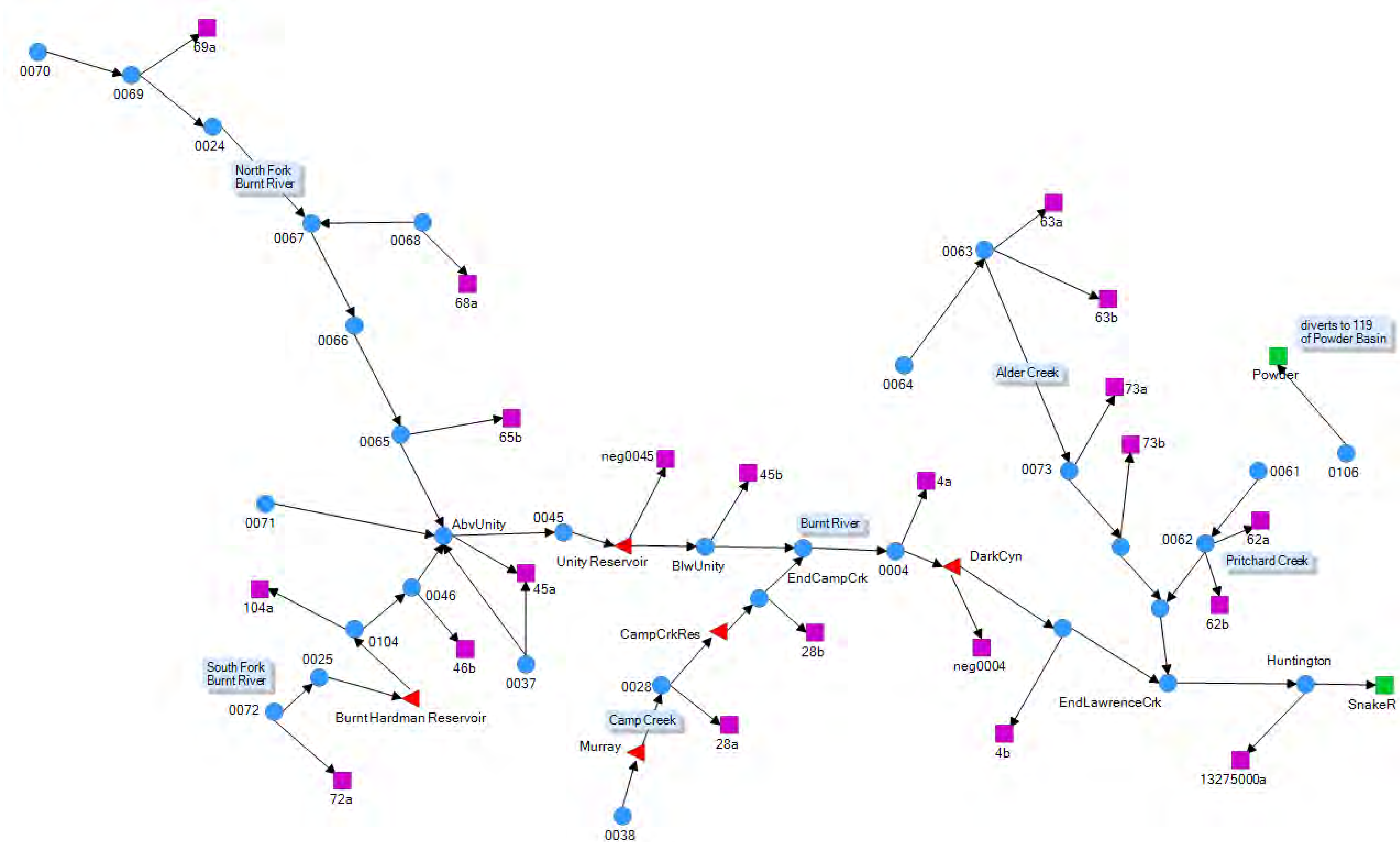

Figure 4-8. Model network of the Burnt River Basin

Red triangle = reservoir; blue circle = node or gain; purple square = demand; green square = sink

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Calibration Results

The MODSIM model was populated with the balanced hydrology data. In addition, the irrigation demand for the scenario analyses was configured to represent the current level of basin development. This ensures that the modeling results are representative of current conditions.

The irrigation demands for the Burnt River Basin were computed assuming a maximum of 22,000 acres of irrigated lands with an associated crop distribution mix. The crop distribution mix was the computed average for the period of record analyzed. In computing irrigation demands, Table 4-3 presents the crop distribution used.

Table 4-3. Crop acreage used in Burnt River alternatives modeling analyses

Crop Acreage Assumption	
Grass/hay	30.7%
Alfalfa	30.5%
Winter grain	6.2%
Summer grain	4.0%
Potatoes	1.2%
Corn	0.4%
Pasture	27.0%

The following figure (Figure 4-9) illustrates the computed monthly average irrigation demand for the period of record analyzed.

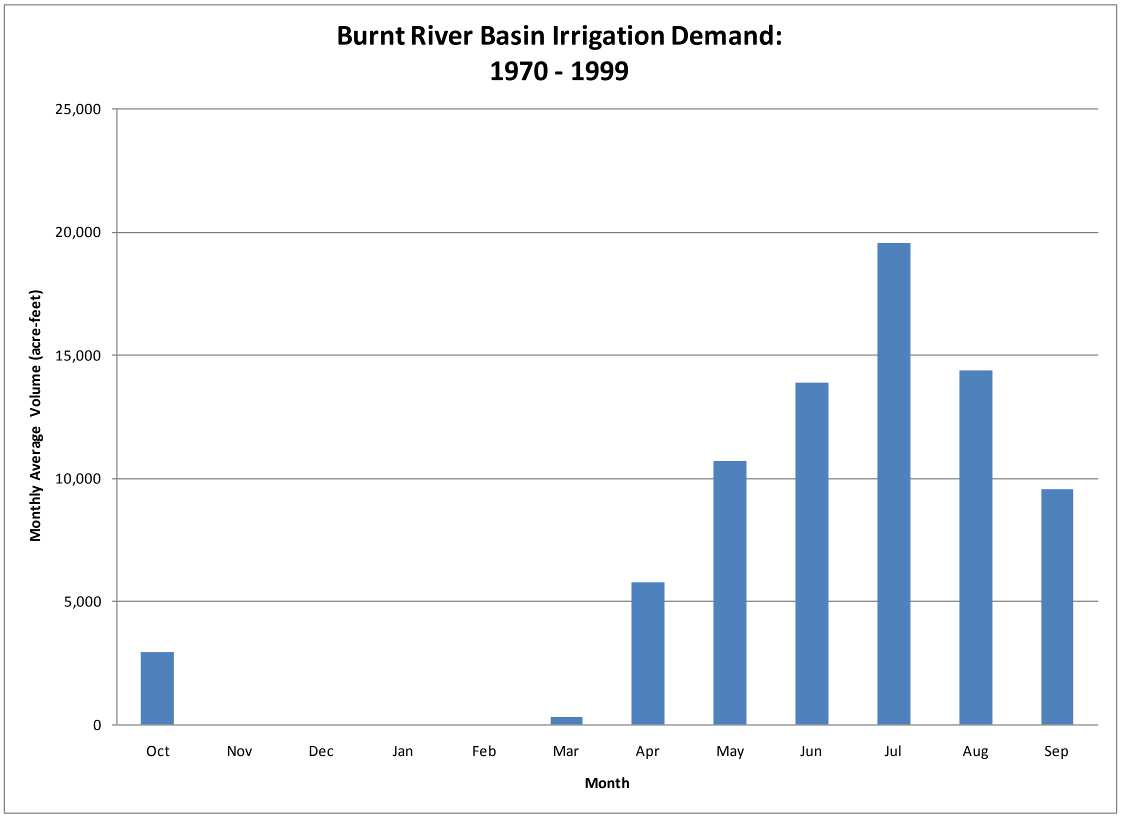

Figure 4-9. Average monthly irrigation demand for Burnt River Basin

The return flow back to the river is a function of total irrigation diversion, crop water use, as well as conveyance and on site efficiencies. A value of infiltration percent was used for all of the irrigation demands to compute the amount of water, not consumptively used, that returned to the river via subsurface flows. It was assumed that none of this water percolated to a deep aquifer and that it returned to the river over a two month period. The following overall water use efficiency and return flow lag percentages were assumed and are presented in Table 4-4.

Table 4-4. Burnt River modeled irrigation assumptions

Infiltration Percent	42%
Return Flow Lag Percent	
Month 0	57%
Month 1	29%
Month 2	14%

Figure 4-10 illustrates the calibrated model results compared to USGS gage data. These results illustrate that the model is representative of basin operations. This result provides a foundation for comparative analyses of the screened alternatives.

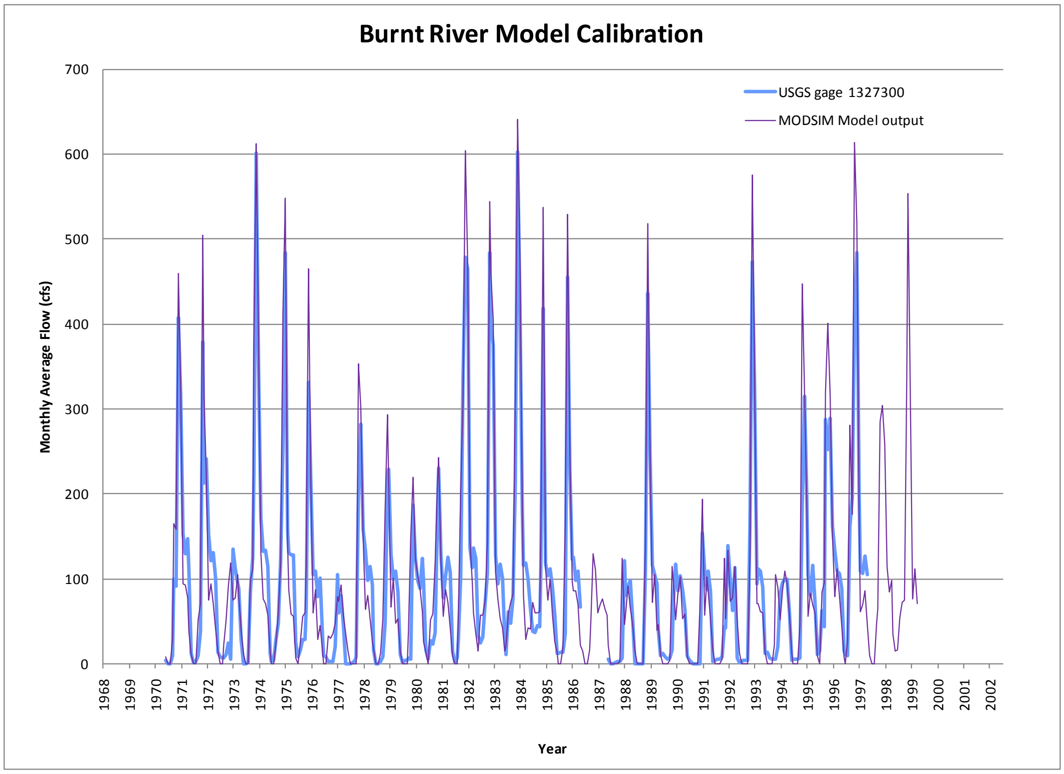

Figure 4-10. MODSIM model calibration results for Burnt River

4.3.2 Powder River Model Development

Network Configuration

The spatial representation of the basin is shown in Figure 4-11. The numbered delineated subbasins were used in balancing the basin hydrology and are used to correspond to model network nodes within the watershed. These nodes are representative of upstream hydrology, reach gains, reach losses, and irrigation diversions. Upstream hydrology and gains were represented as blue circles in the model whereas reach losses or irrigation demands were represented as purple squares. The model network used for the alternatives analysis for the Powder River Basin is shown in Figure 4-12. It should be noted that the model network illustrated in the figure includes the proposed North Powder Reservoir, identified in the screening process.

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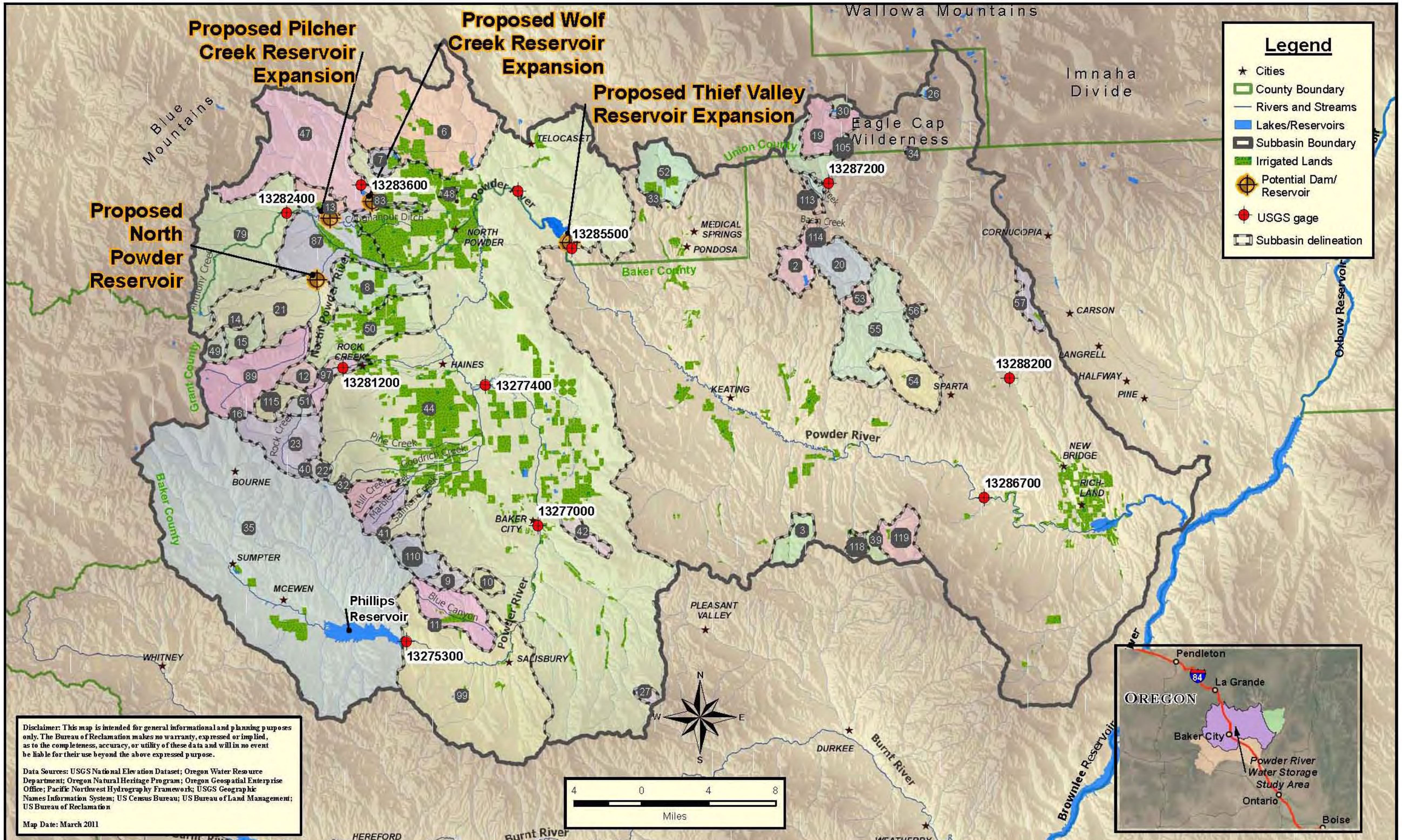

Figure 4-11. Powder River Basin spatial representation used in model network

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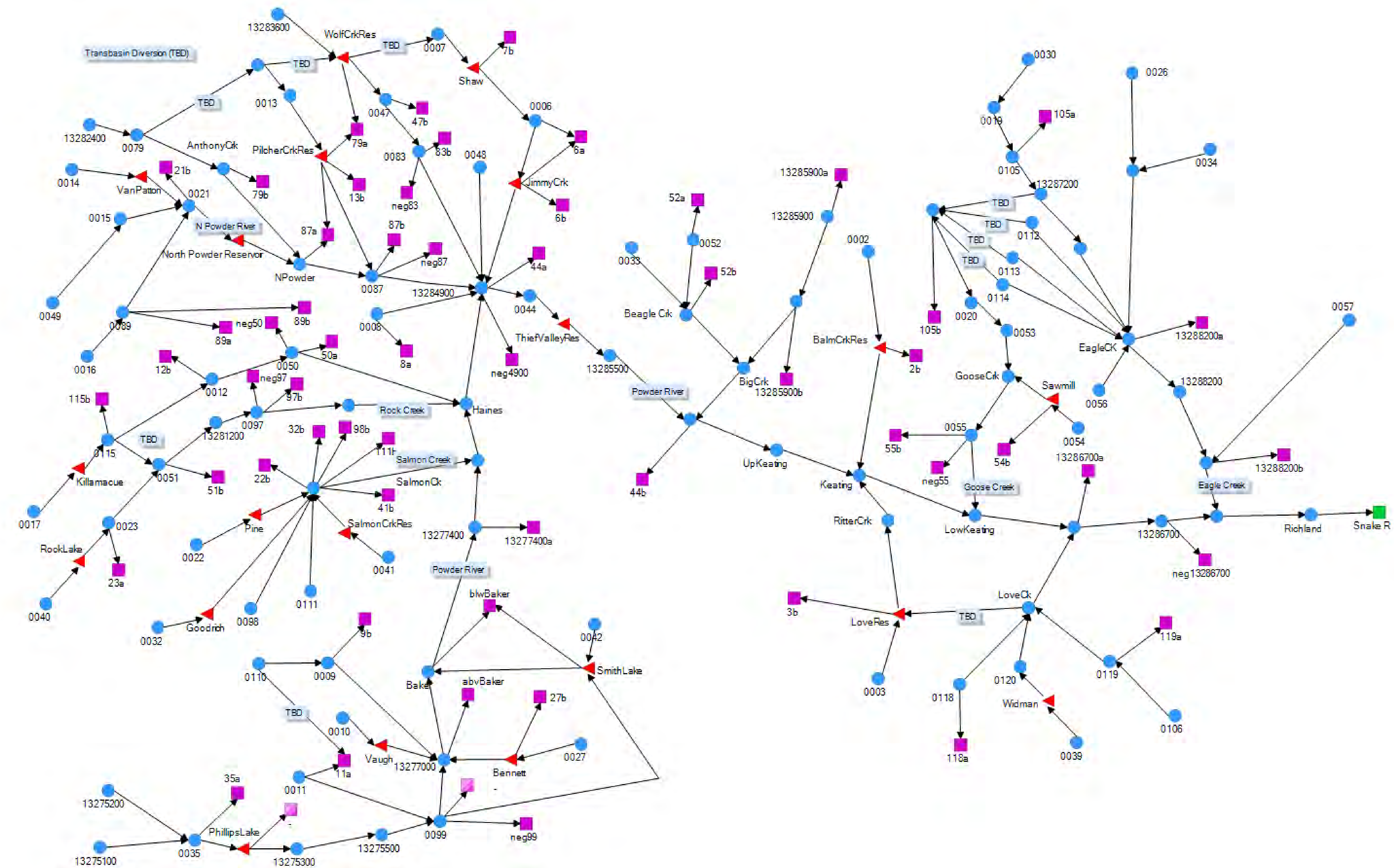

Figure 4-12. Model network of the Powder River Basin

Red triangle = reservoir; blue circle = node or gain; purple square = demand; green square = sink

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Calibration Results

The MODSIM model was populated with the balanced hydrology data. In addition, the irrigation demand for the scenario analyses was configured to represent the current level of basin development. This ensures that the modeling results are representative of current conditions.

The irrigation demands for the Powder River Basin were computed assuming a maximum of 125,000 acres of irrigated lands with an associated crop distribution mix. The crop distribution mix was the computed average for the period of record analyzed (Figure 4-2). In computing irrigation demands, Table 4-5 presents the crop distribution used.

Table 4-5. Crop acreage used in Powder River alternative modeling analyses

Crop Acreage Assumption	
Grass/hay	30.7%
Alfalfa	30.5%
Winter grain	6.2%
Summer grain	4.0%
Potatoes	1.2%
Corn	0.4%
Pasture	27.0%

The following figure (Figure 4-13) illustrates the computed monthly average irrigation demand for the period of record analyzed.

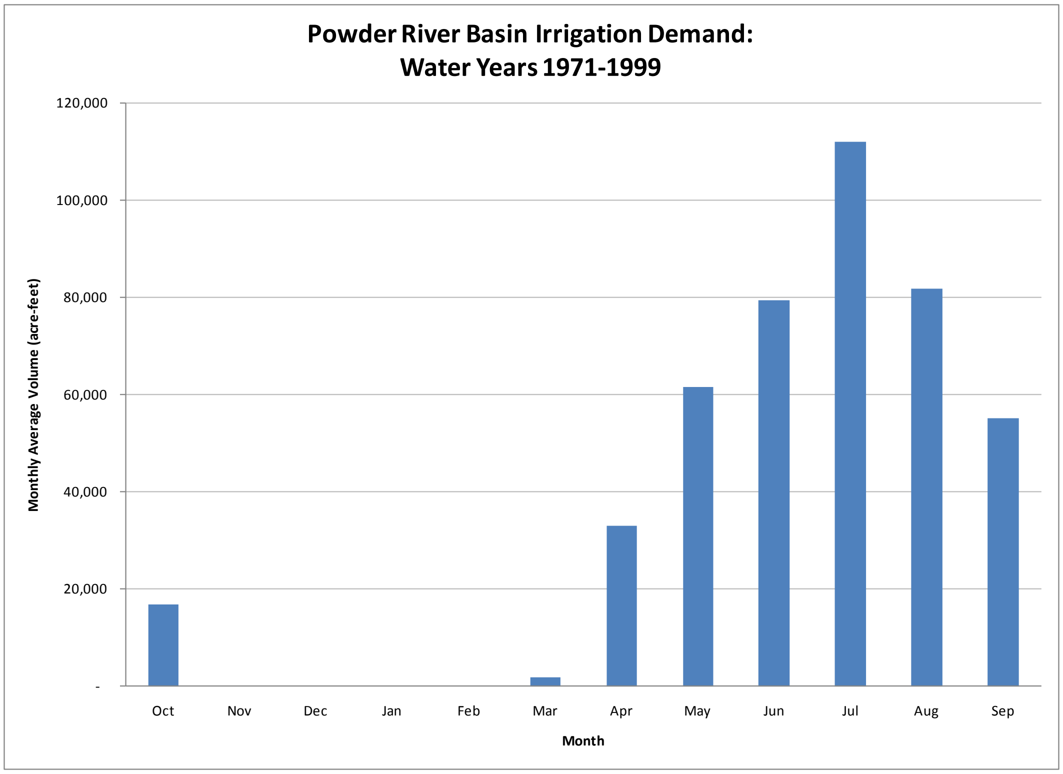

Figure 4-13. Average monthly irrigation demand for Powder River Basin

The return flow back to the river is a function of total irrigation diversion, crop water use, as well as conveyance and on site efficiencies. Two values of infiltration percent were used, depending on the location of the irrigation demands with respect to Thief Valley Reservoir. The infiltration percent was used to compute the amount of water, not consumptively used, that returned to the river via subsurface flows. It was assumed that none of this water percolated to a deep aquifer and that it returned to the river over a two month period. The following overall water use efficiency and return flow lag percentages were assumed and are presented in Table 4-6.

Table 4-6. Modeled irrigation assumptions

Infiltration Percent: above Thief Valley Reservoir	35%
Infiltration Percent: below Thief Valley Reservoir	42%
Return Flow Lag Percent	
Month 0	57%
Month 1	29%
Month 2	14%

Figure 4-14 illustrates the calibrated model results compared to USGS gage data. These results illustrate that the model is representative of basin operations. This result provides a foundation for comparative analyses of the screened alternatives.

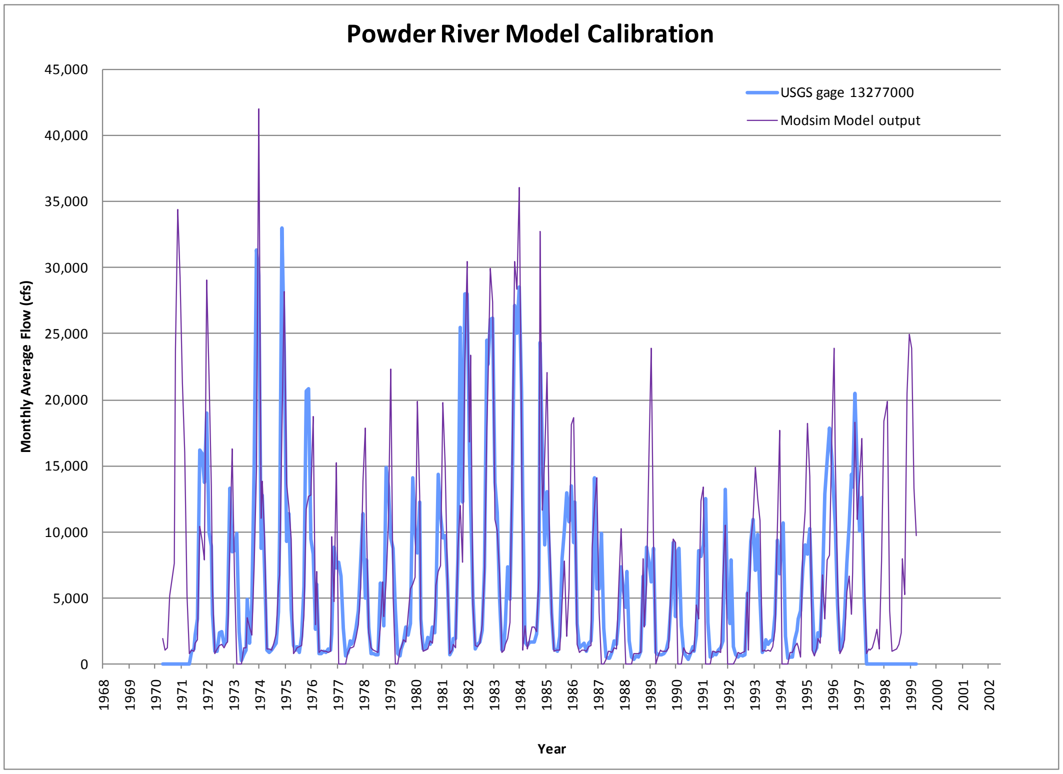

Figure 4-14. MODSIM Model calibration results for Powder River

4.3.3 Pine Creek Model Development

Network Configuration

The spatial representation of the basin is shown in Figure 4-15. The numbered delineated subbasins were used in balancing the basin hydrology and are used to correspond to model network nodes within the watershed. These nodes are representative of upstream hydrology, reach gains, reach losses, and irrigation diversions. Upstream hydrology and gains were represented as blue circles in the model whereas reach losses or irrigation demands were represented as purple squares. The model network used for the alternatives analysis for the Pine Creek Basin is shown in Figure 4-16. It should be noted that the model network illustrated in the figure includes the proposed East Pine Reservoir, identified in the screening process. Therefore, the alternatives analyses included two model networks comprised of a baseline condition and a proposed condition including the East Pine Reservoir.

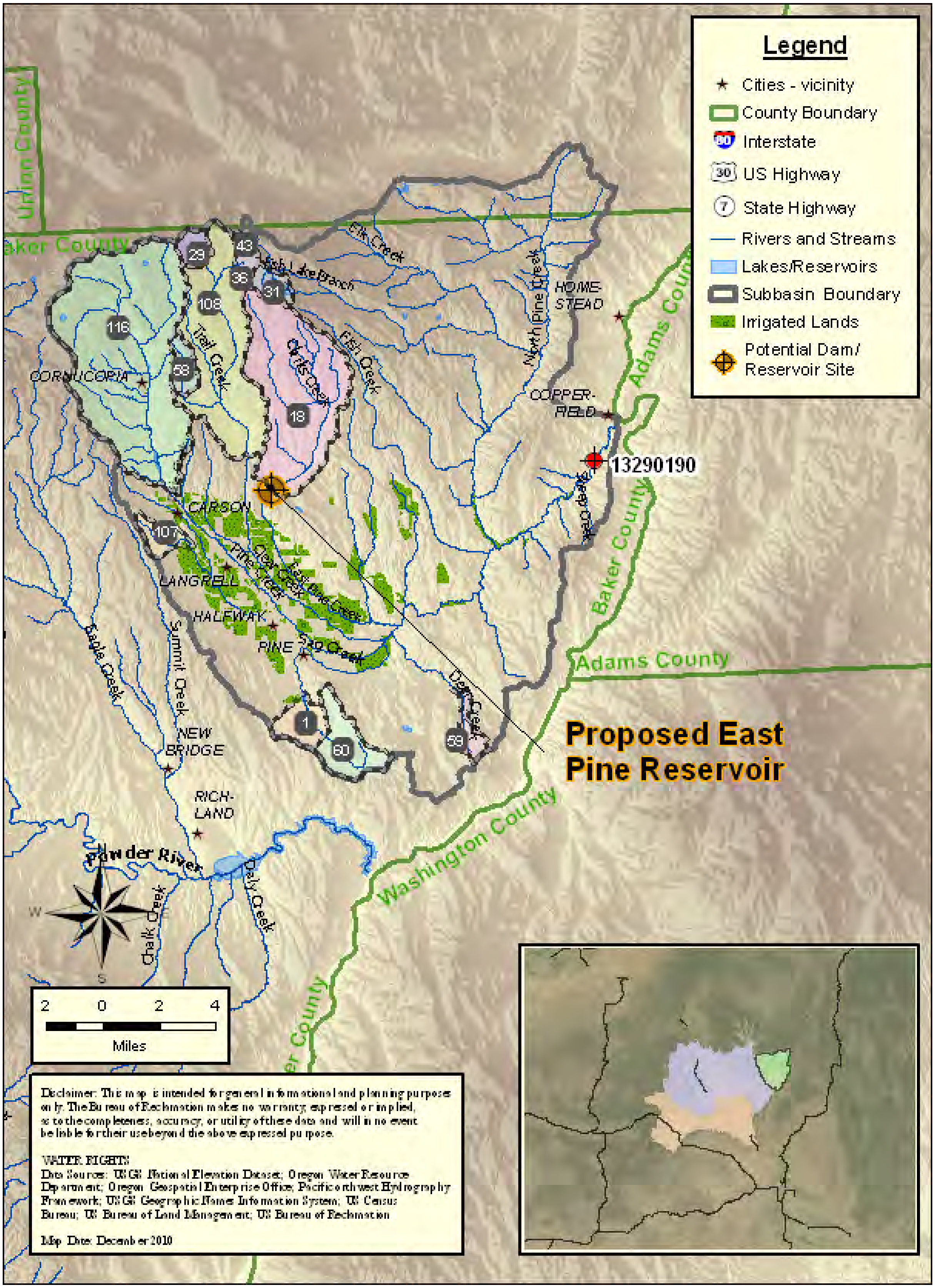

Figure 4-15. Pine Creek Basin spatial representation used in model network

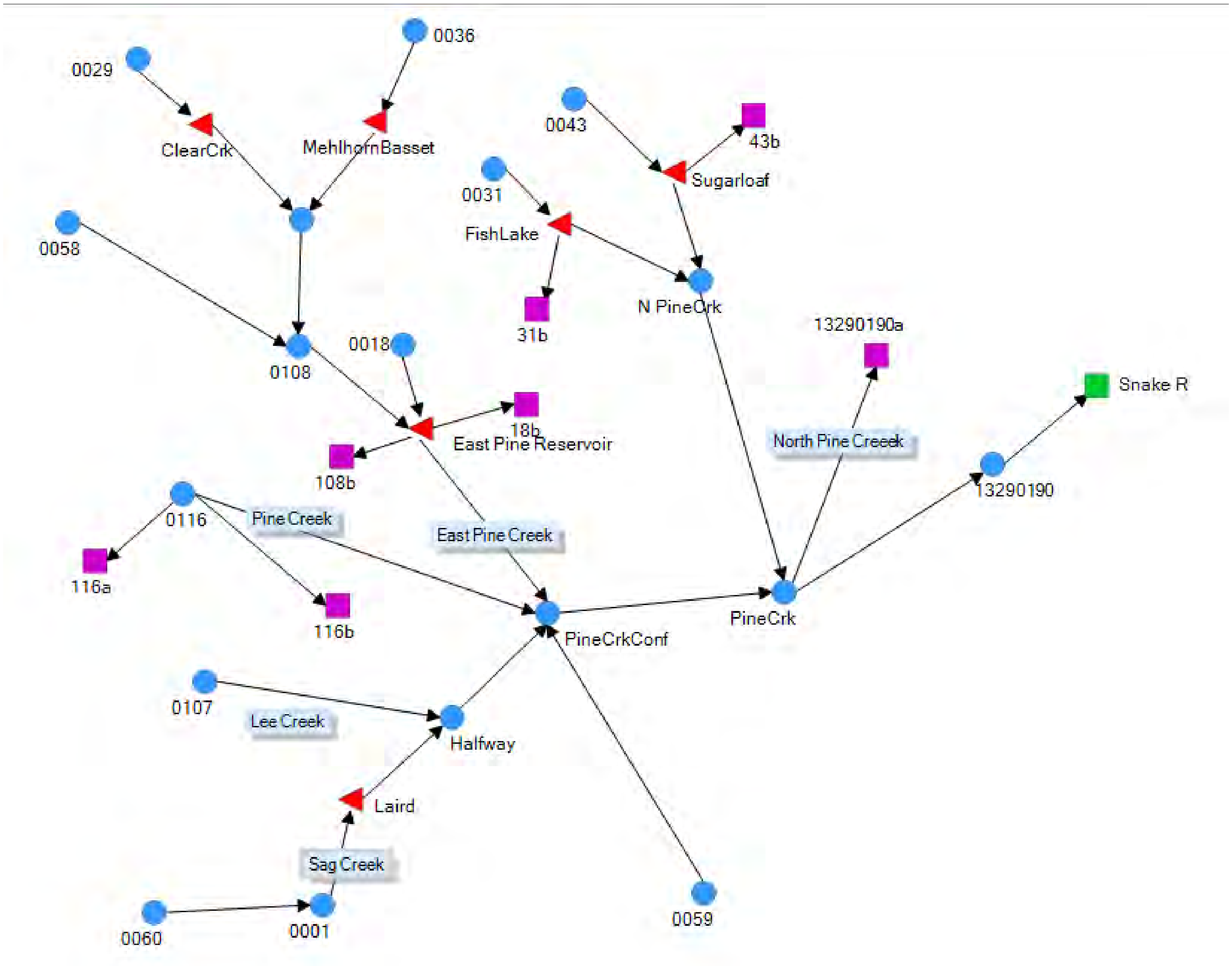

Figure 4-16. Model network of the Pine Creek Basin

Red triangle = reservoir; blue circle = node or gain; purple square = demand; green square = sink

Calibration Results

The MODSIM model was populated with the balanced hydrology data. In addition, the irrigation demand for the scenario analyses was configured to represent the current level of basin development. This ensures that the modeling results are representative of current conditions.

The irrigation demands for the Pine Creek basin were computed assuming a maximum of 18,000 acres of irrigated lands with an associated crop distribution mix. The crop distribution mix was the computed average for the period of record analyzed. In computing irrigation demands, Table 4-7 presents the crop distribution used.

Table 4-7. Crop acreage used in modeling analyses

Crop Acreage Assumption	
Grass/hay	30.7%
Alfalfa	30.5%
Winter grain	6.2%
Summer grain	4.0%
Potatoes	1.2%
Corn	0.4%
Pasture	27.0%

The following figure (Figure 4-17) illustrates the computed monthly average irrigation demand for the period of record analyzed.

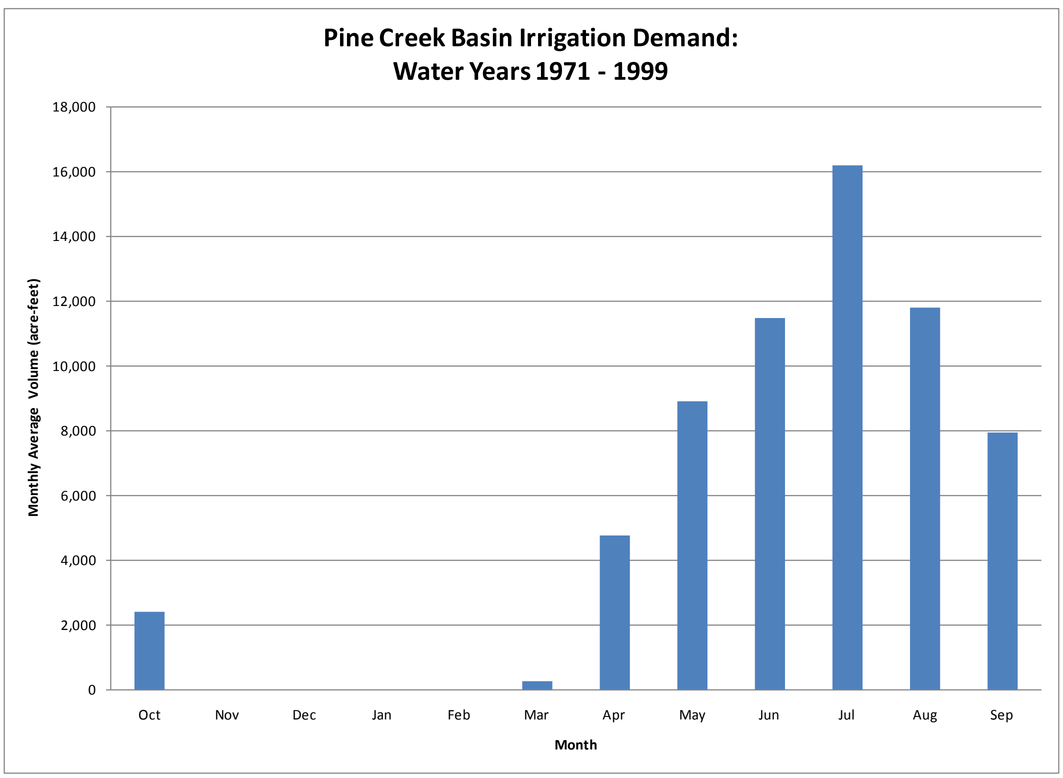

Figure 4-17. Average monthly irrigation demand for Pine Creek Basin

The return flow back to the river is a function of total irrigation diversion, crop water use, as well as conveyance and on site efficiencies. A value of infiltration percent was used for all of the irrigation demands to compute the amount of water, not consumptively used, that returned to the river via subsurface flows. It was assumed that none of this water percolated to a deep aquifer and that it returned to the river over a two month period. The following overall water use efficiency and return flow lag percentages were assumed and are presented in Table 4-8.

Table 4-8. Modeled irrigation assumptions

Infiltration Percent	42%
Return Flow Lag Percent	
Month 0	57%
Month 1	29%
Month 2	14%

Figure 4-18 illustrates the calibrated model results compared to USGS gage data. These results illustrate that the model is representative of basin operations. This result provides a foundation for comparative analyses of the screened alternatives.

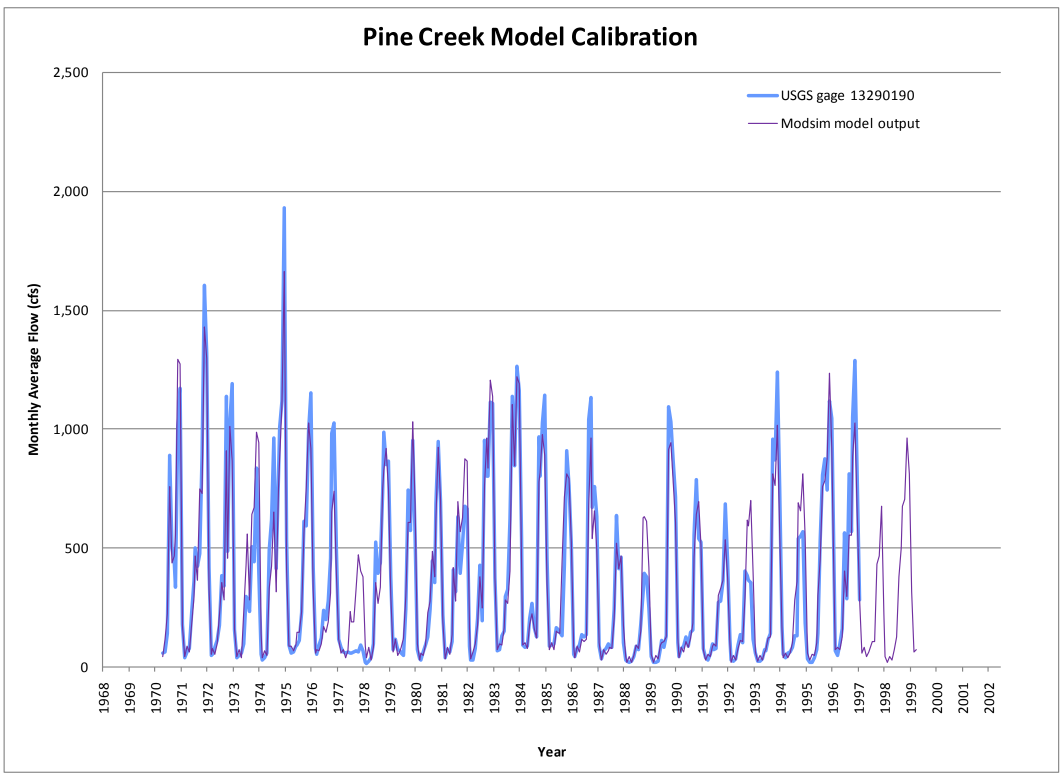

Figure 4-18. MODSIM model calibration results for Powder River

4.4 Alternatives Analysis Modeling

For the proposed reservoir locations selected by the stakeholder work group, alternatives analysis modeling was performed. MODSIM simulations of the proposed reservoirs were done to characterize the differences in irrigation water supplied between the existing condition and with the proposed reservoir in place.

After the initial Level 2 screening process, the stakeholder work group requested that two additional sites, Wolf Creek and Pilcher Creek, be evaluated for storage potential. The following proposed reservoirs or reservoir expansions were therefore evaluated:

- Burnt River basin
    - Hardman Reservoir
- Powder River basin
    - Thief Valley Reservoir Expansion
    - North Powder Reservoir
    - Wolf Creek Reservoir Expansion
    - Pilcher Creek Reservoir Expansion
- Pine Creek basin
    - East Pine Reservoir

The MODSIM models of each basin were used to simulate the potential storable water (water not currently allocated) at each of the proposed reservoirs. The screening criteria for further analysis was established as the computed volume historically available in 80 percent of the water years for the period of record modeled (1971 to 1999).

In order to determine the 80-percent fill reliability, each proposed reservoir was modeled in separate MODSIM models as an off-stream reservoir allowed to accumulate available, storable water for the period of record. The storable volume of water within each proposed reservoir is junior to the other water right holders and is accounted for in the priorities set in the MODSIM models. The accumulated volumes for each year were ranked and the 80th percentile reservoir size determined.

The 80-percent reservoir volumes for the proposed reservoirs were further analyzed and compared to the baseline conditions to quantify associated benefits.

4.4.1 Proposed Hardman Reservoir – Burnt River

Project Description

The proposed Hardman Reservoir site is located on the South Fork of the Burnt River approximately 8 miles upstream (southwest) from Unity Reservoir and 5 miles west of the community of Unity, Oregon (see Figure 4-22). The proposed dam and reservoir are located on land owned by the Burnt River Irrigation District and the U.S. Forest Service.

Storable Volume and Reliability Modeling

The proposed Hardman Reservoir is shown in the model network in Figure 4-8. For the period of record modeled, the Hardman Reservoir site has an estimated average annual flow volume of 16,500 acre-feet per year, as shown in Figure 4-19. Over the same time period, Figure 4-20 illustrates the storable volume a reservoir located at this site would accumulate.

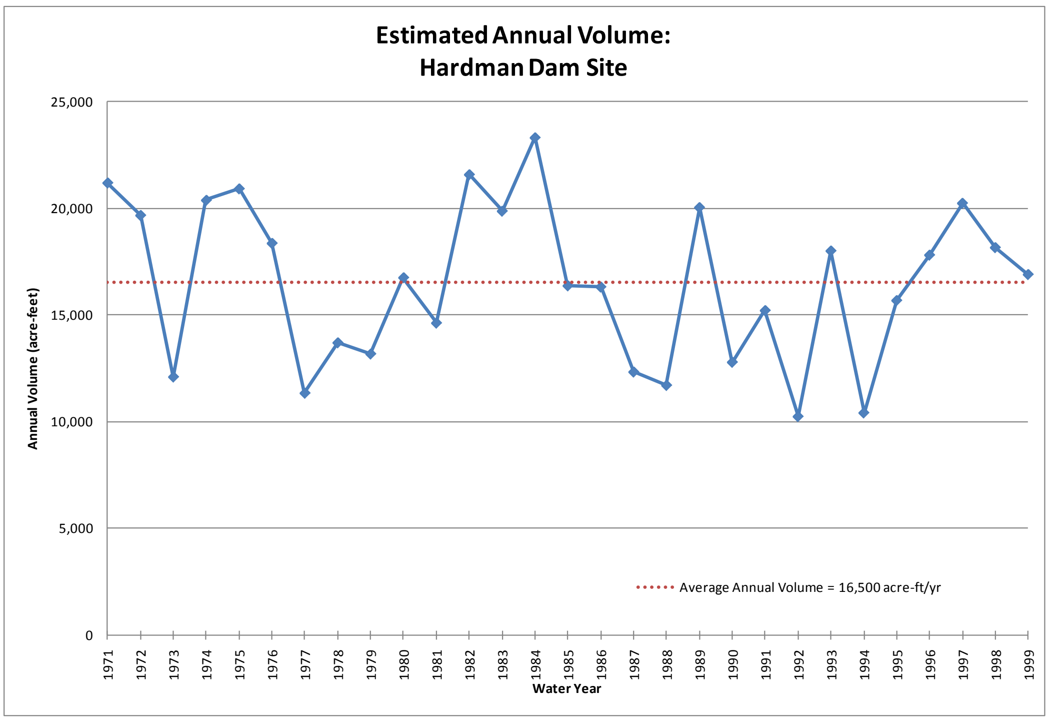

Figure 4-19. Annual water volume at proposed Hardman Reservoir site

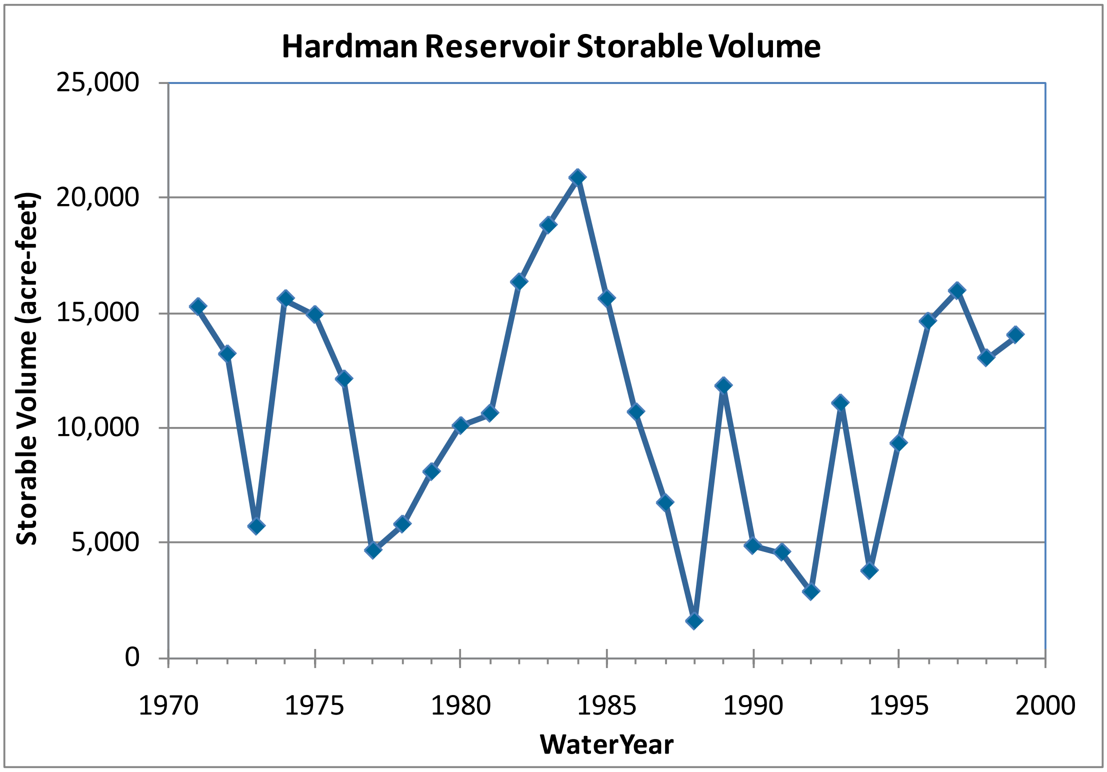

Figure 4-20. Annual storable water at proposed Hardman Reservoir site.

The storable water volumes were ranked and plotted in Figure 4-21.

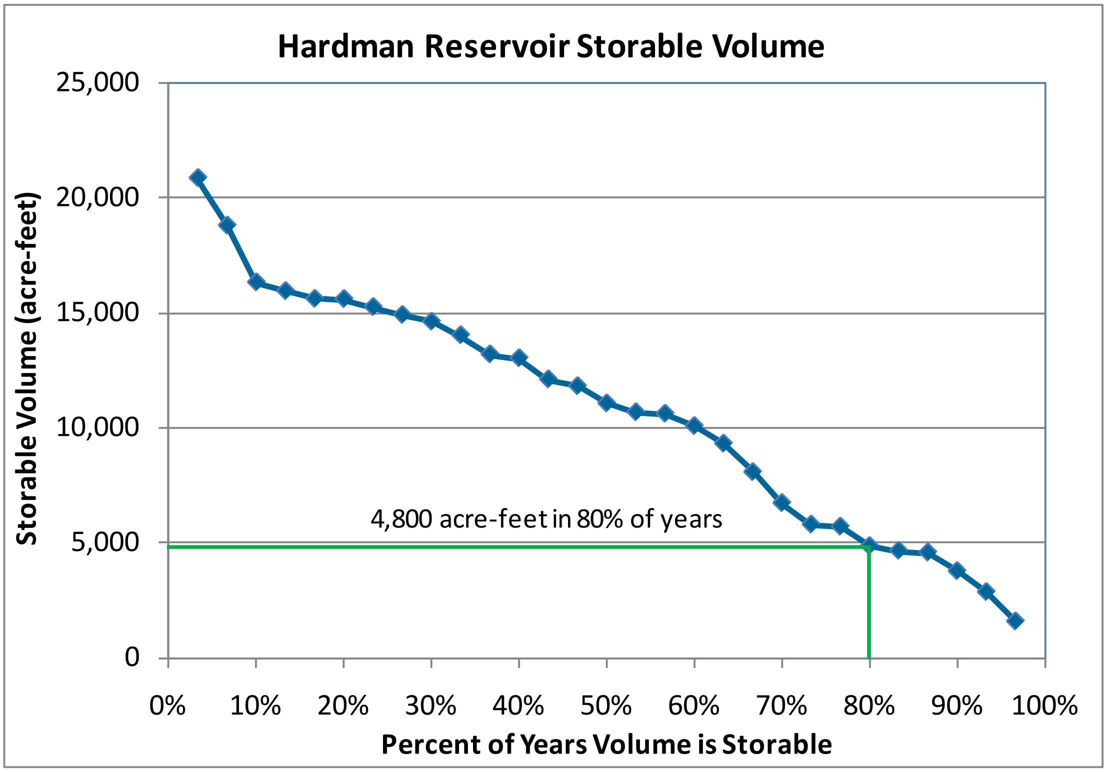

Figure 4-21. Proposed Hardman Reservoir storable water frequency

Storage Model Results

The 80 percent storable volume was selected as a reliable volume for the proposed reservoir and was used for the additional hydrologic and water supply yield assessment. The right to store water within this proposed reservoir enlargement would be based on a 1992 priority water reservation filed by the ODWR. The storage right was assumed to be junior to all of the other current water right holders.

As a result of this analysis, the 80 percent reliable volume for the Hardman Reservoir is 4,800 acre-feet. The estimated inundation area is shown in Figure 4-22. It was determined by utilizing the natural topography contours and an assumed dam height to accommodate the proposed volume results. At this time, the inundation limits illustrated also do not assume any significant inactive storage volume reserved for recreational or fisheries benefits.

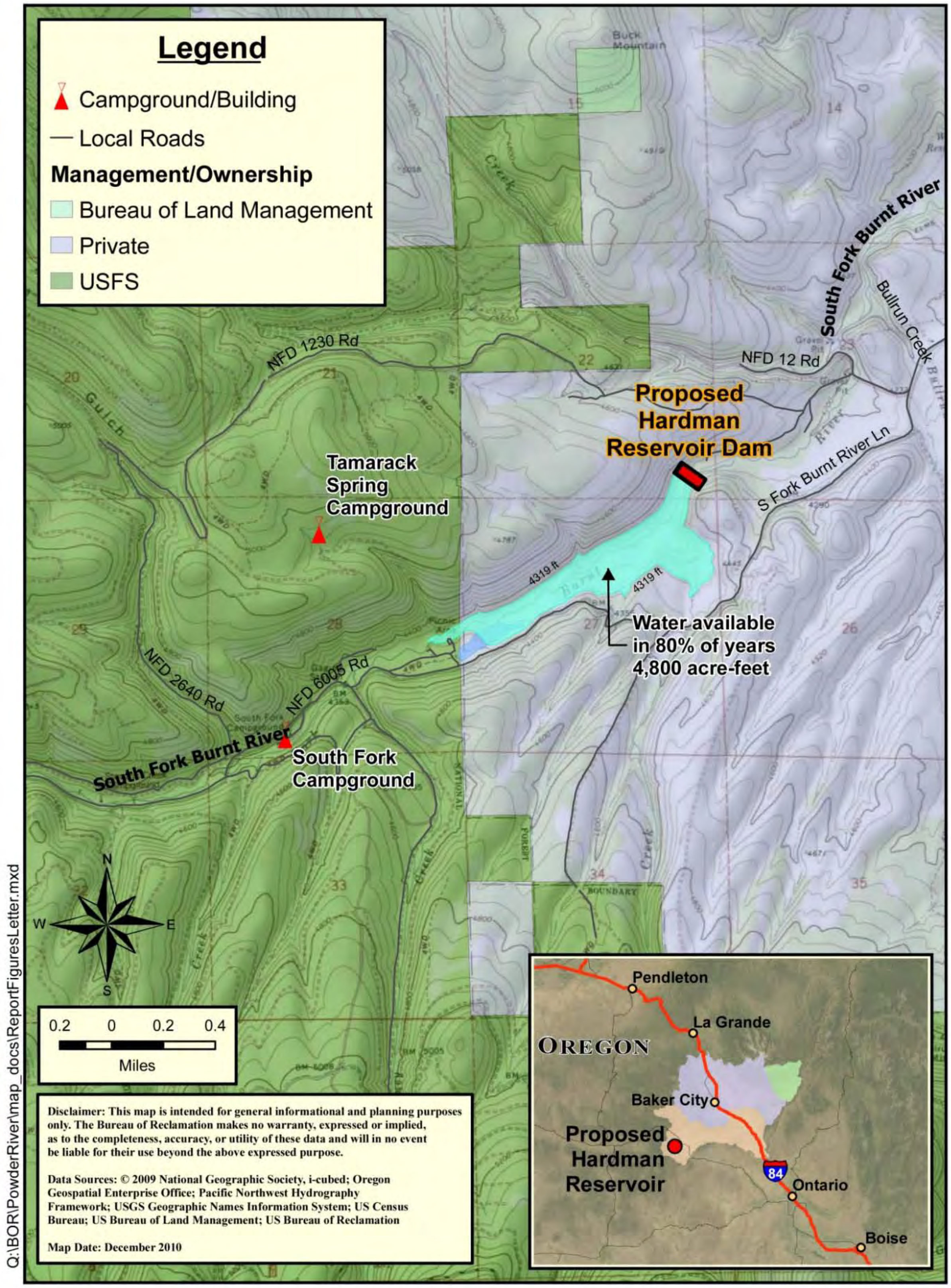

Figure 4-22. Proposed Hardman Reservoir location map

Alternatives Analysis Model Configuration

A model configuration was developed to incorporate the proposed reservoir. Table 4-9 presents the applicable model assumptions and constraints defined for the alternatives analyses. Other model assumptions defined in the calibrated baseline model and not shown here, remain unchanged.

Table 4-9. Proposed Hardman Reservoir analysis model constraints

Constraint	Baseline Configuration	Hardman Reservoir
Reservoir Capacity (acre-feet)	Not applicable	4,800
Reservoir Depth (feet)	Not applicable	92
Minimum Flow Target below dam (cfs)	Not applicable	5
Annual Irrigation Demands	No change	No change

The water stored in the proposed reservoir was assigned a low priority setting to keep it from adversely impacting existing water right holders with senior rights. Irrigation demand was allowed to draw water from the proposed reservoir, as needed, to reduce shortages. This analysis was simulated for the 29-year study period of record (1971-1999).

Alternatives Analysis Model Results

Figure 4-23 shows the maximum water volume stored for each water year modeled. This figure illustrates the years when the proposed reservoir filled or failed to fill. Figure 4-24 and Figure 4-25 show the volume of water supplied from storage with the proposed reservoir expansion. The estimated water supplied from the proposed Hardman Reservoir was calculated from the results of the MODSIM models as the difference in shortage under existing conditions (without the proposed reservoir) and with the proposed reservoir.

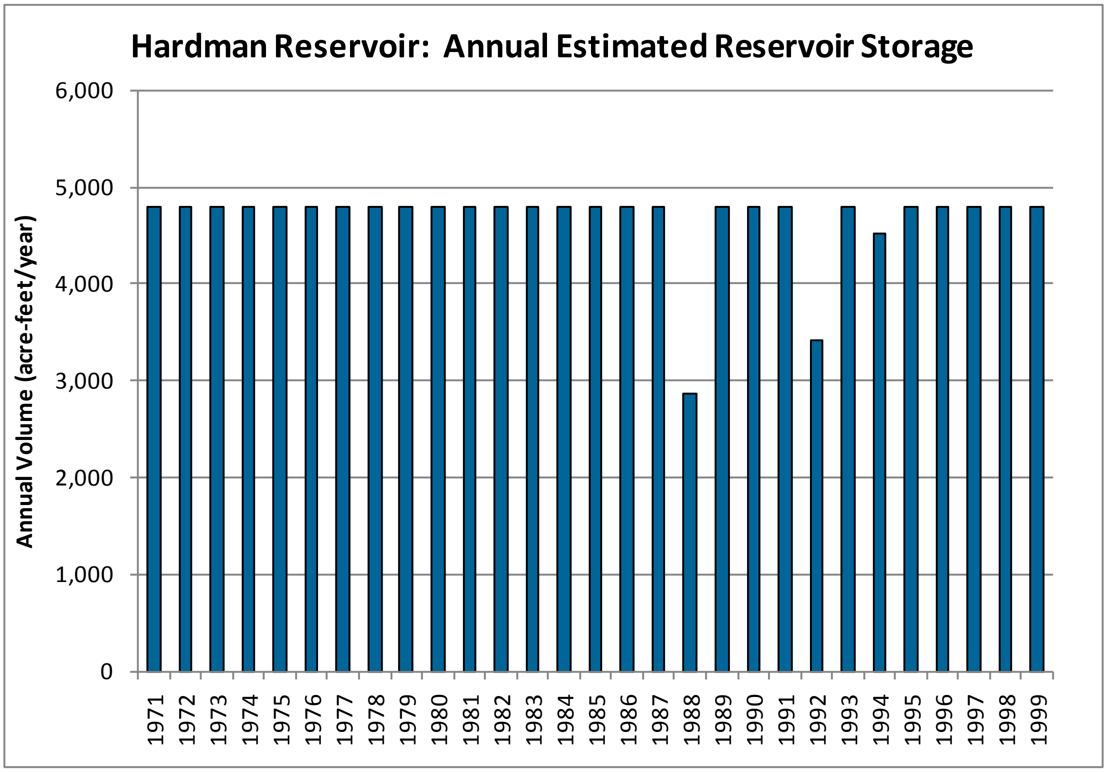

Figure 4-23. Estimated maximum volume of water stored in proposed Hardman Reservoir for each water year.

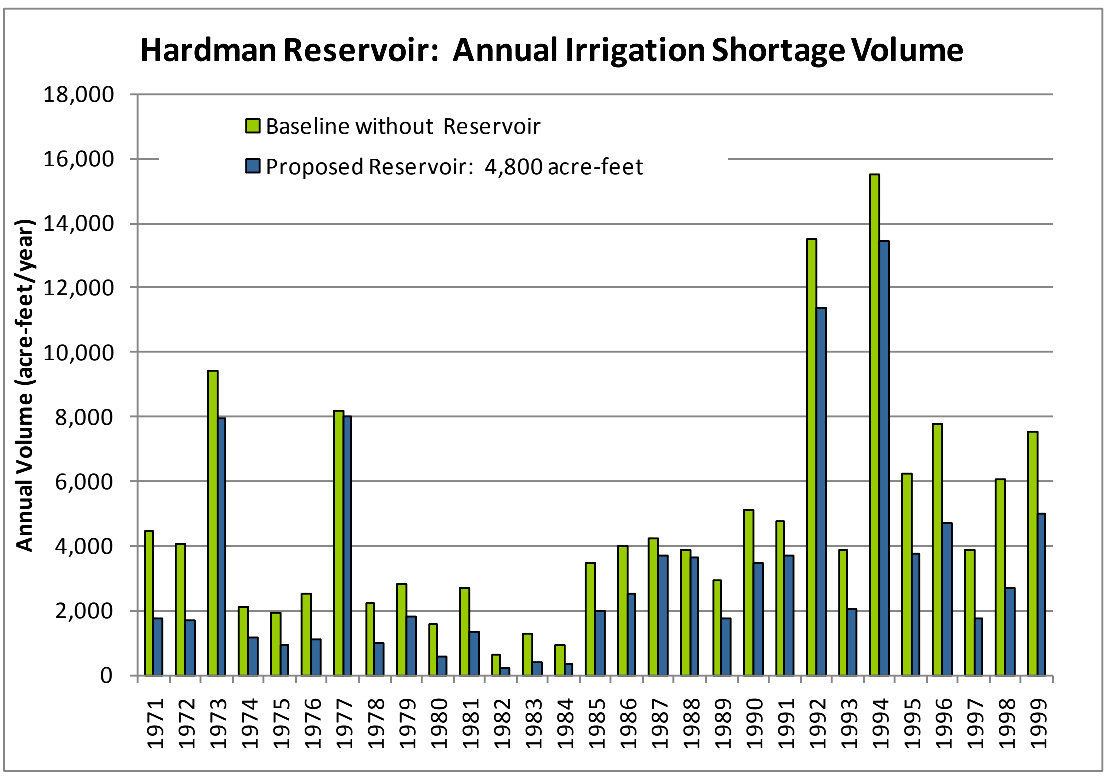

Figure 4-24. Estimated irrigation shortage with and without the proposed Hardman Reservoir

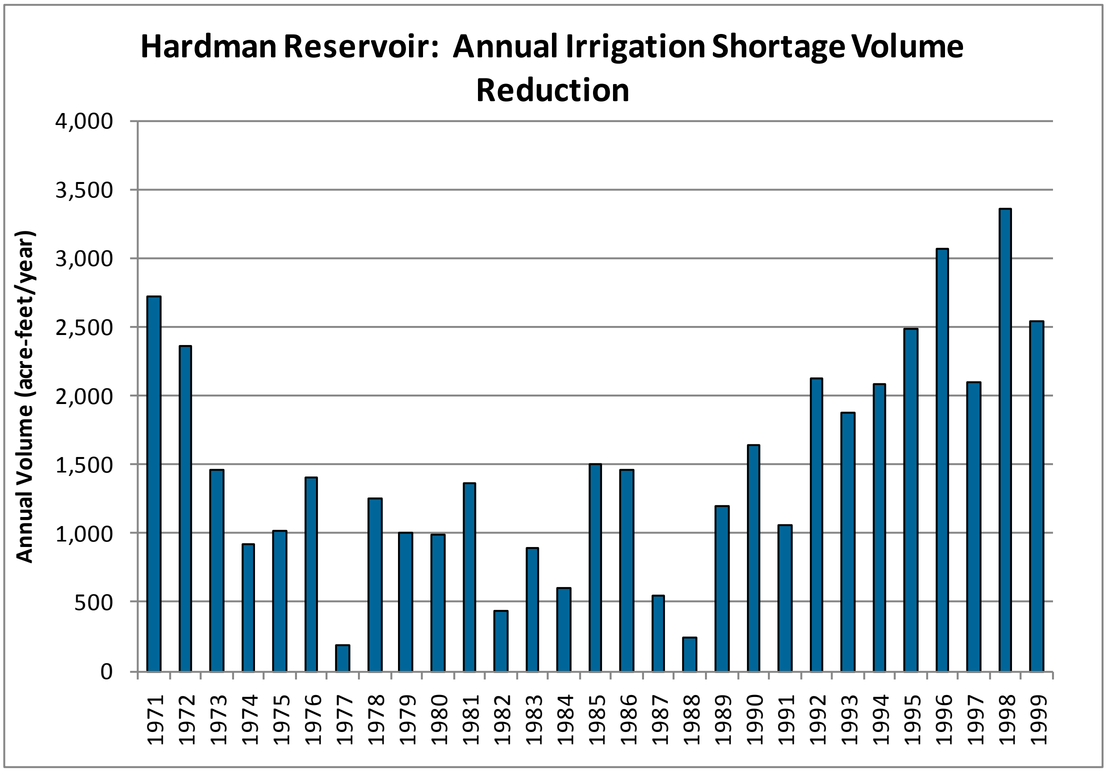

Figure 4-25. Estimated reduction in annual irrigation shortage within the Burnt River Basin with the proposed Hardman reservoir

The proposed reservoir results in a change to the hydrograph of the flow downstream of the project (Figure 4-26). Figure 4-27 illustrates the current hydrology pattern and the modeled demand pattern in proximity of this site. This figure illustrates the timing differences in flow between the run-off pattern and irrigation demand pattern. Downstream flows are lower in October through March for the proposed reservoir condition compared to existing conditions (without the proposed reservoir). The lower flows during this period represent water being stored in the reservoir (Figure 4-28). Conversely, downstream flows are higher in April through September for the proposed reservoir compared with existing conditions. An instream flow right filed by the State was set as a minimum flow target. At this location, the assumed target was 5 cfs. Water stored is released during the irrigation season in response to irrigation demand and the assumed 5 cfs minimum flow target. The assumed 5 cfs minimum release requirement below the reservoir was a target flow condition, set in the MODSIM model, and was satisfied 100 percent of the time.

The change in the hydrograph not only occurs below the proposed reservoir, but also changes the flow (to a lesser extent) from the Burnt River to the Snake River. Figure 4-29 shows the average monthly flow in the Burnt River near the confluence with the Snake River.

Overall, the proposed reservoir changes the hydrograph and reduces the shortage for irrigation water demand below the reservoir compared to existing conditions (Table 4-10). The 4,800 acre-feet of additional storage in the system reduces the irrigation shortage by approximately 1,500 acre-feet with a net reduction in water volume that reached the Snake River of 1,000 acre-feet between the proposed reservoir model configuration and existing baseline condition. This net reduction is the result of the irrigation diversions reusing irrigation return water passing through the system. The majority of the shortage reduction of 1,500 acre-feet is realized by those diversions within the vicinity of the project.

While the proposed Hardman Reservoir could provide recreational and environmental benefits, the results of the MODSIM model simulations did not assume any significant inactive storage volume that would be reserved in storage for recreational or fisheries benefits. The reservoir could be sized to hold water in inactive storage. However, the result would be either reduced annual water supply benefits or a larger reservoir in order to produce the same benefits.

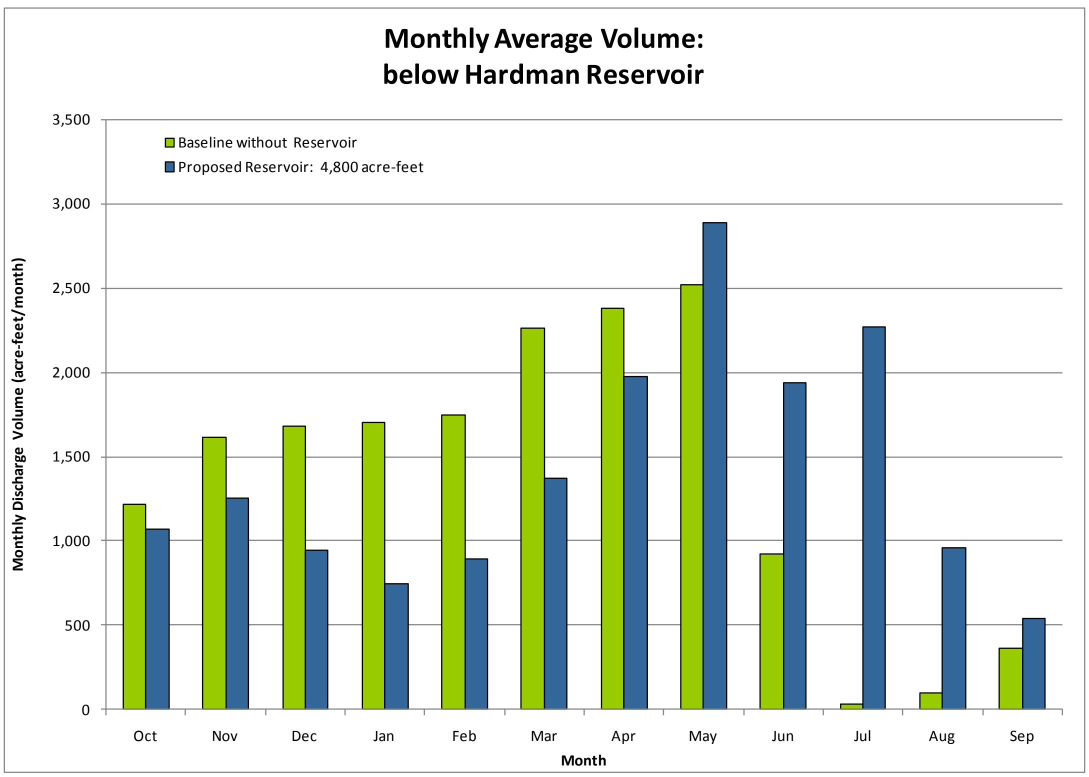

Figure 4-26. Estimated monthly average flow below the proposed Hardman Reservoir

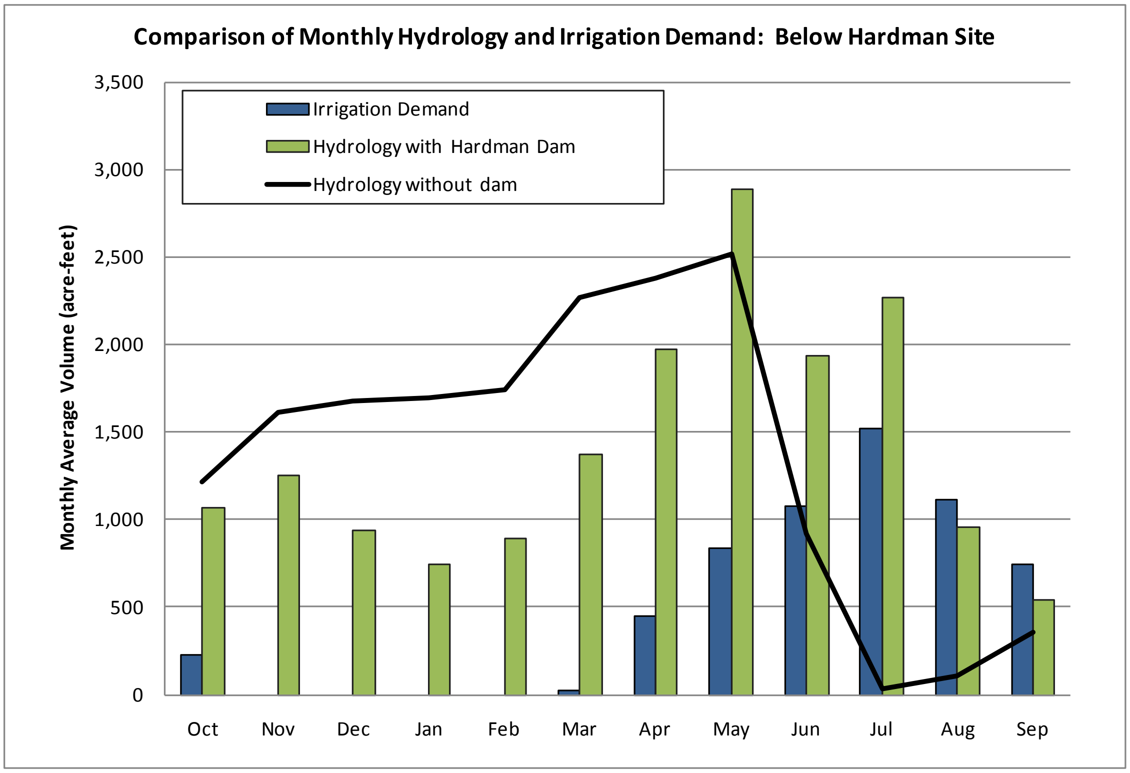

Figure 4-27. Estimated monthly average flow below the project and irrigation demand located below the proposed Hardman Reservoir

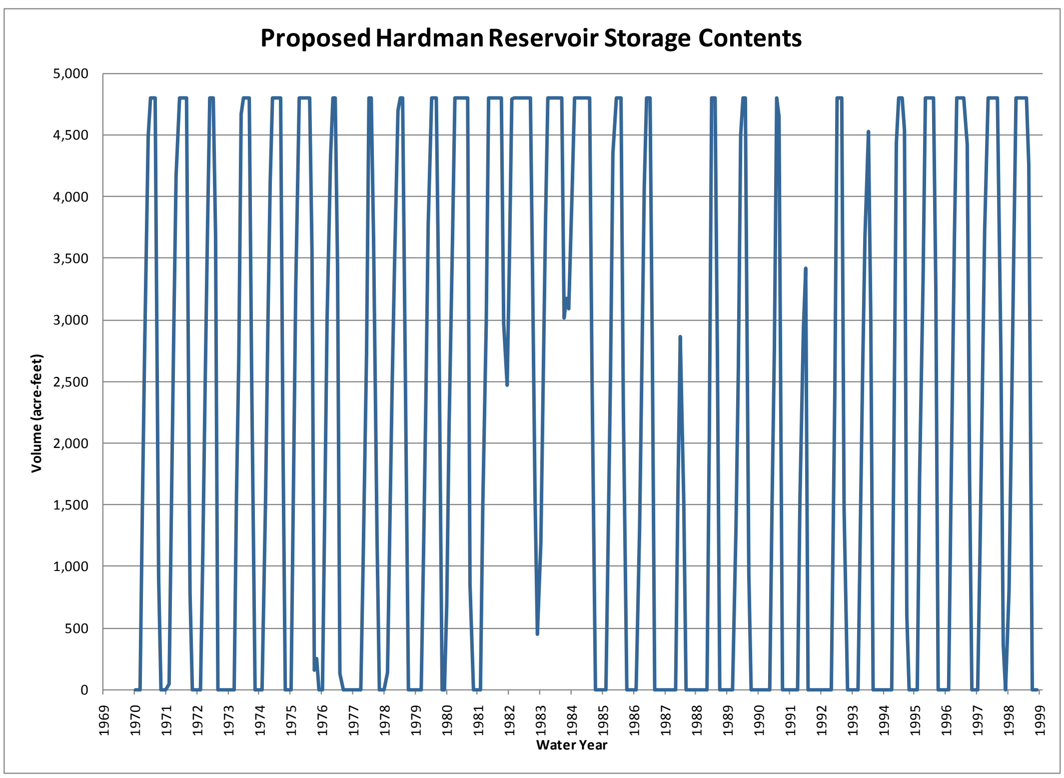

Figure 4-28. Modeled storage contents of proposed Hardman Reservoir

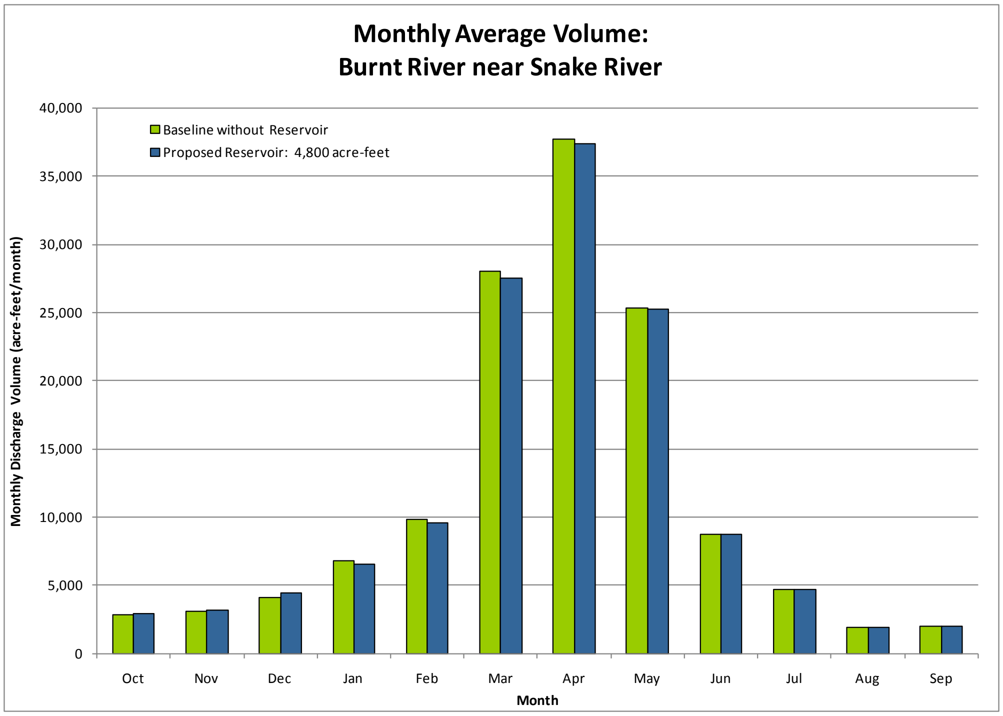

Figure 4-29. Estimated monthly average flow in Burnt River near Snake River confluence with the proposed Hardman Reservoir

Table 4-10. Proposed Hardman Facility Storage Summary Table

Irrigation Shortages Modeled Water Years: 1971 - 1999						
Average Annual Irrigation Shortage Baseline Condition (acre-feet/year)			4,741			
Average Annual Irrigation Shortage with Hardman Reservoir (acre-feet/year)			3,225			
Average Annual Irrigation Shortage Reduction (acre-feet/year)			1,516			
	Monthly Average Flow at Reservoir Site Model Water Years: 1971 – 1999			Monthly Average Flow on Burnt River near Snake River Model Water Years: 1971 – 1999		
Month	Below Hardman Reservoir (acre-feet/month)	Baseline Condition (acre-feet/month)	Difference	With Hardman Reservoir (acre-feet/month)	Baseline Condition (acre-feet/month)	Difference
October	1,071	1,219	(148)	2,932	2,843	89
November	1,256	1,616	(360)	3,189	3,134	55
December	942	1,677	(735)	4,491	4,149	342
January	748	1,699	(951)	6,521	6,843	(321)
February	891	1,743	(852)	9,616	9,817	(202)
March	1,370	2,264	(894)	27,512	28,016	(504)
April	1,971	2,382	(412)	37,347	37,739	(391)
May	2,887	2,515	372	25,289	25,359	(70)
June	1,938	923	1,015	8,771	8,763	8
July	2,268	31	2,237	4,689	4,689	-
August	956	103	854	1,916	1,916	-
September	542	360	182	1,978	1,978	-
Average Annual Change (acre-feet/year)			308			(994)

4.4.2 Proposed Thief Valley Reservoir Enlargement – Powder River

Project Description

The existing Thief Valley Dam is located on the Powder River approximately 7 miles east of the community of North Powder, Oregon. The project is owned by Reclamation and operated by the Lower Powder River Irrigation District. The proposed reservoir enlargement would be located on land owned by Reclamation and privately-owned land.

Storable Volume and Reliability Modeling

The Thief Valley Reservoir is shown in the model network in Figure 4-12. For the period of record modeled, the Thief Valley Reservoir site has an estimated average annual flow volume of 165,000 acre-feet, as shown in Figure 4-30. Over the same time period, Figure 4-31 illustrates the storable volume an expanded reservoir at this site would accumulate.

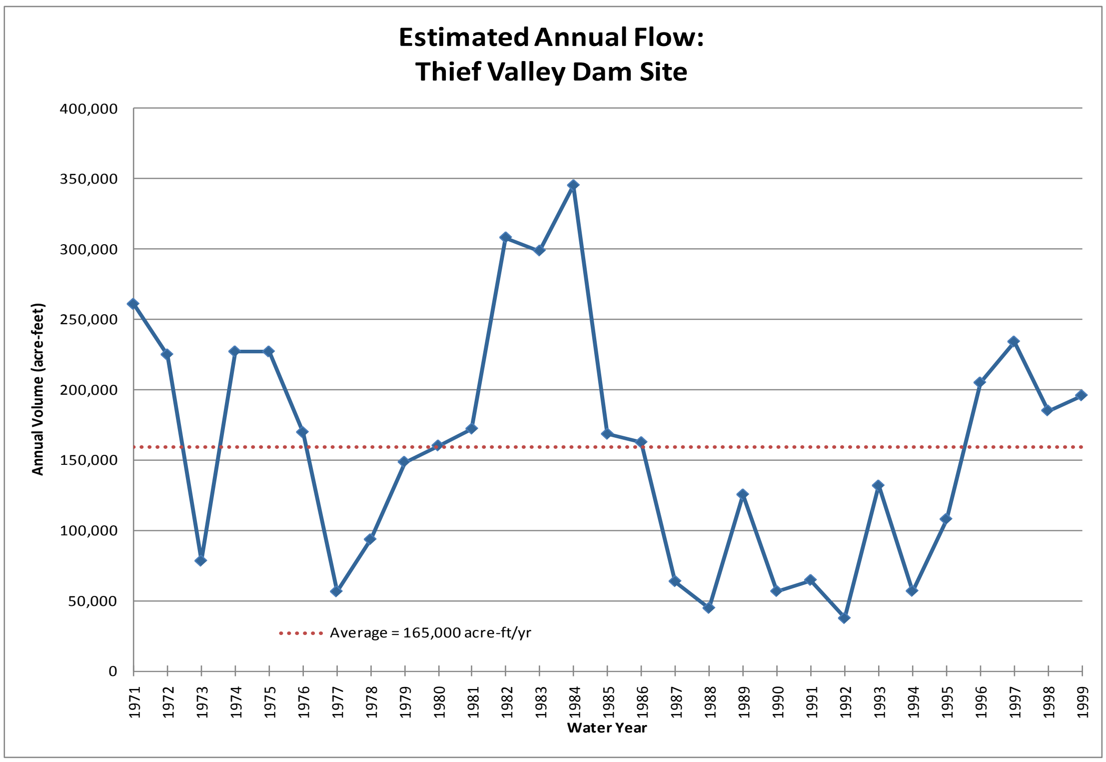

Figure 4-30. Annual water volume at Thief Valley Reservoir site

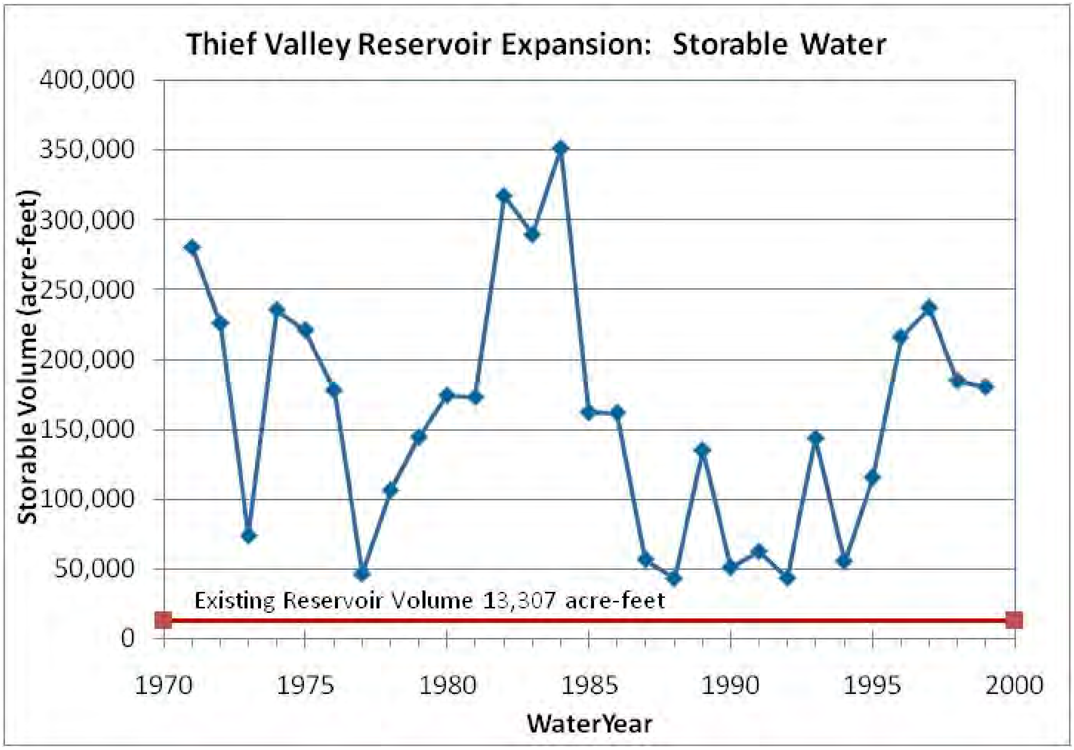

Figure 4-31. Annual storable water at Thief Valley Reservoir expansion site

The storable water volumes were ranked and plotted in Figure 4-32.

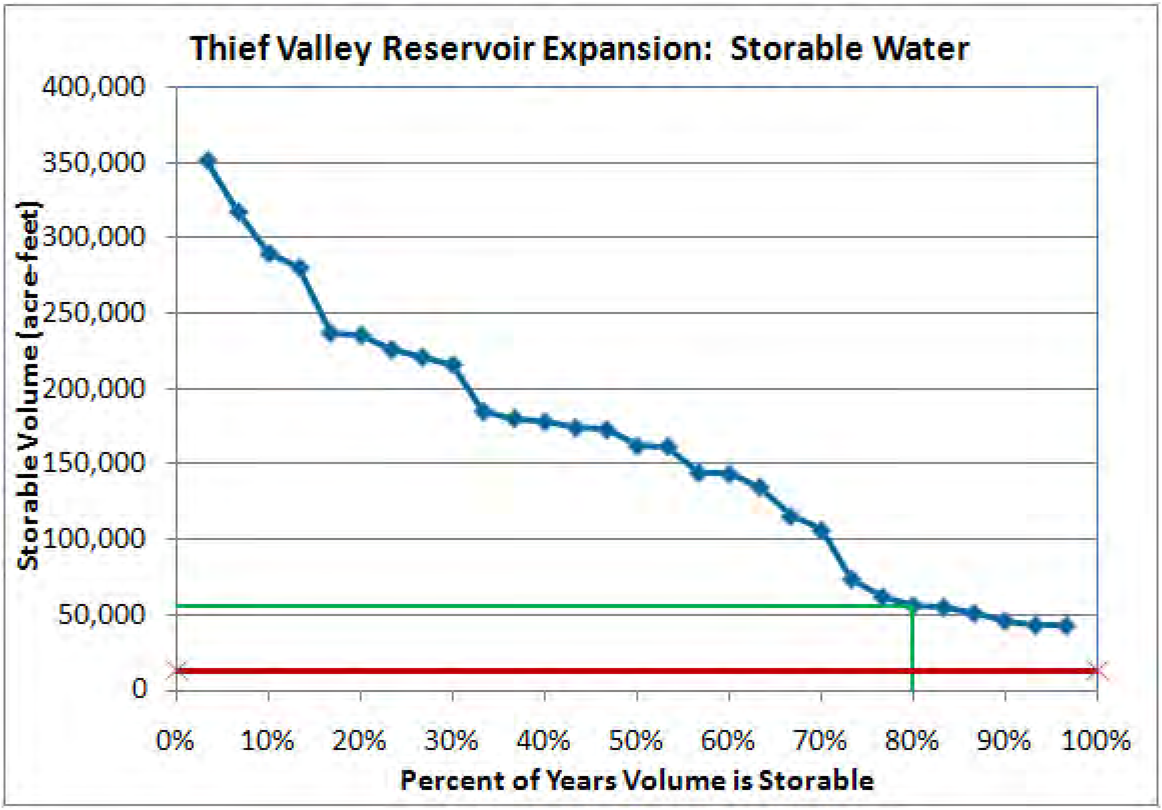

Figure 4-32. Thief Valley Reservoir expansion storable water frequency

Storage Model Results

The 80 percent storable volume was selected as a reliable volume for the proposed reservoir enlargement and was used for the additional hydrologic and water supply yield assessment. The right to store water within this proposed reservoir enlargement would be based on a 1992 priority water reservation filed by the ODWR. The storage right was assumed to be junior to all of the other current water right holders.

As a result of this analysis, the 80 percent reliable volume for Thief Valley Reservoir is 56,307 acre-feet. The existing reservoir storage volume is 13,307 acre-feet; therefore, Thief Valley Reservoir was modeled in the alternatives analysis with an additional volume of 43,000 acre-feet.

The estimated inundation area is shown in Figure 4-33 and was determined by utilizing the natural topography contours and an assumed dam height to accommodate the proposed volume results. At this time, the inundation limits illustrated also do not assume any significant inactive storage volume reserved for recreational or fisheries benefits.

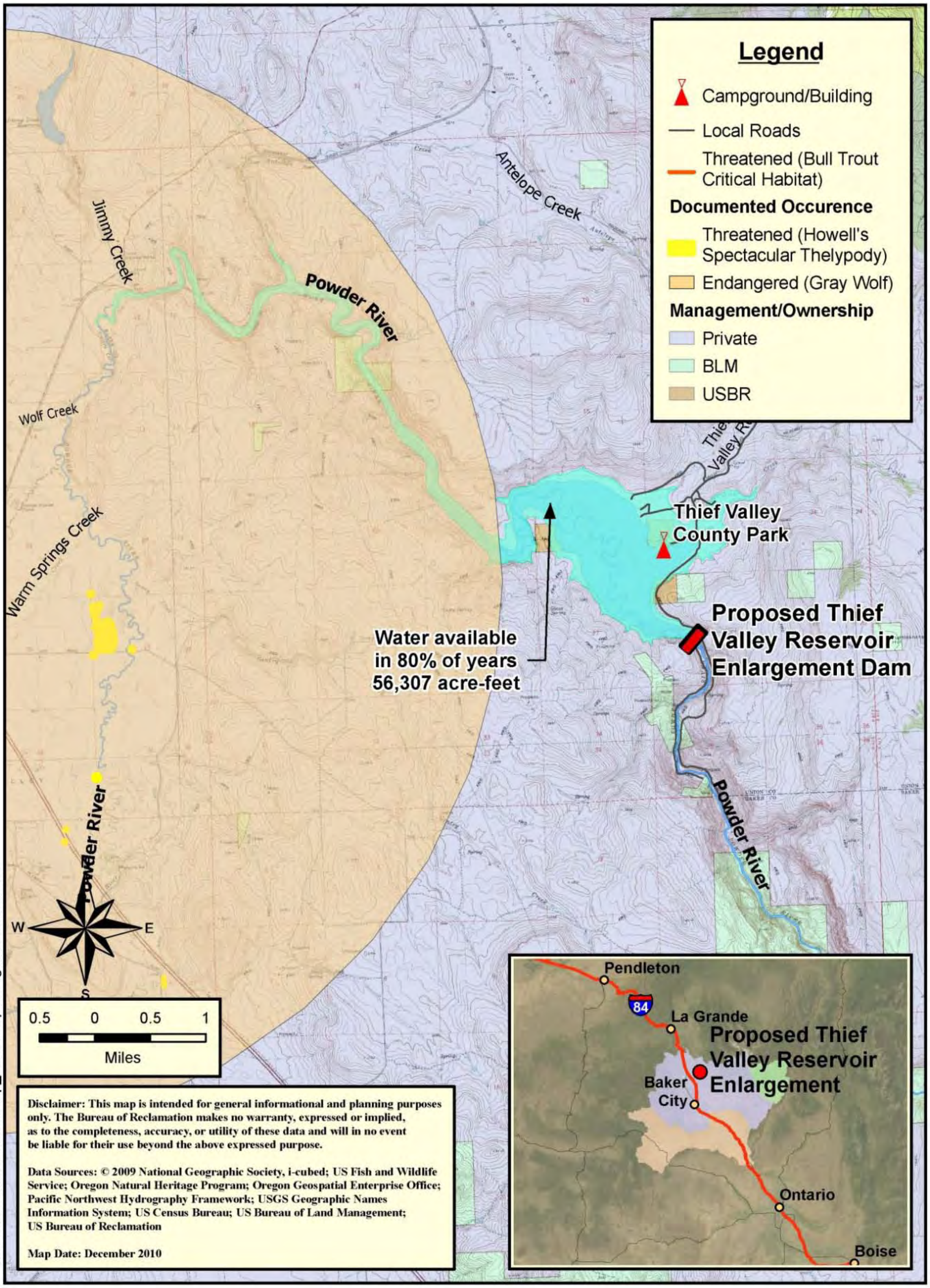

Figure 4-33. Proposed Thief Valley Reservoir Enlargement Location Map

The storable volumes are far greater than the water needs in the area downstream of the proposed reservoir enlargement. Since a majority of the existing water demand shortage is located upstream of Thief Valley Reservoir, additional conveyance facilities will be required to distribute the water acquired with the additional reservoir storage. Two different conveyance facility locations were proposed in this analysis. Alternative 1 placed the pumping plant upstream of the dam. The second configuration, Alternative 2, placed the facility downstream of the dam. Each alternative would consist of a pumping facility and conveyance piping. The pumping facilities and distribution routes are presented conceptually in Figure 4-34. Both routings have multiple landowners that include the Bureau of Land Management and private owners.

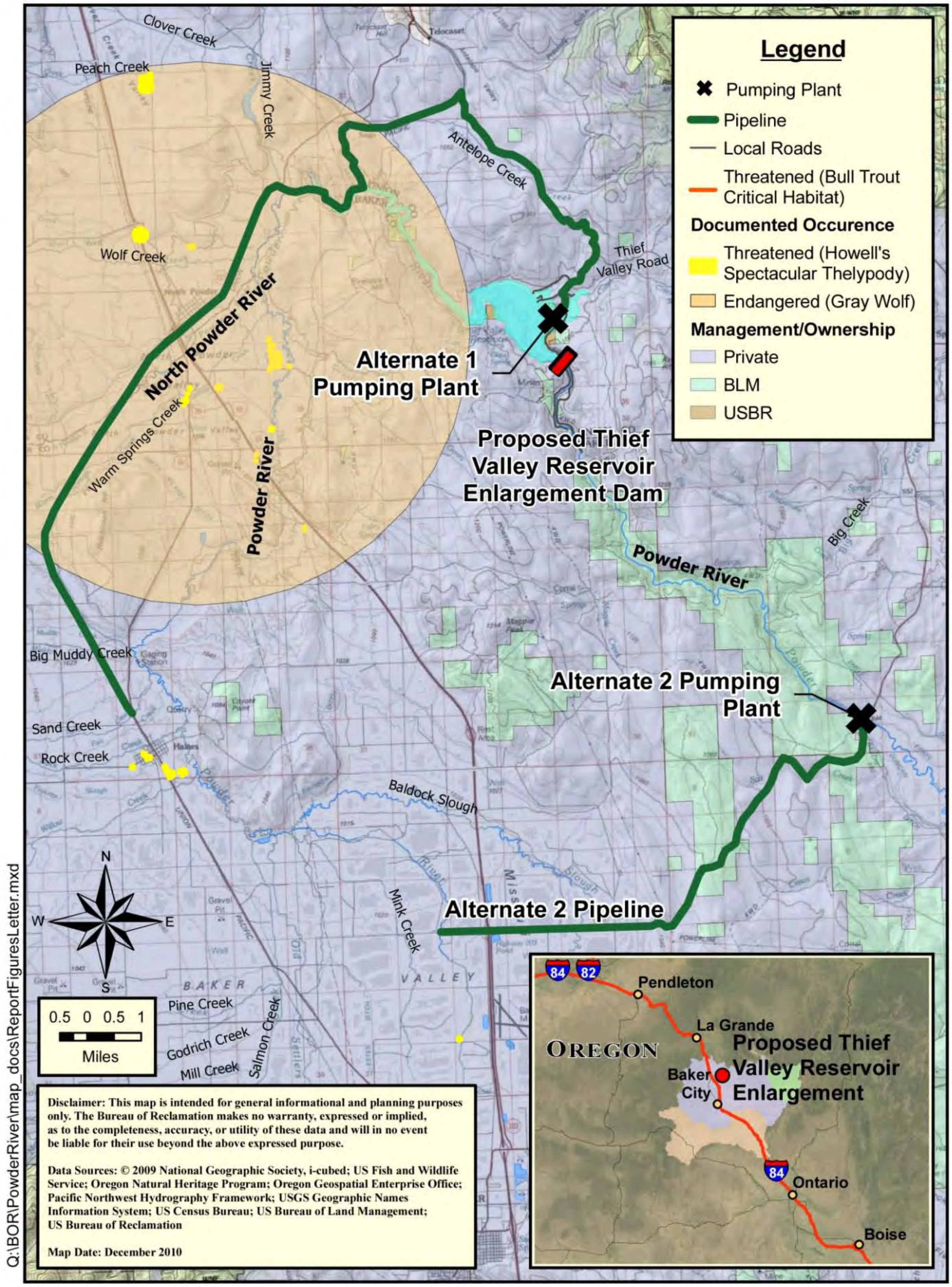

Figure 4-34. Proposed Thief Valley Reservoir Enlargement Pumps and Pipelines Location Map

Alternatives Analysis Model Configuration

Two model configurations were developed for the Thief Valley Reservoir Expansion. Alternative 1 was defined as incorporating the pumping plant upstream of Thief Valley Dam. Alternative 2 located the pumping plant downstream of the dam. Alternate dam locations were not considered because of the obvious cost savings associated with using the existing facility. Table 4-11 presents the applicable model assumptions and constraints defined for the alternatives analyses. Other model assumptions defined in the calibrated baseline model and not shown here, remain unchanged. Other alternative configurations were considered, but the two selected for modeling were considered to be generally representative of a range of outcomes.

Table 4-11. Thief Valley alternatives analysis model constraints

Constraint	Baseline Configuration	Pumping Plant: Alternative 1	Pumping Plant: Alternative 2
Reservoir Capacity (acre-feet)	13,307	56,307	56,307
Reservoir Depth (feet)	53	110	110
Minimum Flow Target below dam (cfs)	50	50	50
Pumping Plant Location	Not applicable	Upstream of dam	Downstream of dam
Annual Irrigation Demands	No change	30,500 acre-feet existing irrigation demand located upstream of reservoir and served by proposed pumping plant	30,500 acre-feet existing irrigation demand located upstream of reservoir and served by proposed pumping plant

The irrigation demand included a low priority setting on the pumping diversion to keep it from adversely impacting existing water right holders with senior rights. It was assumed that the pumping plant and conveyance structures would satisfy existing irrigation diversions located upstream of Thief Valley that are typically shorted during drier water years. This was because the location of the reservoir is downstream of the majority of irrigation demands. Irrigation demand located downstream of the dam was allowed to draw water stored in the existing reservoir and from the proposed reservoir enlargement, as needed, to reduce shortages. The alternatives were simulated for the 29-year study period of record (1971-1999).

Alternatives Analysis Model Results

Figure 4-35 shows the maximum water volume stored for each water year modeled. This figure illustrates the years when the proposed reservoir enlargement filled or failed to fill. Figure 4-36 shows the volume of water supplied from storage with the proposed reservoir expansion. On average, the proposed reservoir enlargement with pumping facilities supplies 30,500 acre-feet of water to those upstream irrigation diversions that are shorted than when compared to the existing conditions.

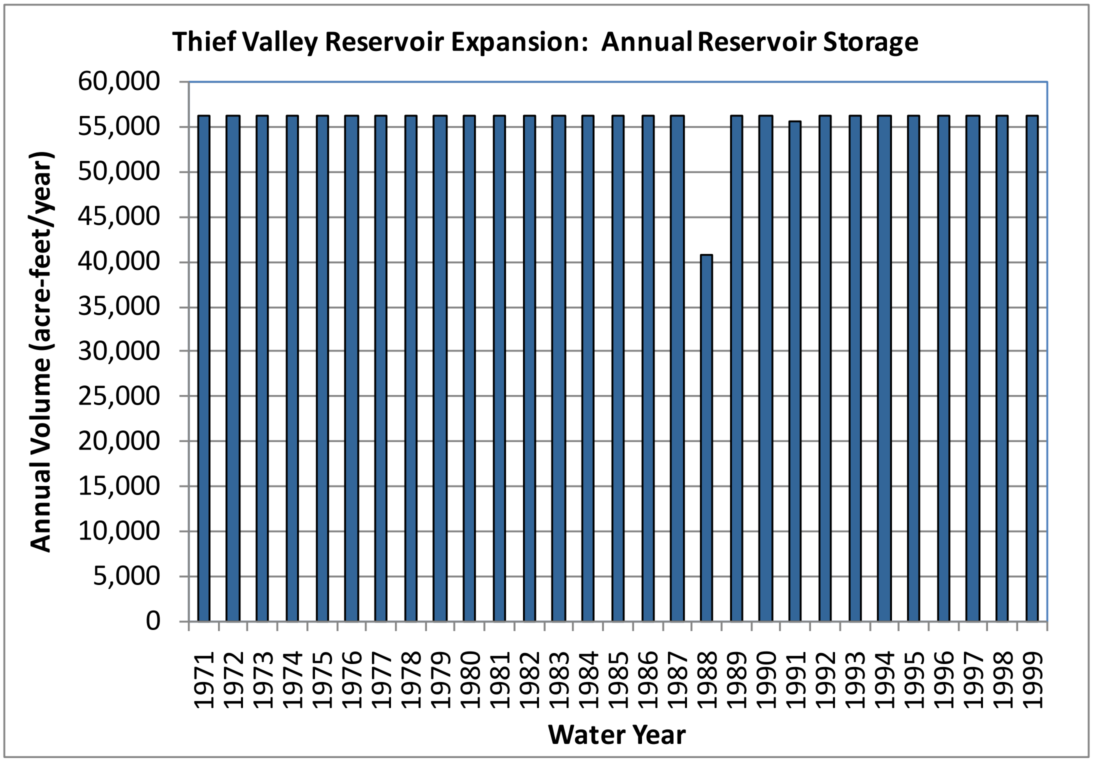

Figure 4-35. Estimated maximum volume of water stored by the proposed Thief Valley reservoir enlargement for Alternatives 1 and 2

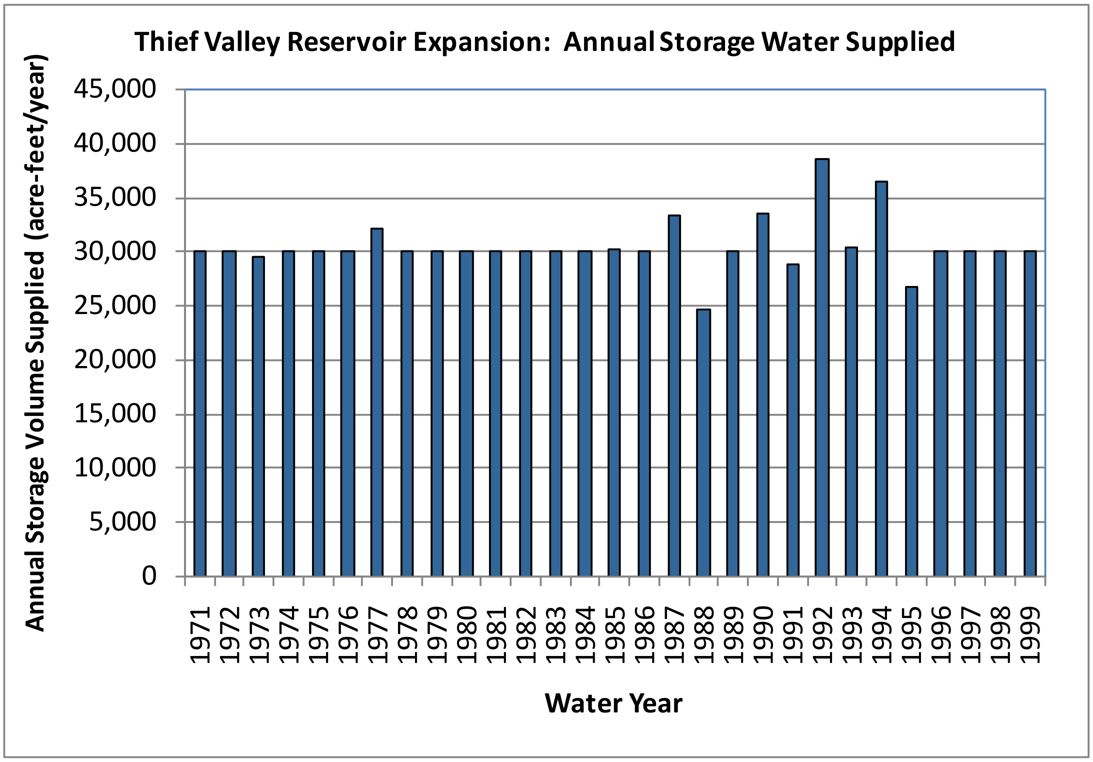

Figure 4-36. Estimated volume of water supplied by the proposed Thief Valley reservoir enlargement for Alternatives 1 and 2

Each of the two alternatives modeled result in a change to the hydrograph downstream of the dam.

Alternative 1 Results

Alternative 1 was configured with a pumping facility located upstream of the dam to satisfy an annual irrigation demand of 30,000 acre-feet that currently exists upstream of the dam. Figure 4-37 presents the average monthly flow comparison between Alternative 1 and the baseline configuration. The downstream flows were less with the reservoir enlargement when compared to the existing condition. These flow reductions were due to the additional water being stored in the enlarged reservoir during the late winter and spring months and the pumping facility located above the dam.

Water stored is also released during the irrigation season in response to downstream irrigation demand and the assumed 50 cfs minimum flow target. The assumed 50 cfs minimum release requirement below the reservoir was a target flow condition all year, set in the MODSIM model, and was satisfied 100 percent of the time immediately downstream of the project.

Under this alternative, irrigation demands are being satisfied without having the flows pass through the Thief Valley project. Figure 4-38 illustrates the comparison of baseline and Alternative 1 flows below Thief Valley in relationship to the irrigation demands. The net result is a minimal reduction in flows later in the season (August and September, for example) where the additional reservoir capacity is capable of satisfying both upstream and downstream irrigation demands. This annual net reduction in flow below the dam averages approximately 19,600 acre-feet for the period of record modeled. Modeled reservoir storage contents are presented in Figure 4-39.

Figure 4-40 illustrates the change in flow to the Snake River. As a result of the pumping facilities producing an increase in satisfaction of the existing irrigation demand, additional water is consumptively used within the basin. With the increase in reservoir capacity, the annual net reduction in water to the Snake River averages approximately 20,100 acre-feet for the period of record analyzed (Table 4-12). This also indicates that approximately 500 acre-feet of irrigation shortages are satisfied, on average, below the project.

Water stored is also released during the irrigation season in response to downstream irrigation demand and the assumed 50 cfs minimum flow target. The assumed 50 cfs minimum release requirement below the reservoir was a target flow condition all year, set in the MODSIM model, and was satisfied 100 percent of the time immediately downstream of the project.

While the proposed Thief Valley Reservoir enlargement could provide recreational and environmental benefits, it did not assume any significant inactive storage volume would be reserved in storage for recreational or fisheries benefits during the modeling exercises. In order to retain water in inactive storage, either annual water supply benefits would be reduced or a larger reservoir would be required in order to supply the same modeled irrigation benefits.

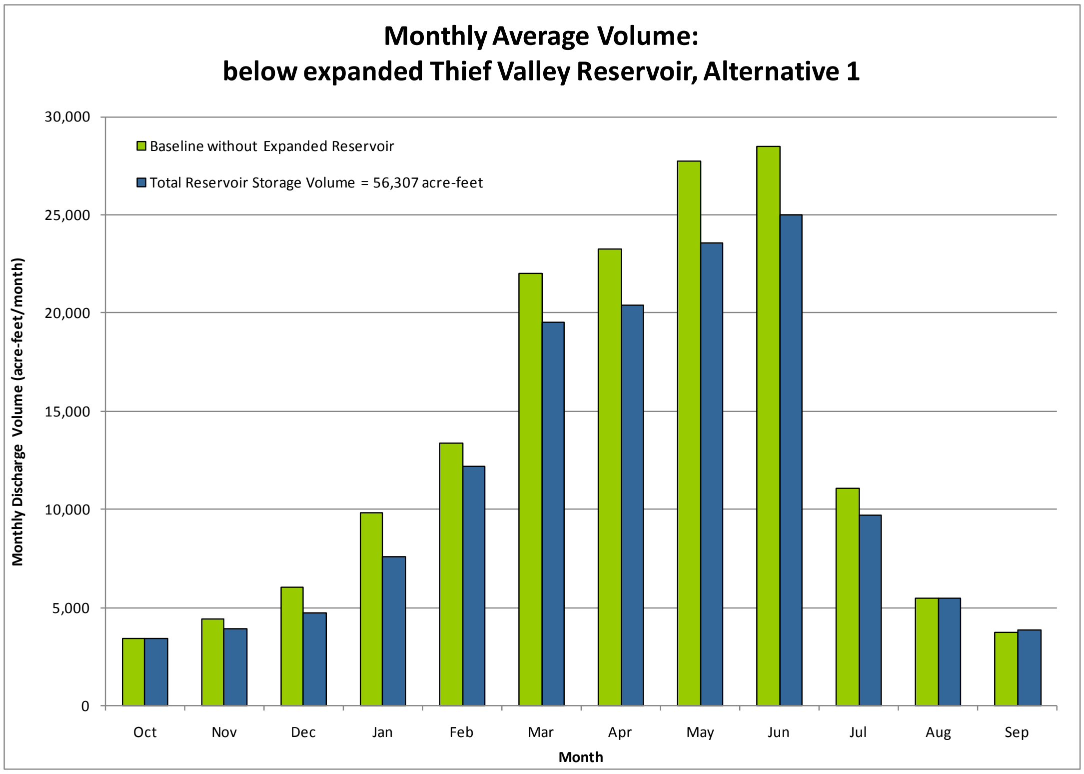

Figure 4-37. Estimated monthly average flow below Thief Valley Reservoir enlargement, Alternative 1

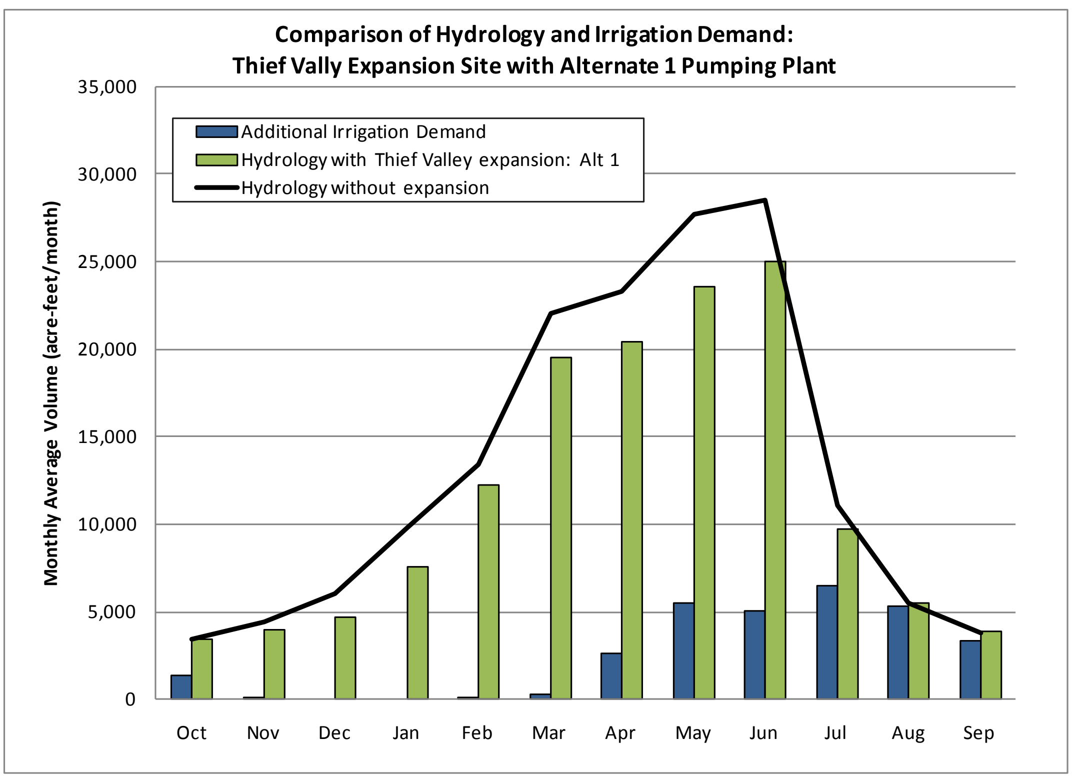

Figure 4-38. Estimated monthly average flow below the project and upstream irrigation demand, Alternative 1

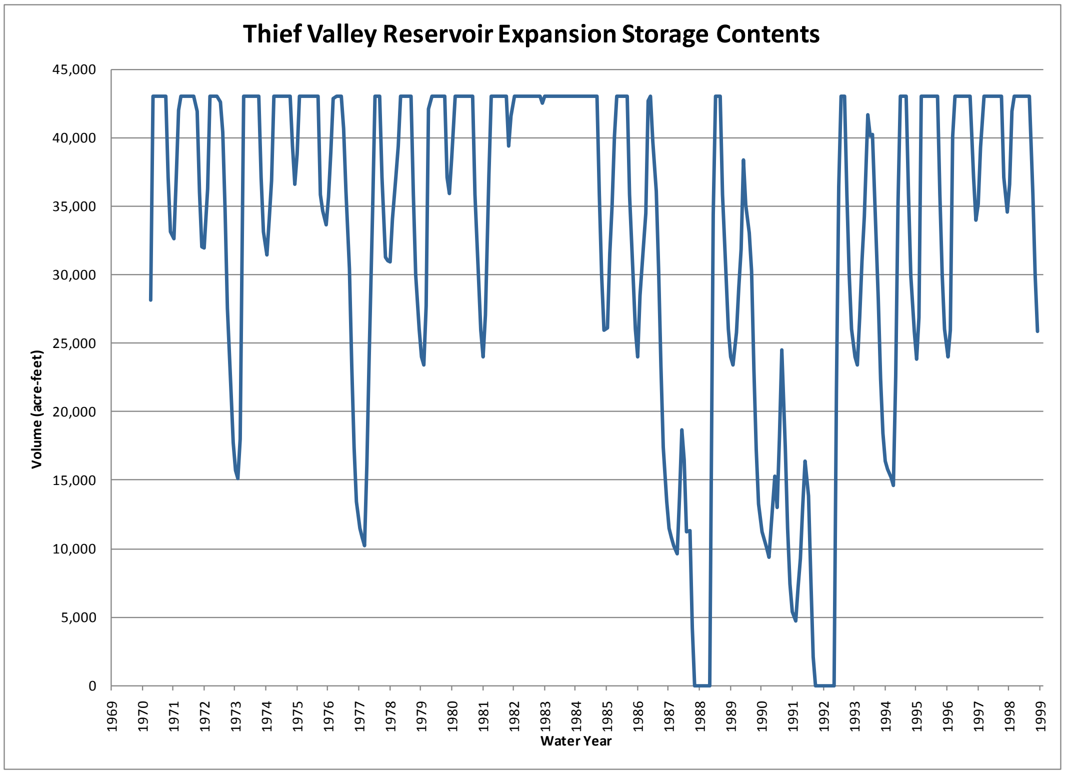

Figure 4-39. Modeled storage contents of reservoir expansion, Alternative 1

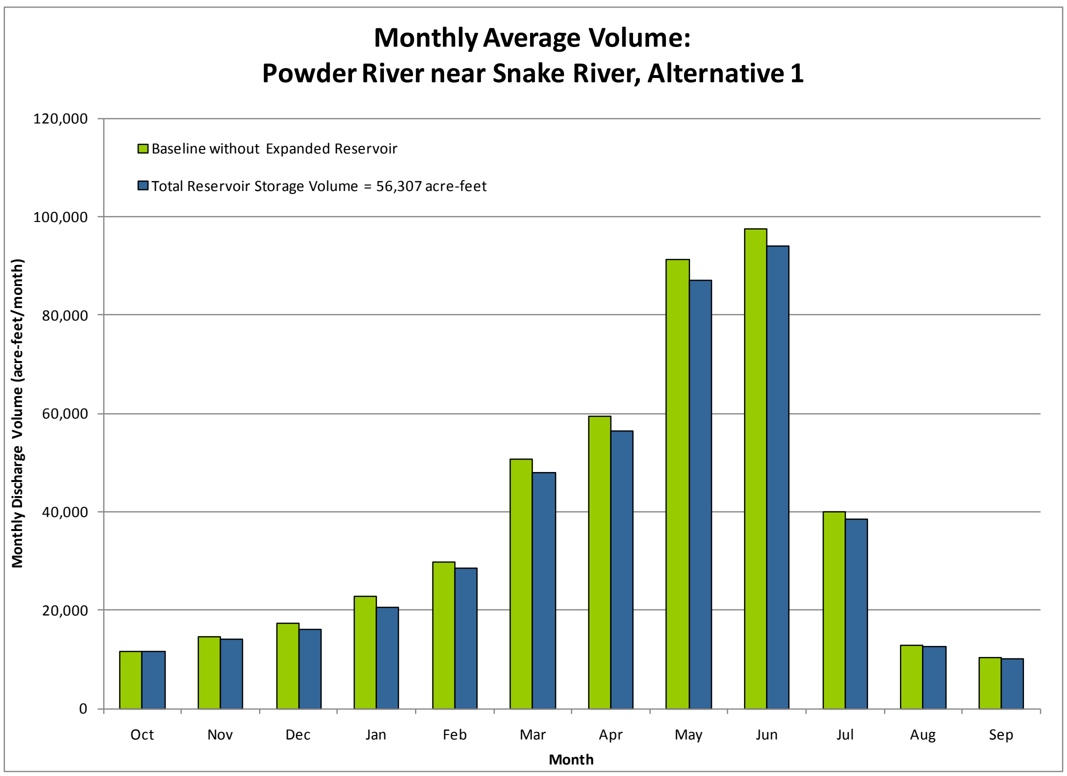

Figure 4-40. Estimated monthly average flow in Powder River near Snake River confluence, Alternative 1

Table 4-12. Proposed Thief Valley Facility Enlargement Storage Summary Table Alternative 1

Month	Monthly Average Flow below Thief Valley Reservoir Model Water Years: 1971 – 1999			Monthly Average Flow on Powder River near Snake River Model Water Years: 1971 – 1999		
	Expanded Reservoir (acre-feet/month)	Baseline Condition (acre-feet/month)	Difference	Expanded Reservoir (acre-feet/month)	Baseline Condition (acre-feet/month)	Difference
October	3,440	3,457	(493)	11,704	11,650	54
November	3,943	4,435	(1,300)	14,218	14,679	(461)
December	4,728	6,029	(2,249)	16,141	17,441	(1,300)
January	7,598	9,847	(1,191)	20,640	22,889	(2,249)
February	12,216	13,407	(2,541)	28,572	29,763	(1,191)
March	19,506	22,048	(2,903)	48,068	50,609	(2,541)
April	20,377	23,280	(4,161)	56,429	59,375	(2,947)
May	23,582	27,743	(3,479)	87,153	91,313	(4,160)
June	24,993	28,471	(1,377)	94,178	97,656	(3,478)
July	9,693	11,070	5	38,625	40,058	(1,433)
August	5,482	5,477	143	12,653	12,839	(186)
September	3,897	3,754	-	10,219	10,399	(181)
Average Annual Change (acre-feet/year)			(19,546)			(20,071)

Alternative 2 Results

Alternative 2 was configured with a pumping facility located downstream of the dam to satisfy an annual irrigation demand of 30,000 acre-feet that currently exists upstream of the dam. Figure 4-41 presents the average monthly flow comparison between Alternative 2 and the baseline configuration. The downstream flows are less with the reservoir enlargement when compared to the existing condition for part of the year. These flow reductions are due to the additional water being stored in the enlarged reservoir during the late winter and spring months.

During the irrigation season, there is significantly more water discharged downstream of the project. This is due to the accumulated reservoir storage being delivered to the downstream pumping plant. The upstream irrigation demands are being satisfied by passing flows through the Thief Valley project and then back upstream via the pumping plant. Figure 4-42 illustrates the comparison of baseline and Alternative 2 flows below Thief Valley in relationship to the additional upstream irrigation demands (Figure 4-43). The net result is an increase in flows released below the project. This annual net increase in flow below the dam averages approximately 9,400 acre-feet for the period of record modeled. This includes the net decrease during the early part of the year when water is stored for later delivery.

Figure 4-44 illustrates the change in flow to the Snake River. As a result of the increased irrigation demand, additional water is consumptively used within the basin. With the increase in reservoir capacity, the annual net reduction in water to the Snake River averages approximately 20,300 acre-feet (Table 4-13).

While the proposed Thief Valley Reservoir enlargement could provide recreational and environmental benefits, it did not assume any significant inactive storage volume would be reserved in storage for recreational or fisheries benefits. The reservoir could be sized to hold water in inactive storage. However, the result would be either reduced annual water supply benefits or a larger reservoir in order to produce the same benefits.

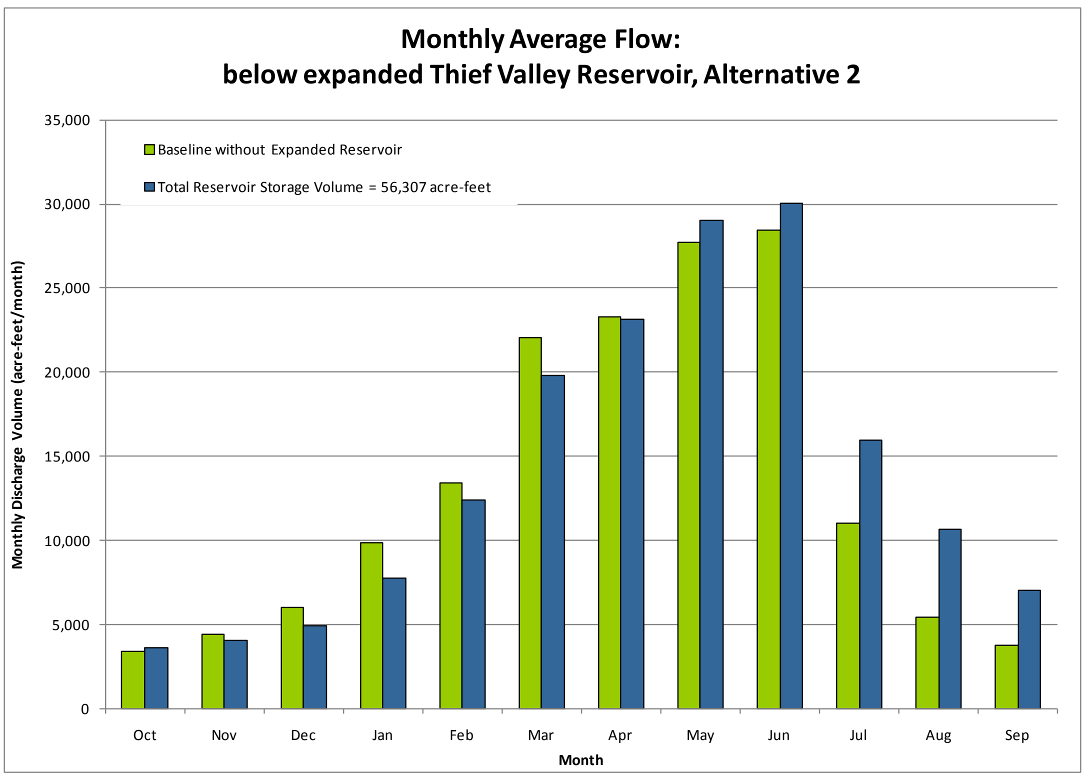

Figure 4-41. Estimated monthly average flow below Thief Valley Reservoir enlargement, Alternative 2

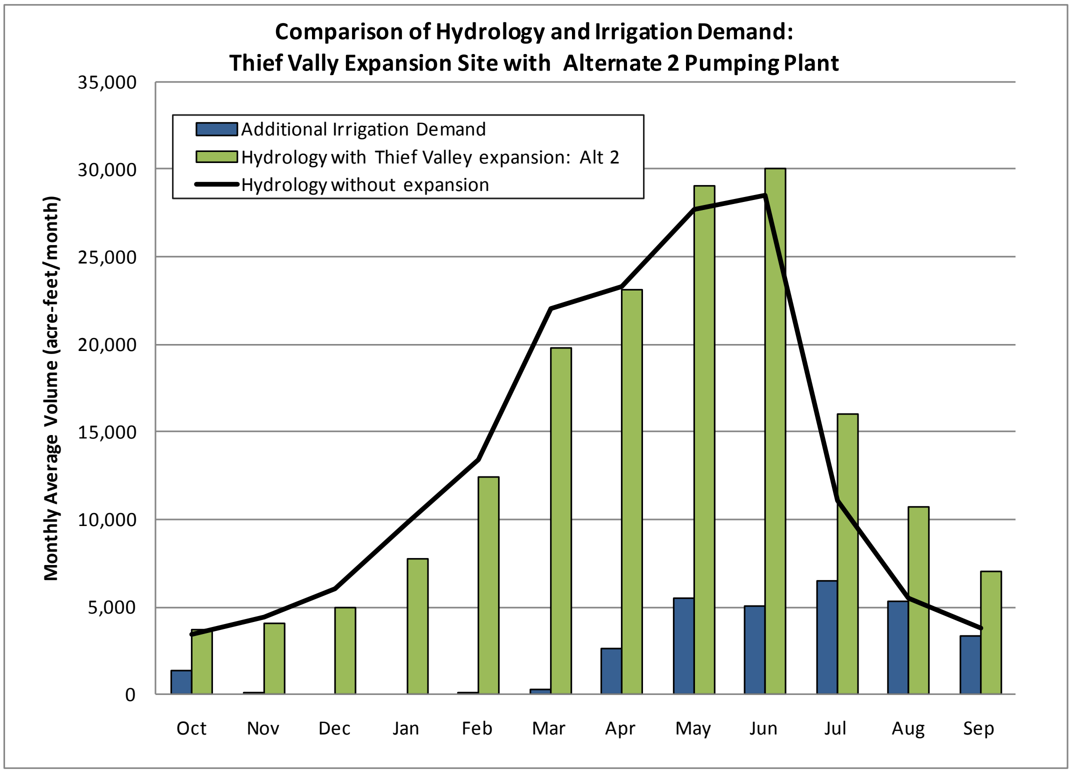

Figure 4-42. Estimated monthly average flow below the project and upstream irrigation demand, Alternative 2

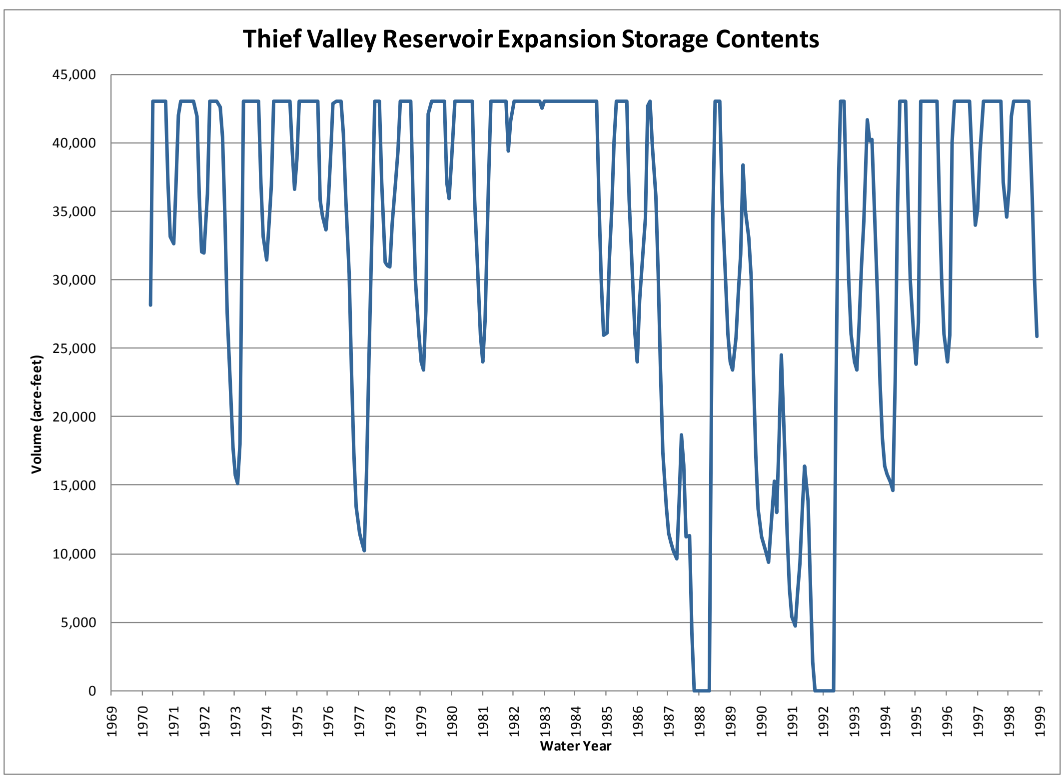

Figure 4-43. Modeled storage contents of reservoir expansion, Alternative 2

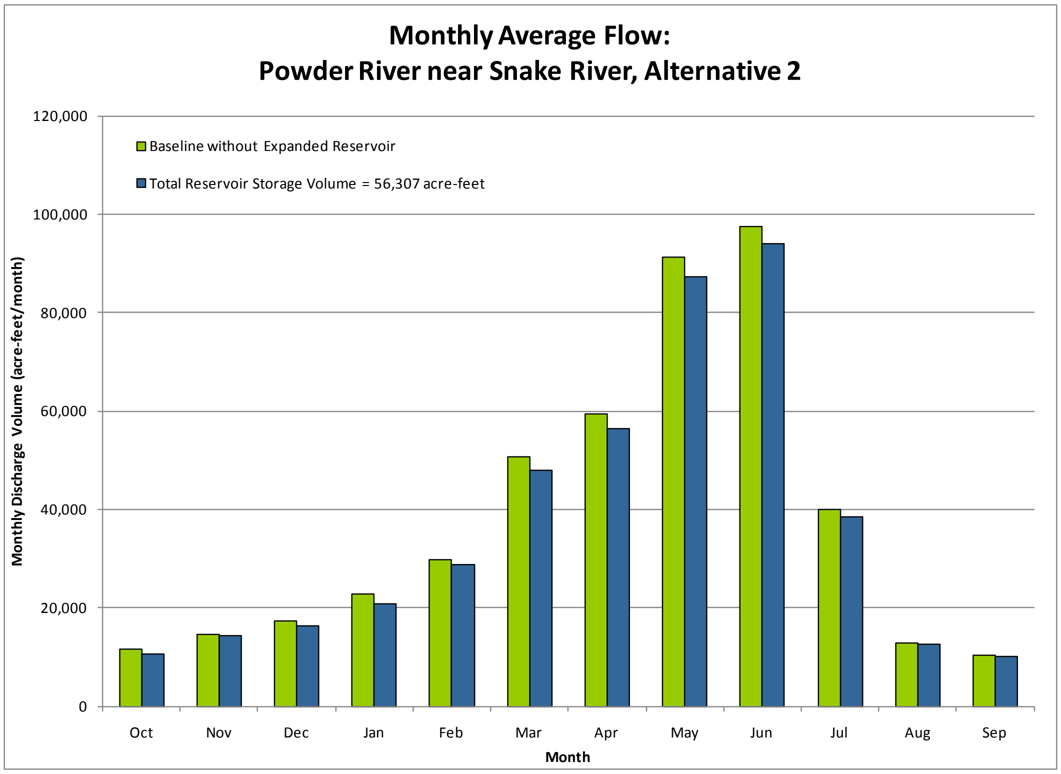

Figure 4-44. Estimated monthly average flow in Powder River near Snake River confluence, Alternative 2

Table 4-13. Proposed Thief Valley Facility Enlargement Storage Summary Table Alternative 2

	Monthly Average Flow below Thief Valley Reservoir Model Water Years: 1971 – 1999			Monthly Average Flow on Powder River near Snake River Model Water Years: 1971 – 1999		
Month	Expanded Reservoir (acre-feet/month)	Baseline Condition (acre-feet/month)	Difference	Expanded Reservoir (acre-feet/month)	Baseline Condition (acre-feet/month)	Difference
October	3,661	3,457	(343)	10,603	11,650	(1,047)
November	4,093	4,435	(1,083)	14,384	14,679	(294)
December	4,946	6,029	(2,068)	16,371	17,441	(1,070)
January	7,779	9,847	(958)	20,833	22,889	(2,055)
February	12,449	13,407	(2,253)	28,820	29,763	(944)
March	19,795	22,048	(164)	48,091	50,609	(2,519)
April	23,116	23,280	1,287	56,432	59,375	(2,943)
May	29,030	27,743	1,576	87,295	91,313	

Month	Monthly Average Flow below Thief Valley Reservoir Model Water Years: 1971 – 1999			Monthly Average Flow on Powder River near Snake River Model Water Years: 1971 – 1999		
						(4,018)
June	30,047	28,471	4,918	94,188	97,656	(3,468)
July	15,988	11,070	5,207	38,635	40,058	(1,423)
August	10,684	5,477	3,279	12,666	12,839	(173)
September	7,033	3,754	-	10,103	10,399	(297)
Average Annual Change (acre-feet/year)			9,399		9,399	(20,252)

4.4.3 Proposed North Powder Reservoir – Powder River

Project Description

The proposed North Powder Reservoir site is located on the North Powder River in the northeastern part of the Powder River watershed, approximately 20 miles northeast of Baker, Oregon and 9 miles east of North Powder, Oregon. The proposed dam and reservoir is located on land owned privately and land owned by the U.S. Forest Service.

Storable Volume and Reliability Modeling

The proposed North Powder Reservoir is shown in the model network in Figure 4-12. For the period of record modeled, the North Powder Reservoir site has an estimated average annual flow volume of 43,600 acre-feet per year, as shown in Figure 4-45. Over the same time period, Figure 4-46 illustrates the storable volume a reservoir located at this site would accumulate.

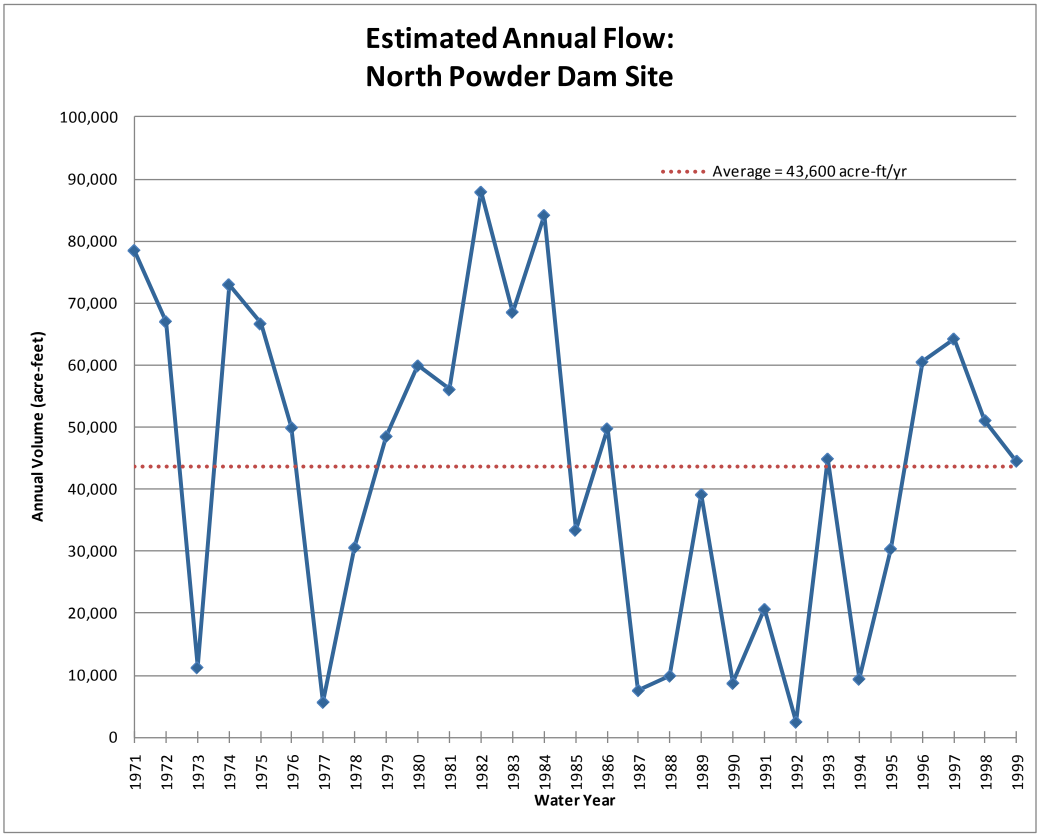

Figure 4-45. Annual water volume at proposed North Powder Reservoir site

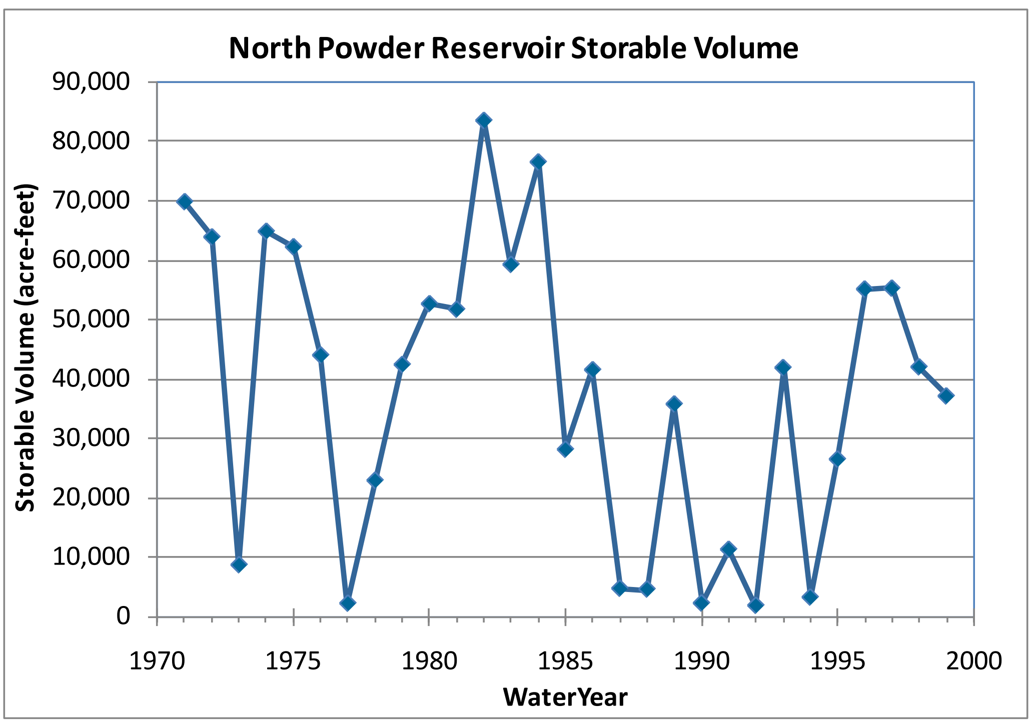

Figure 4-46. Annual storable water at proposed North Powder Reservoir site

The storable water volumes were ranked and plotted in Figure 4-47.

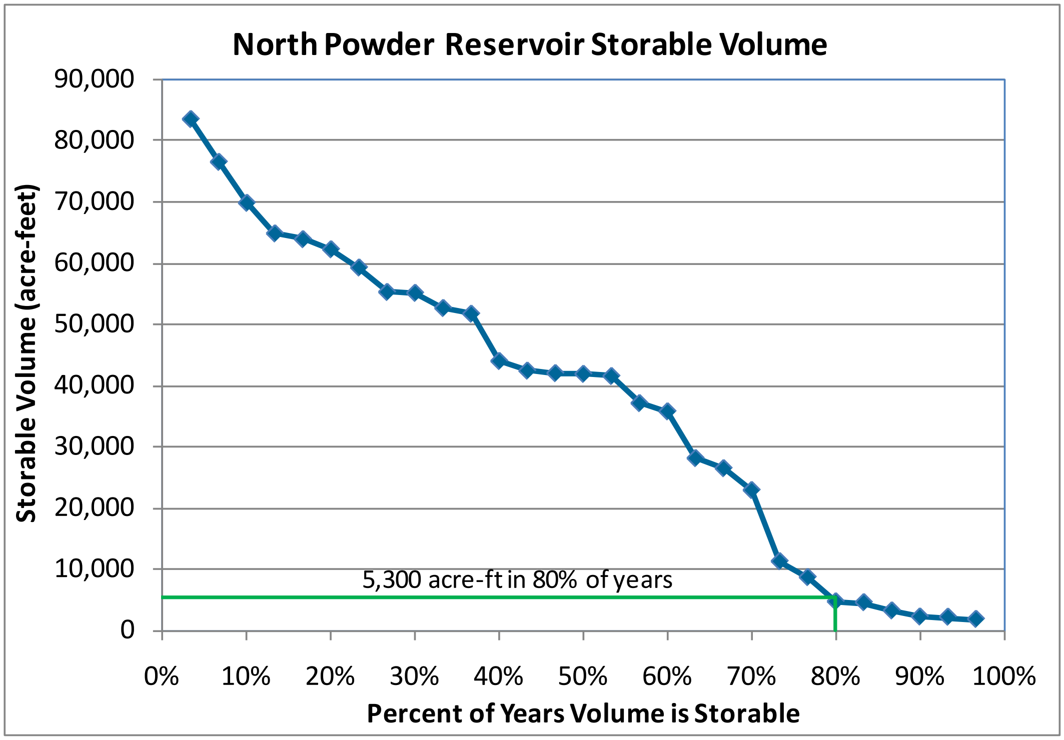

Figure 4-47. Proposed North Powder Reservoir storable water frequency

Storage Model Results

The 80 percent storable volume was selected as a reliable volume for the proposed reservoir enlargement and was used for the additional hydrologic and water supply yield assessment. The right to store water within this proposed reservoir enlargement would be based on a 1992 priority water reservation filed by the ODWR. The storage right was assumed to be junior to all of the other current water right holders.

As a result of this analysis, the 80 percent reliable volume for the North Powder Reservoir is 5,300 acre-feet. The estimated inundation area is shown in Figure 4-48 and was determined by utilizing the natural topography contours and an assumed dam height to accommodate the proposed volume results. At this time, the inundation limits illustrated also do not assume any significant inactive storage volume reserved for recreational or fisheries benefits.

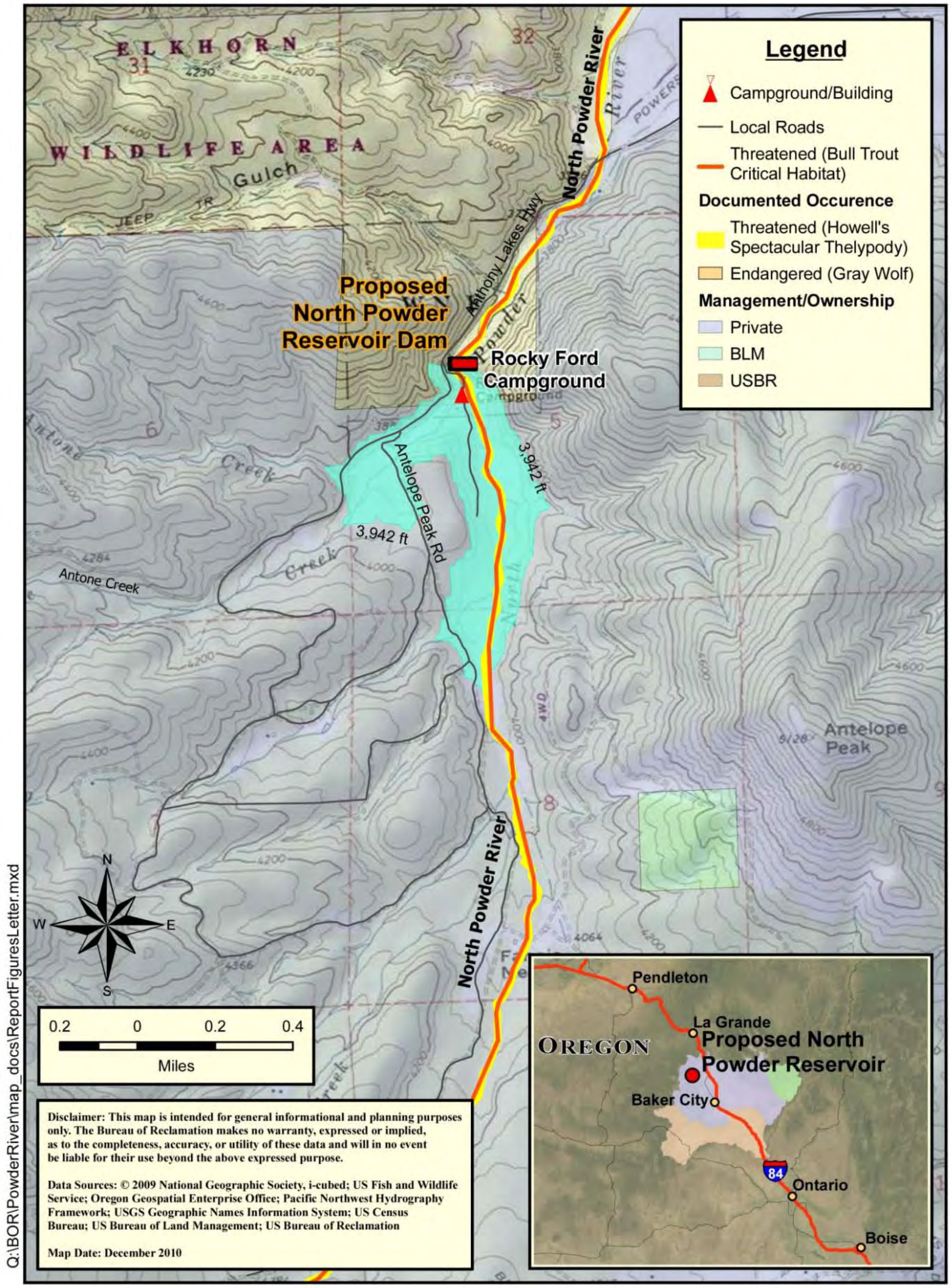

Figure 4-48. Proposed North Powder Reservoir location map

Alternatives Analysis Model Configuration

A model configuration was developed to incorporate the proposed reservoir. Table 4-14 presents the applicable model assumptions and constraints defined for the alternatives analyses. Other model assumptions defined in the calibrated baseline model and not shown here, remain unchanged.

Table 4-14. North Powder Reservoir analysis model constraints

Constraint	Baseline Configuration	North Powder Reservoir
Reservoir Capacity (acre-feet)	Not applicable	5,300
Reservoir Depth (feet)	Not applicable	169
Minimum Flow Target below dam (cfs)	Not applicable	5
Annual Irrigation Demands	No change	No change

The water stored in the proposed reservoir was assigned a low priority setting to keep it from adversely impacting existing water right holders with senior rights. Irrigation demand was allowed to draw water from the proposed reservoir, as needed, to reduce shortages. This analysis was simulated for the 29-year study period of record (1971-1999).

Alternatives Analysis Model Results

Figure 4-49 shows the maximum water volume stored for each water year modeled. This figure illustrates the years when the proposed reservoir filled or failed to fill. Figure 4-50 and Figure 4-51 show the volume of water supplied from storage with the proposed reservoir expansion. The estimated water supplied from the proposed North Powder Reservoir was calculated from the results of the MODSIM models as the difference in shortage under existing conditions (without the proposed reservoir) and with the proposed reservoir.

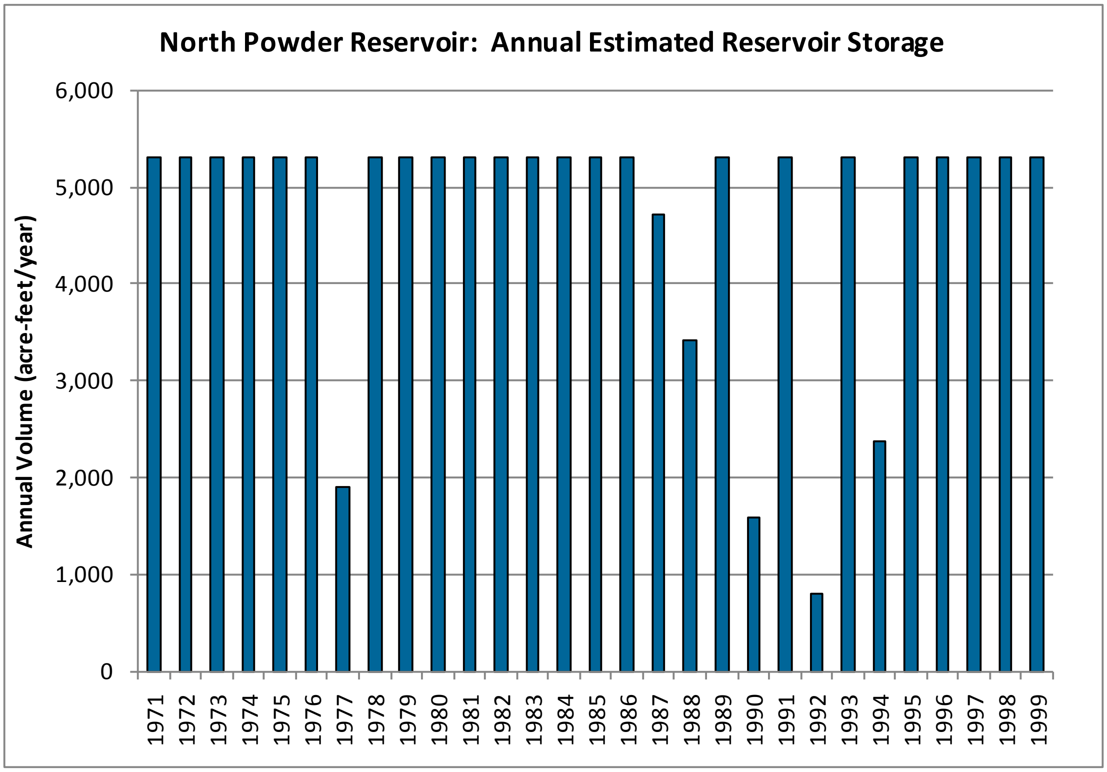

Figure 4-49. Estimated maximum volume of water stored in proposed North Powder reservoir for each water year

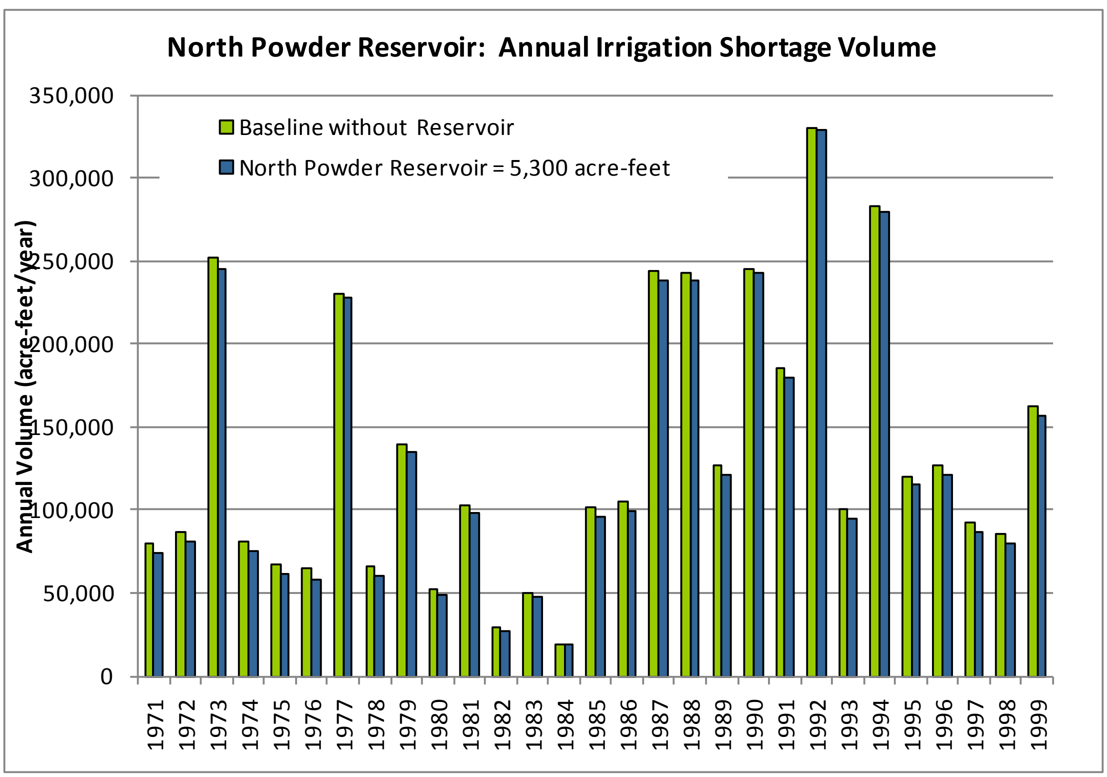

Figure 4-50. Estimated irrigation shortage with and without the proposed North Powder Reservoir

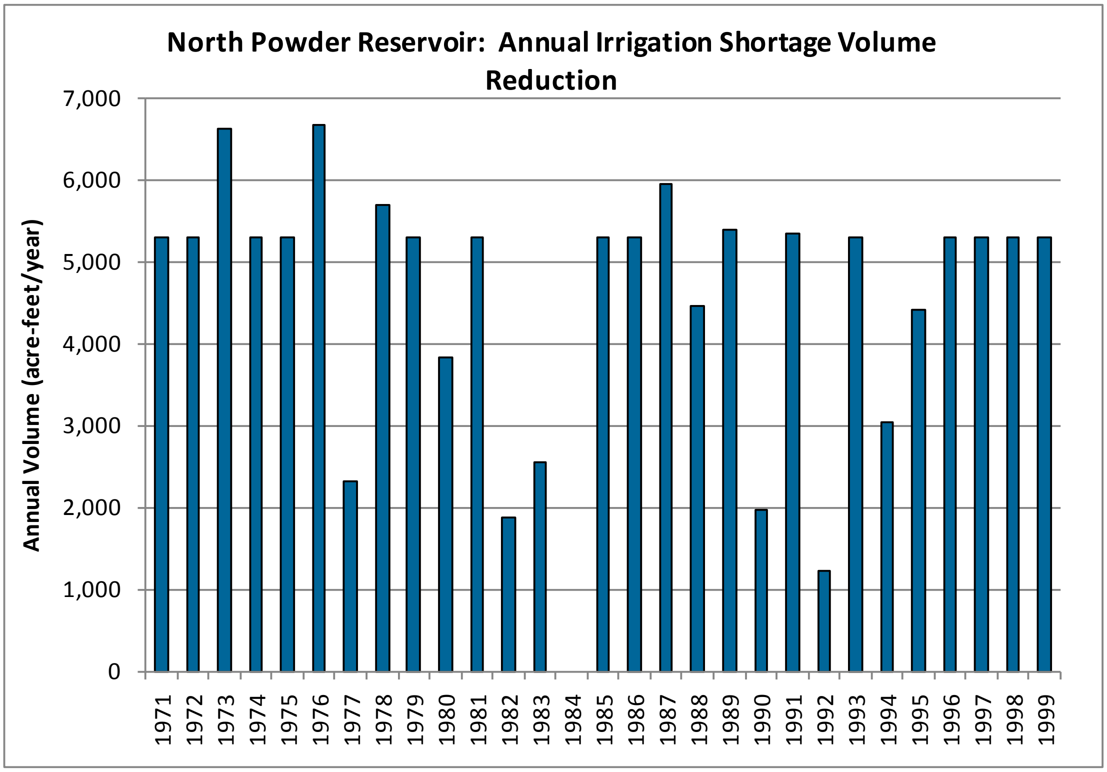

Figure 4-51. Estimated reduction in annual irrigation shortage within the Powder River Basin with the proposed North Powder reservoir

It should be noted that in a couple of years, the irrigation shortage reduction is greater than the 5,300 acre-feet of available storage in the proposed reservoir (Figure 4-51). The additional shortage reduction is an artifact of the minimum flow designation below the project. While there is a 5 cfs minimum flow requirement immediately below the project, the flow was not protected below the confluence with Anthony Creek. Therefore, the target flow assisted in reducing irrigation shortages upstream of Thief Valley Reservoir when compared to the baseline condition.

The proposed reservoir results in a change to the hydrograph of the flow downstream of the project (Figure 4-52). Figure 4-53 illustrates the current hydrology pattern and the modeled demand pattern in proximity of this site. This figure also illustrates the timing differences in flow between the run-off pattern and irrigation demand pattern. Downstream flows are lower in October through March for the proposed reservoir condition compared to existing conditions (without the proposed reservoir). The lower flows during this period represent water being stored in the reservoir (Figure 4-54). Conversely, downstream flows are higher in April through September for the proposed reservoir compared with existing conditions. Water stored is released during the irrigation season in response to irrigation demand and the assumed 5 cfs minimum flow target. An instream flow right filed by the State was set as a minimum flow target. At this location, the assumed target was 5 cfs.

The assumed 5 cfs minimum release requirement below the reservoir was a target flow condition, set in the MODSIM model, and was satisfied approximately 50 percent of the time. This is an artifact of the very low incoming flow volumes during the later summer months. Based on the model constraints and assumptions used, there was no water available after meeting irrigation demands to continue the minimum flow requirement.

The change in the hydrograph not only occurs below the proposed reservoir, but also changes the flow (to a lesser extent) from the Powder River to the Snake River. Figure 4-55 shows the average monthly flow in the Powder River near the confluence with the Snake River.

Overall, the proposed reservoir changes the hydrograph and reduces the shortage for irrigation water demand below the reservoir compared to existing conditions. The 5,300 acre-feet of additional storage in the system reduces the irrigation shortage by approximately 4,500 acre-feet with a net reduction in water volume that reached the Snake River of 2,600 acre-feet between the proposed reservoir model configuration and existing baseline condition (Figure 4-15). This net reduction is the result of the irrigation diversions reusing irrigation return water passing through the system.

While the proposed North Powder Reservoir could provide recreational and environmental benefits, the results of the MODSIM model simulations indicated that there would not be enough water to reliably satisfy additional demands beyond those currently included. The simulation did not assume any significant inactive storage volume that would be reserved in storage for recreational or fisheries benefits. The reservoir could be sized to hold water in inactive storage. However, the result would be either reduced annual water supply benefits or a larger reservoir in order to produce the same benefits.

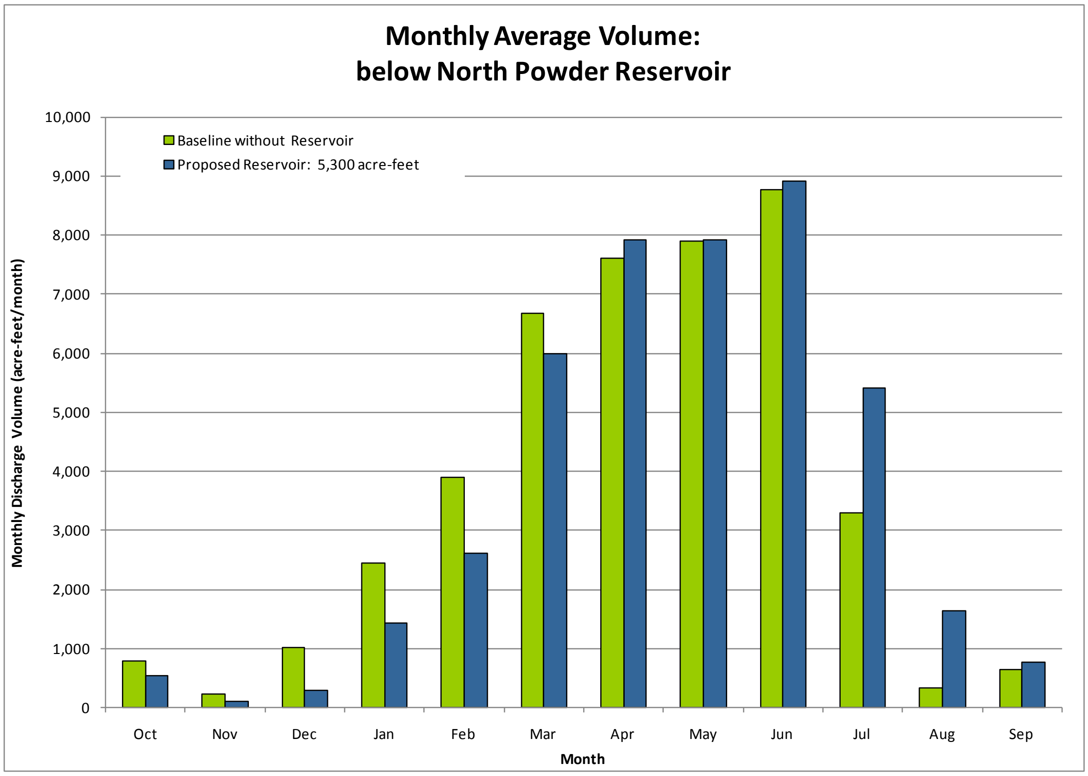

Figure 4-52. Estimated monthly average flow below the proposed North Powder Reservoir

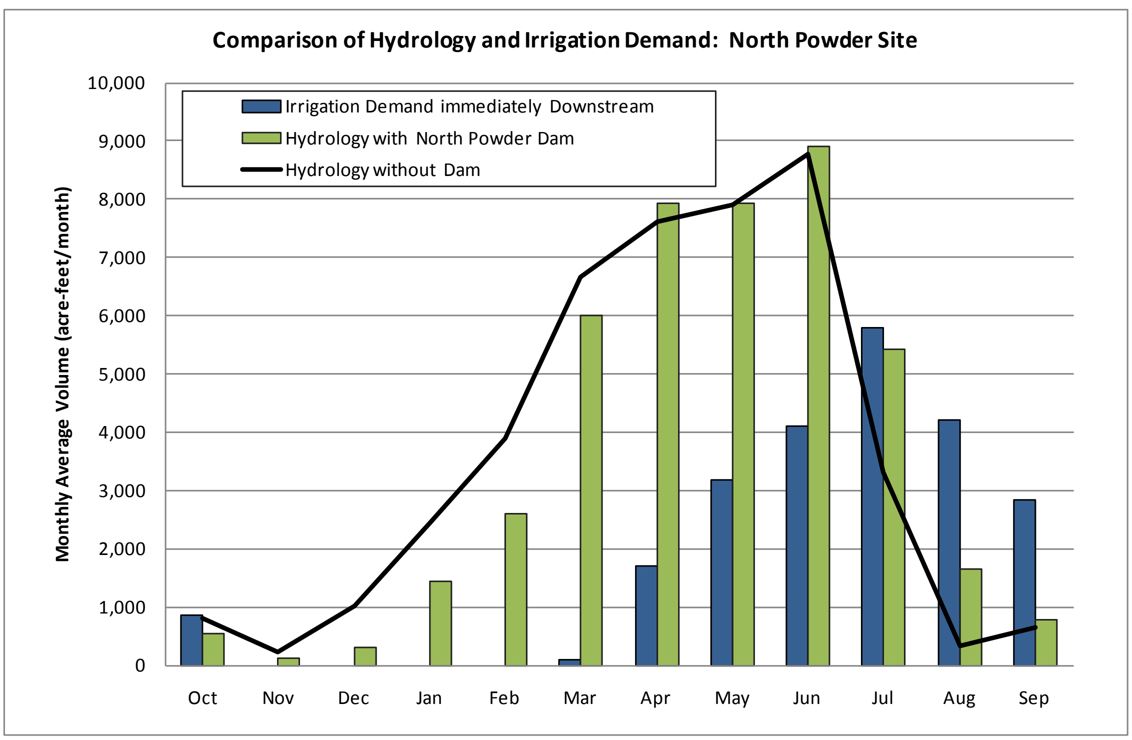

Figure 4-53. Estimated monthly average flow below the project and irrigation demand located below the proposed North Powder Reservoir

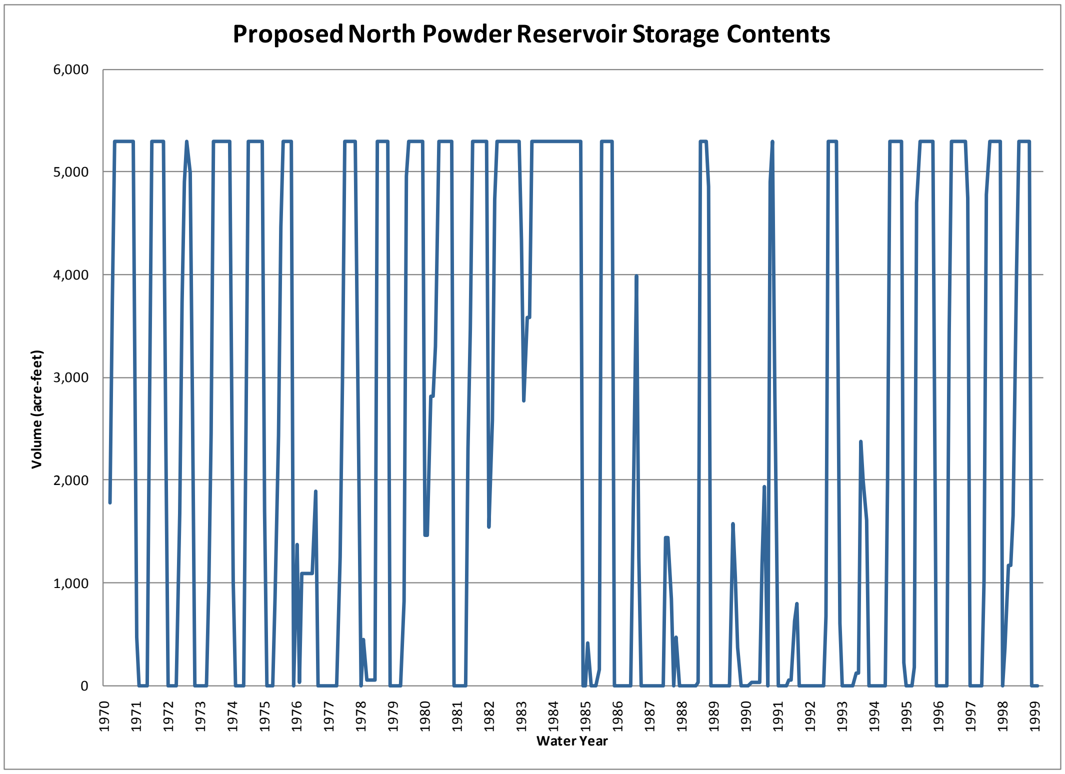

Figure 4-54. Modeled storage contents of proposed North Powder Reservoir

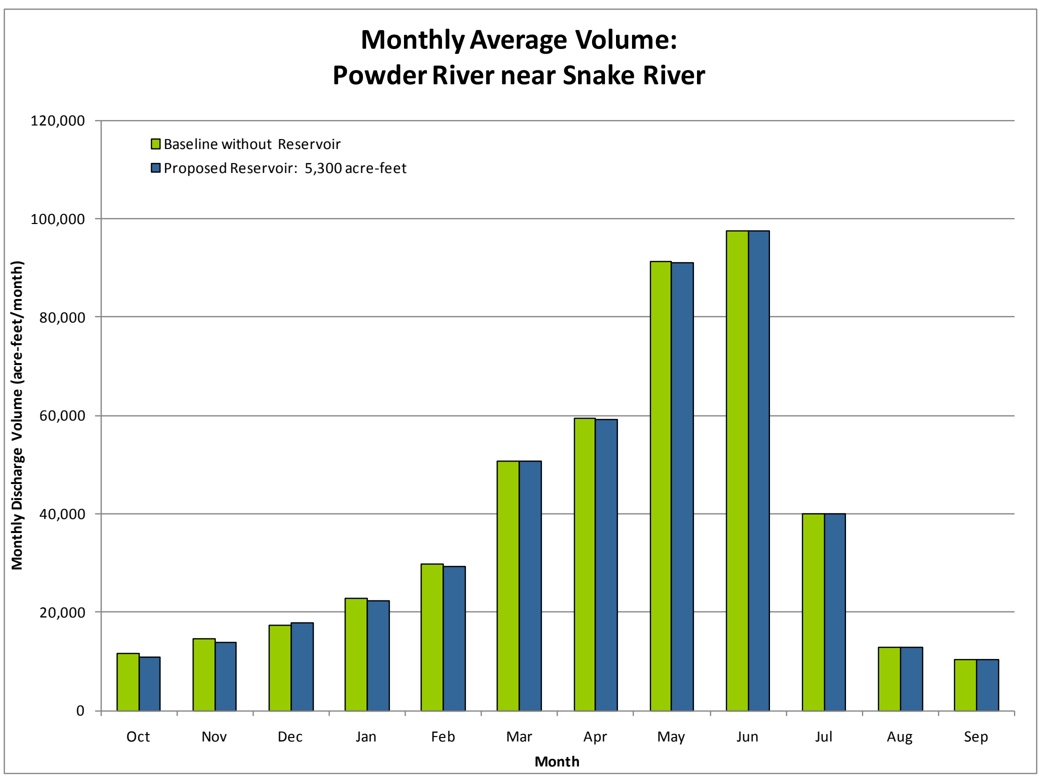

Figure 4-55. Estimated monthly average flow in Powder River near Snake River confluence with the proposed North Powder Reservoir

Table 4-15. Proposed North Powder Facility Storage Summary Table

Irrigation Shortages Modeled Water Years: 1971 - 1999:						
Average Annual Irrigation Shortage Baseline Condition (acre-feet/year)			133,520			
Average Annual Irrigation Shortage with North Powder Reservoir (acre-feet/year)			129,028			
Average Annual Irrigation Shortage Reduction (acre-feet/year)			4,492			
	Monthly Average Flow at Reservoir Site Model Water Years: 1971 – 1999			Monthly Average Flow on Powder River near Snake River Model Water Years: 1971 – 1999		
Month	Below North Powder Reservoir (acre-feet/month)	Baseline Condition (acre-feet/month)	Difference	With North Powder Reservoir (acre-feet/month)	Baseline Condition (acre-feet/month)	Difference
October	549	797	(248)	10,814	11,650	(836)
November	111	237	(126)	13,748	14,679	(930)
December	304	1,017	(713)	17,728	17,441	287
January	1,445	2,441	(996)	22,427	22,889	(461)
February	2,613	3,895	(1,282)	29,360	29,763	(403)
March	5,992	6,669	(677)	50,721	50,609	112
April	7,927	7,612	316	59,240	59,375	(135)
May	7,925	7,904	21	91,153	91,313	(161)
June	8,916	8,771	145	97,646	97,656	(10)
July	5,413	3,302	2,111	40,064	40,058	6
August	1,645	327	1,318	12,867	12,839	28
September	770	639	132	10,342	10,399	(58)
Average Annual Change (acre-feet/year)			(0)			(2,561)

4.4.4 Proposed Wolf Creek Reservoir Expansion – Powder River

Project Description

The existing Wolf Creek Dam and Reservoir is located on Wolf Creek, a tributary to the North Powder River, approximately 6 miles west of the community of North Powder, Oregon. The project is owned and operated by the Powder Valley Water Control District. It is approximately 128 feet high with an existing storage capacity of 10,800 acre-feet. It was completed in 1974 for irrigation needs.

Storable Volume and Reliability Modeling

The Wolf Creek Reservoir is shown in the model network in Figure 4-12. For the period of record modeled, the Wolf Creek Reservoir site has an estimated average annual flow volume of 28,400 acre-feet, as shown in Figure 4-56. Over the same time period, Figure 4-57 illustrates the storable volume an expanded reservoir at this site would accumulate.

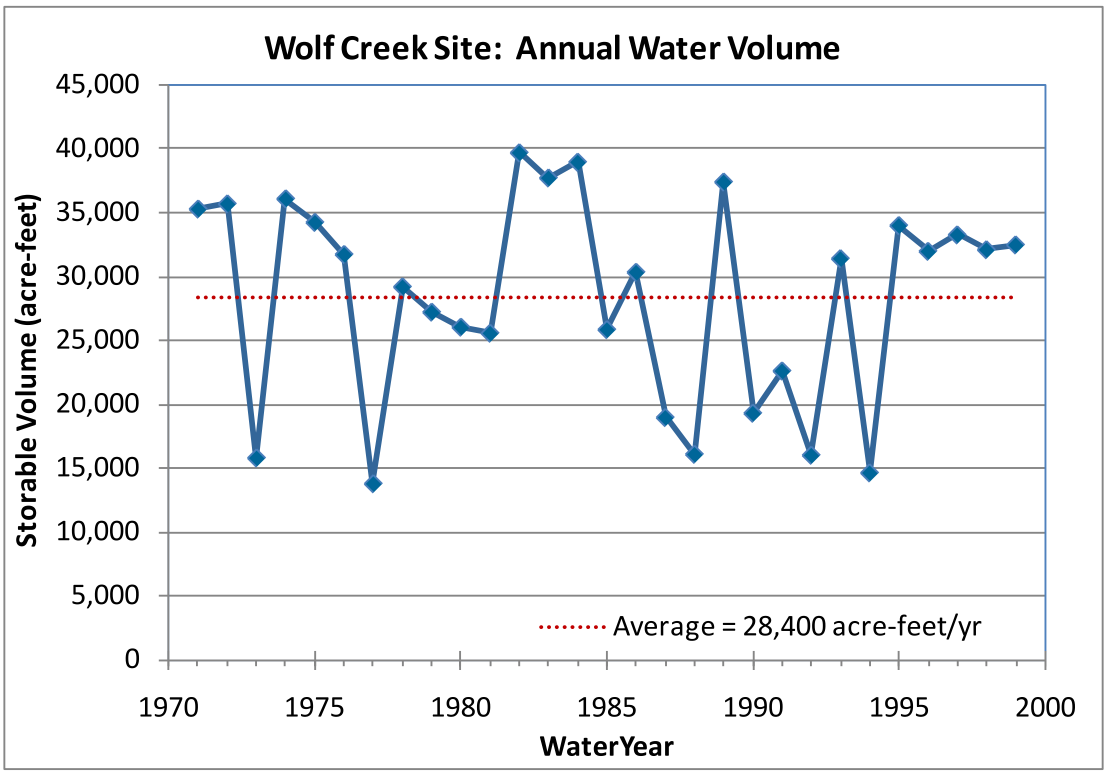

Figure 4-56. Annual water volume at Wolf Creek Reservoir site

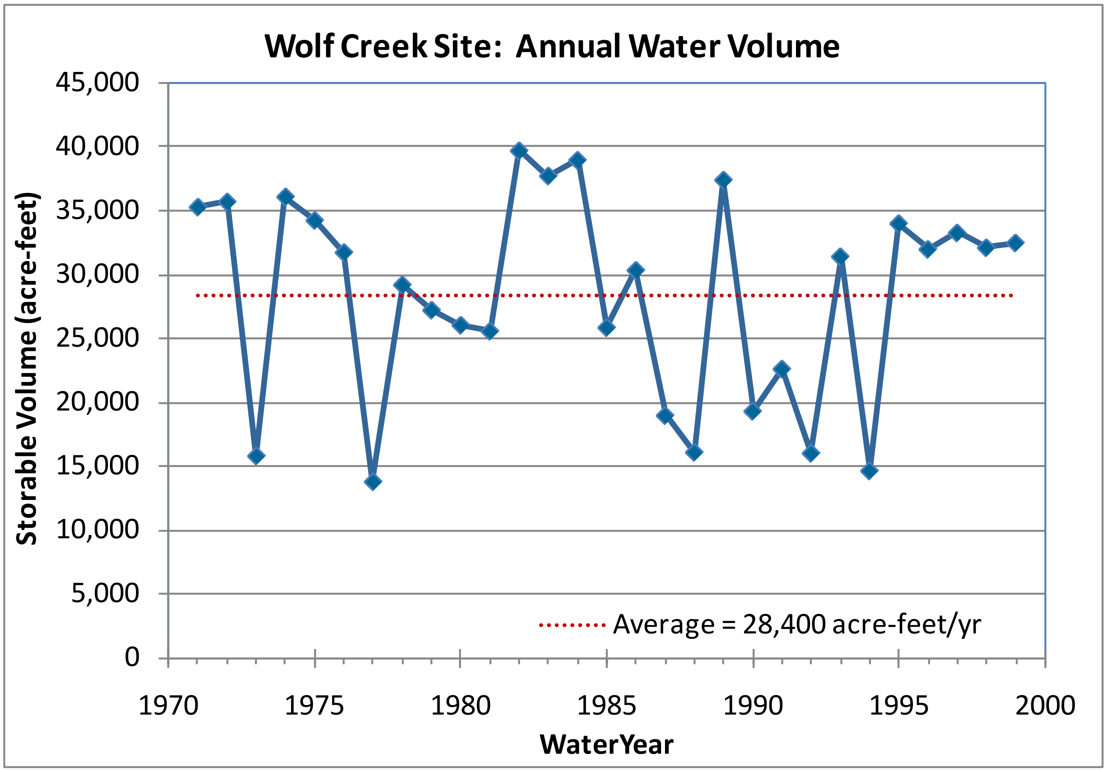

Figure 4-57. Annual storable water at Wolf Creek Reservoir expansion

The storable water volumes were ranked and plotted in Figure 4-58.

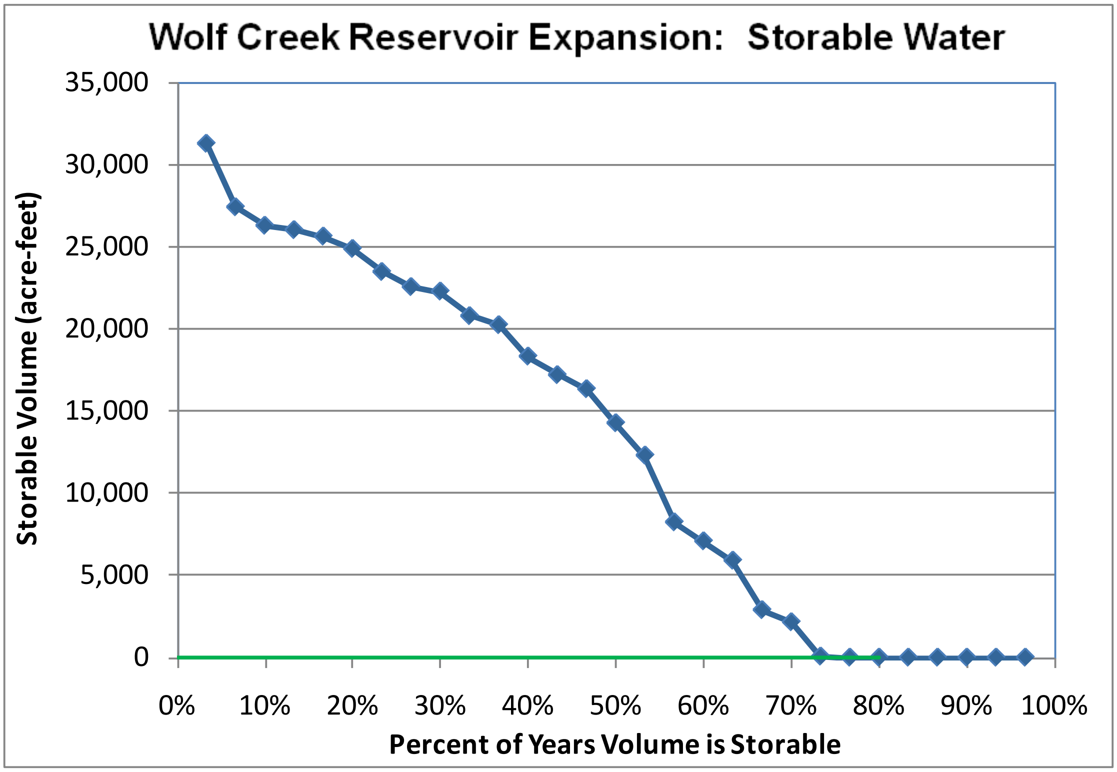

Figure 4-58. Wolf Creek Reservoir expansion storable water frequency

Model Results

The results of the model run indicate that the Wolf Creek Reservoir expansion does not warrant further investigation in this appraisal study. Based on 80-percent fill reliability, this proposed project fails to satisfy the established screening criteria.

4.4.5 Proposed Pilcher Creek Reservoir Expansion – Powder River

Project Description

The existing Pilcher Creek Dam and Reservoir is located on Pilcher Creek, a tributary to the North Powder River, approximately 7 miles west of the community of North Powder, Oregon. The project is owned and operated by the Powder Valley Water Control District. It is approximately 110 feet high with an existing storage capacity of 5,900 acre-feet. It was completed in 1984 for irrigation needs.

Storable Volume and Reliability Modeling

The Pilcher Creek Reservoir is shown in the model network in Figure 4-12. For the period of record modeled, the Pilcher Creek Reservoir site has an estimated average annual flow volume of 9,900 acre-feet, as shown in Figure 4-59. Over the same time period, Figure 4-60 illustrates the storable volume an expanded reservoir at this site would accumulate.

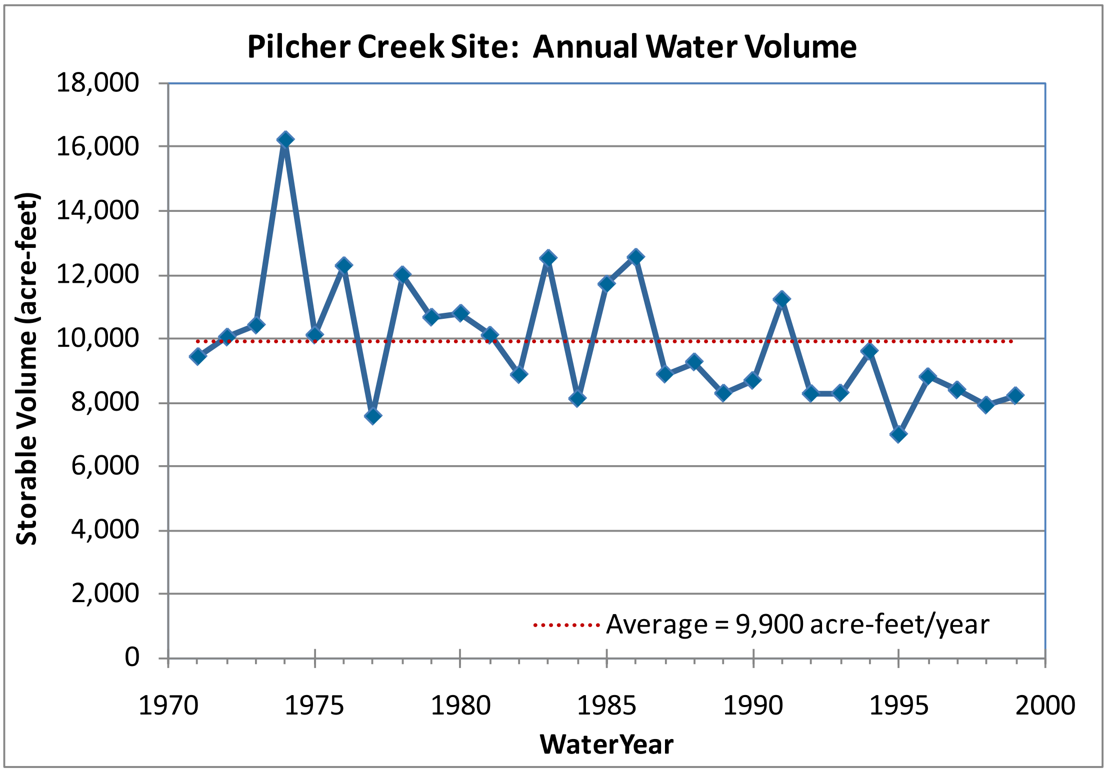

Figure 4-59. Annual water volume at Pilcher Creek Reservoir site

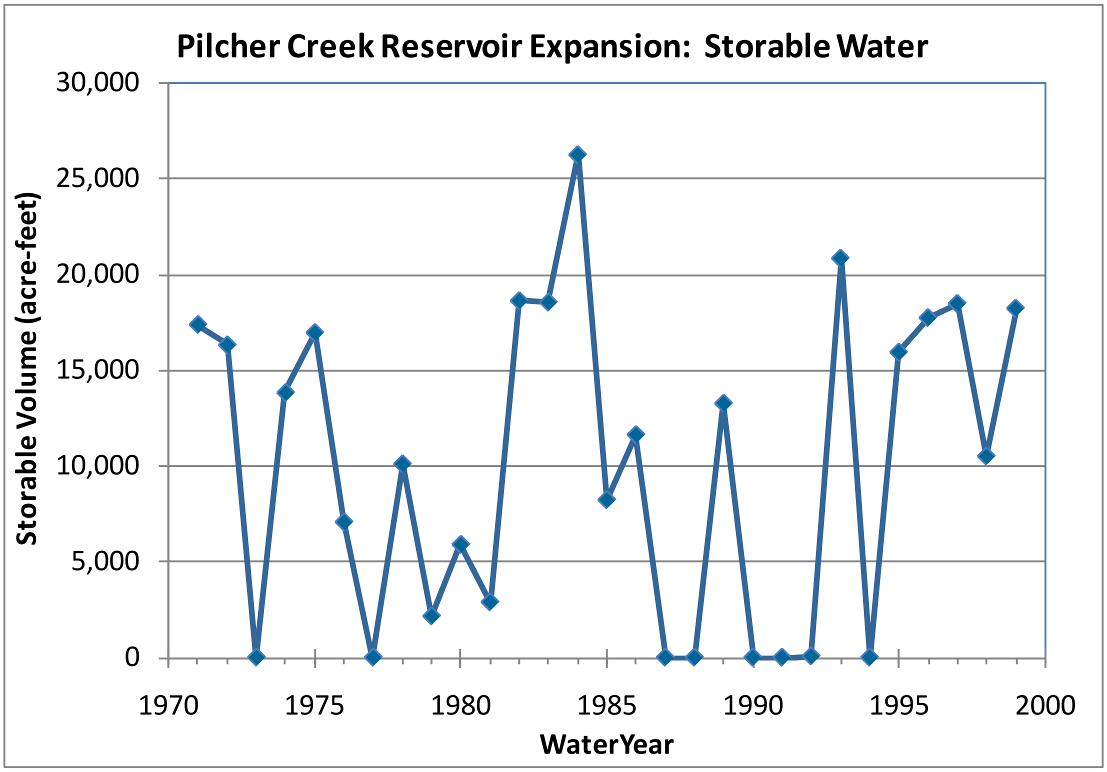

Figure 4-60. Annual storable water at Pilcher Creek Reservoir expansion

The storable water volumes were ranked and plotted in Figure 4-61.

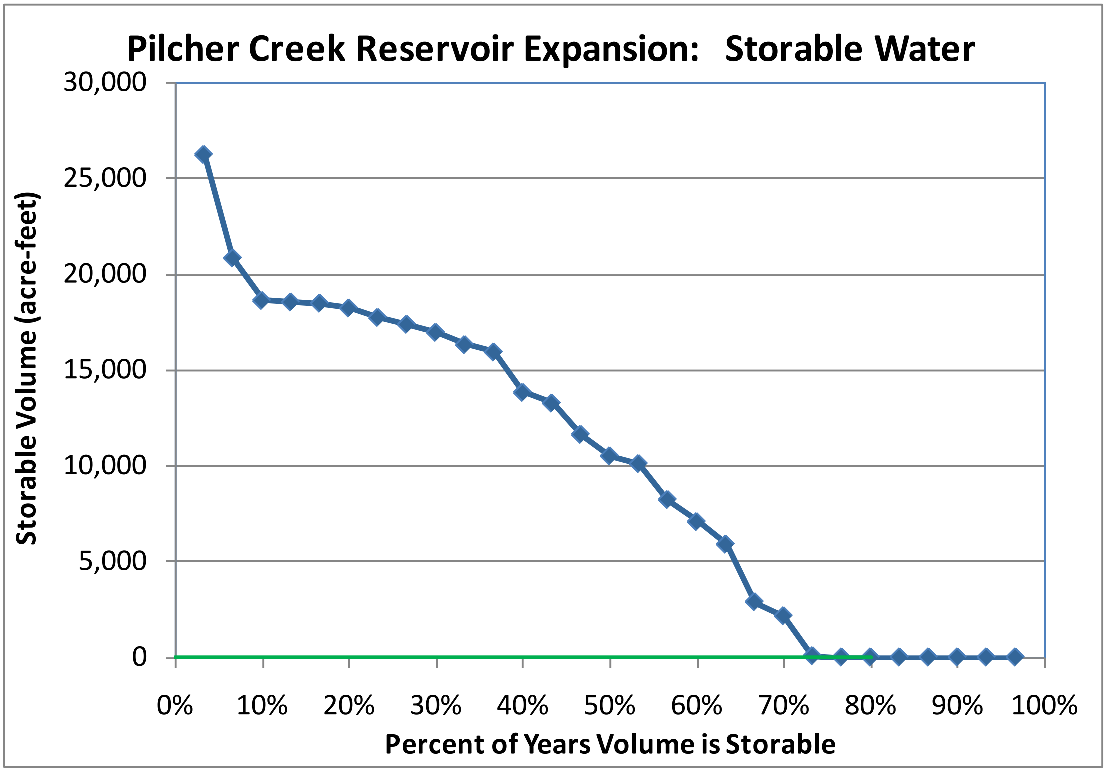

Figure 4-61. Pilcher Creek Reservoir expansion storable water frequency

Model Results

The results of the model run indicate that the Pilcher Creek Reservoir expansion does not warrant further investigation in this appraisal study. Based on 80-percent fill reliability, this project fails to satisfy the established screening criteria.

4.4.6 Proposed East Pine Reservoir – Pine Creek

Project Description

The proposed East Pine Reservoir site is located on the South Fork of the Burnt River approximately 8 miles upstream (southwest) from Unity Reservoir and 5 miles west of the community of Unity, Oregon (see Figure 4-15). The proposed dam and reservoir are located on land that is privately owned and land owned by the U.S. Forest Service.

Storable Volume and Reliability Modeling

The proposed East Pine Reservoir is shown in the model network in Figure 4-16. For the period of record modeled, the East Pine Reservoir site has an estimated average annual flow volume of 16,500 acre-feet per year, as shown in Figure 4-62. Over the same time period, Figure 4-63 illustrates the storable volume a reservoir located at this site would accumulate.

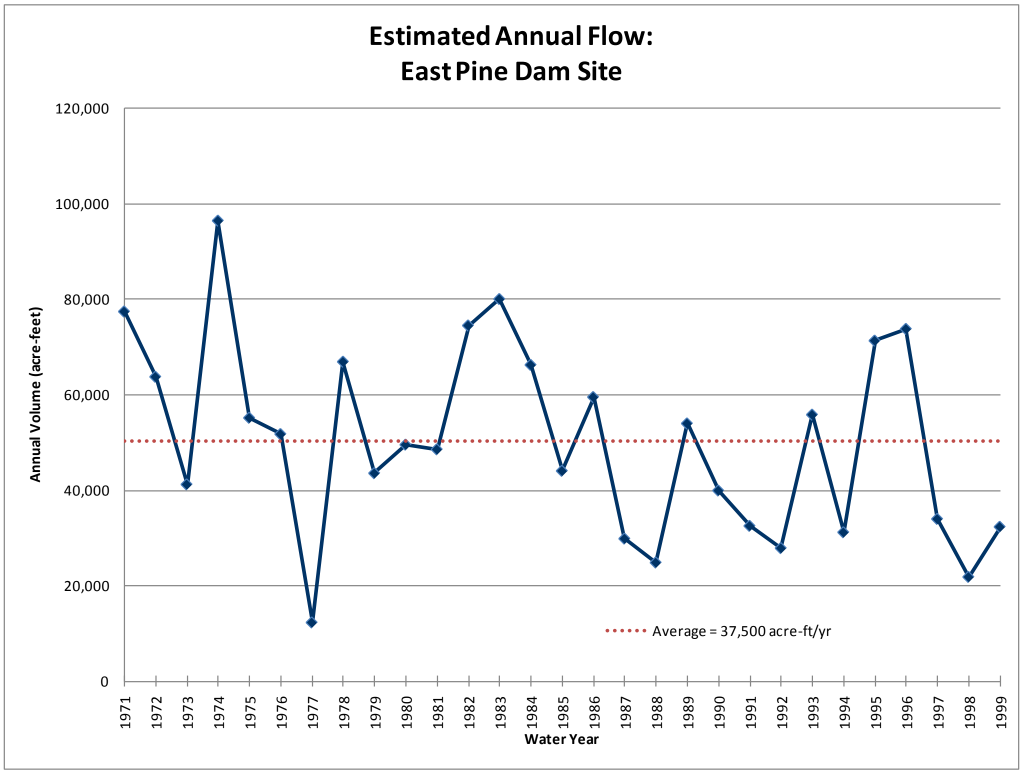

Figure 4-62. Annual water volume at proposed East Pine Reservoir site

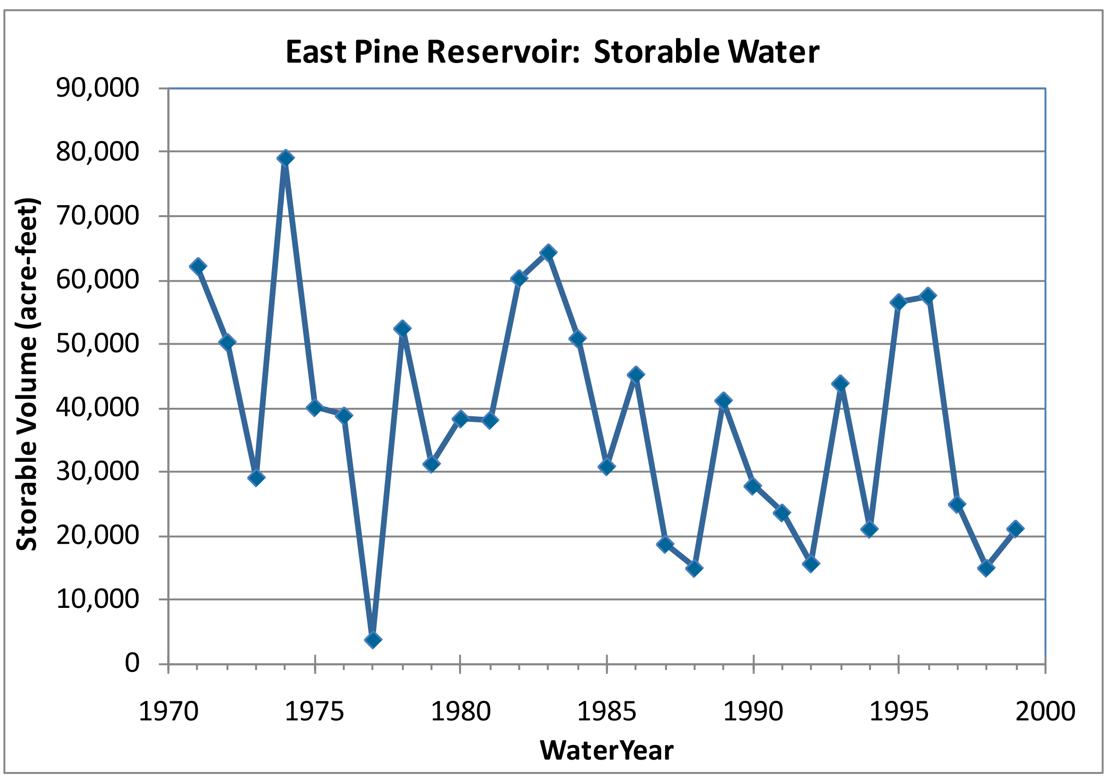

Figure 4-63. Annual storable water at proposed East Pine Reservoir site

The storable water volumes were ranked and plotted in Figure 4-64.

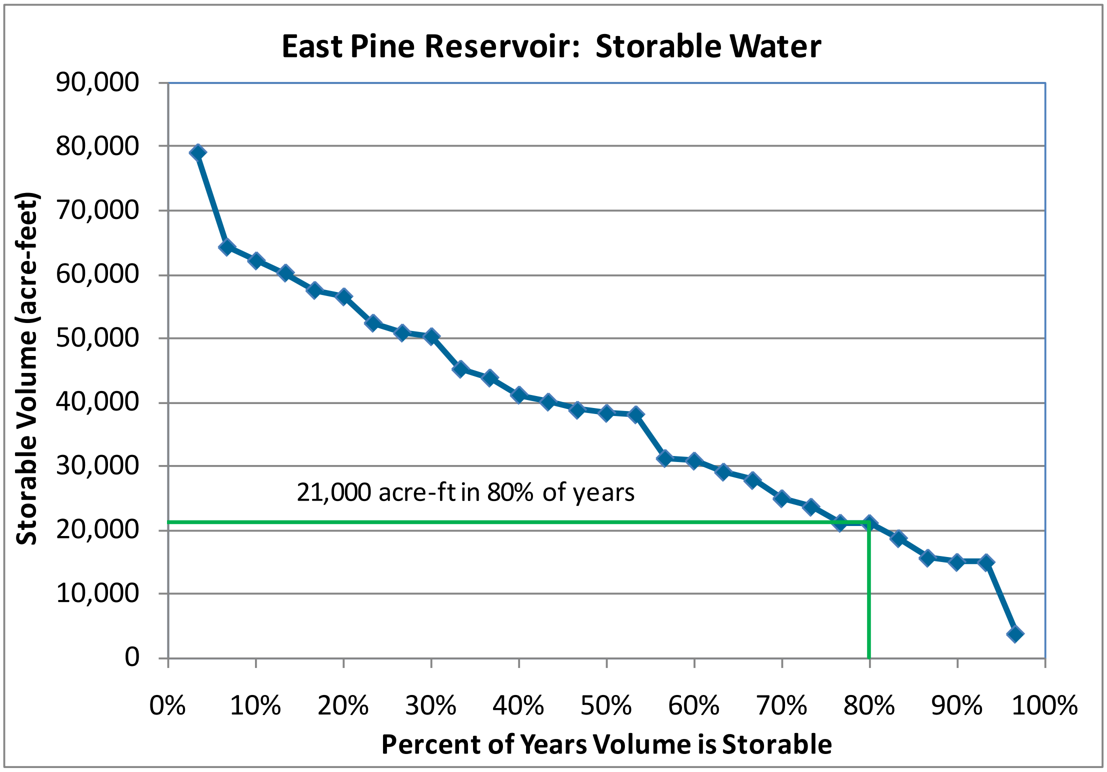

Figure 4-64. Proposed East Pine Reservoir storable water frequency

Storage Model Results

The 80 percent storable volume was selected as a reliable volume for the proposed reservoir and was used for the additional hydrologic and water supply yield assessment. The right to store water within this proposed reservoir enlargement would be based on a 1992 priority water reservation filed by the ODWR. The storage right was assumed to be junior to all of the other current water right holders.

As a result of this analysis, the 80 percent reliable volume for the East Pine Reservoir is 21,000 acre-feet. The estimated inundation area is shown in Figure 4-65 and was determined by utilizing the natural topography contours and an assumed dam height to accommodate the proposed volume results. At this time, the inundation limits illustrated also do not assume any significant inactive storage volume reserved for recreational or fisheries benefits.

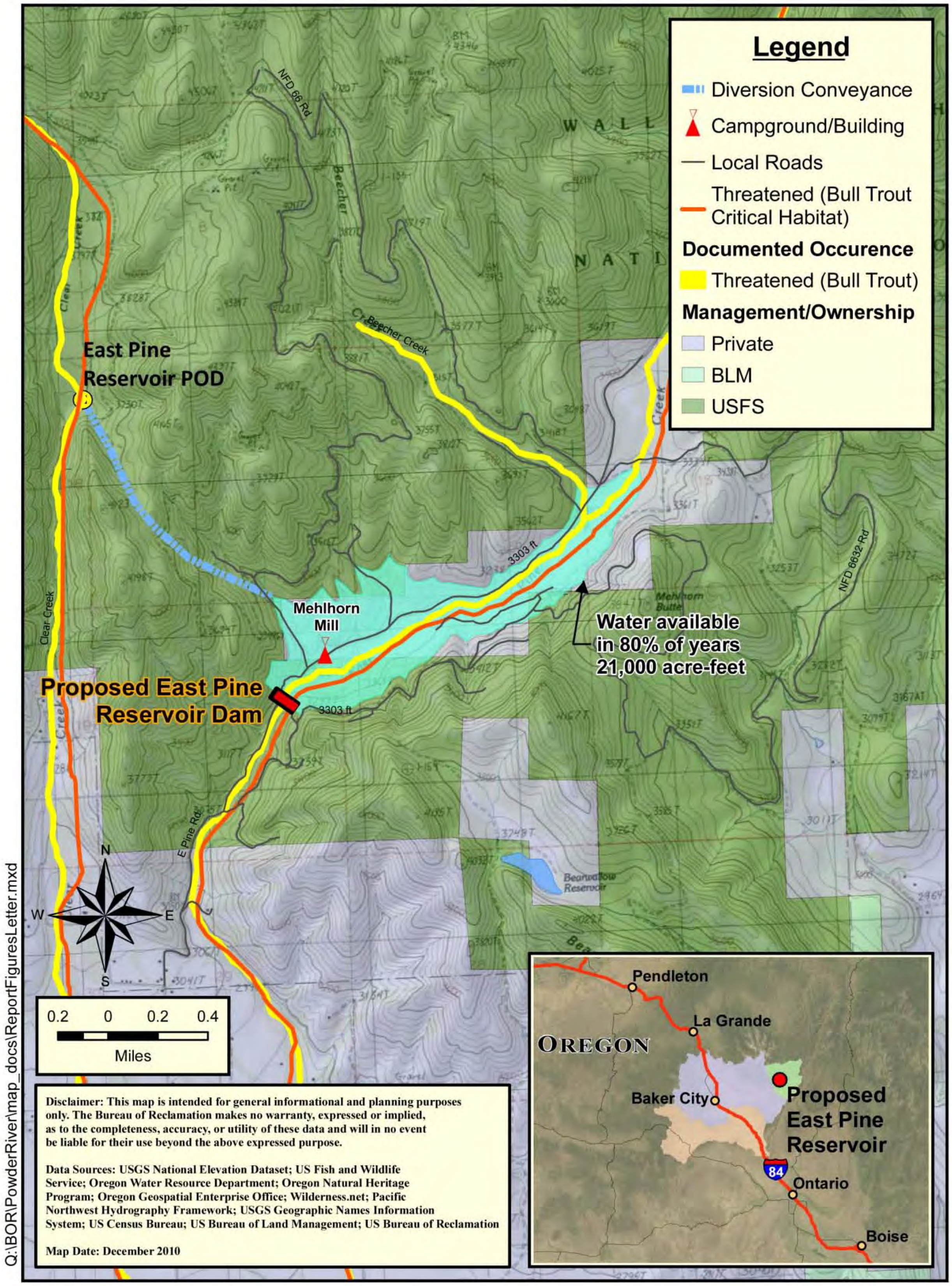

Figure 4-65. Proposed East Pine Reservoir location map

Alternatives Analysis Model Configuration

A model configuration was developed to incorporate the proposed reservoir. Table 4-16 presents the applicable model assumptions and constraints defined for the alternatives analyses. Other model assumptions defined in the calibrated baseline model and not shown here, remain unchanged.

Table 4-16. East Pine Reservoir analysis model constraints

Constraint	Baseline Configuration	East Pine Reservoir
Reservoir Capacity (acre-feet)	Not applicable	21,000
Reservoir Depth (feet)	Not applicable	221
Minimum Flow Target below dam (cfs)	Not applicable	5
Annual Irrigation Demands	No change	No change

The water stored in the proposed reservoir was assigned a low priority setting to keep it from adversely impacting existing water right holders with senior rights. Irrigation demand was allowed to draw water from the proposed reservoir, as needed, to reduce shortages. This analysis was simulated for the 29-year study period of record (1971-1999).

Alternatives Analysis Model Results

Figure 4-66 shows the maximum water volume stored for each water year modeled. This figure illustrates the years when the proposed reservoir filled or failed to fill. Figure 4-67 and Figure 4-68 show the volume of water supplied from storage with the proposed reservoir expansion. The estimated water supplied from the proposed East Pine Reservoir was calculated from the results of the MODSIM models as the difference in shortage under existing conditions (without the proposed reservoir) and with the proposed reservoir.

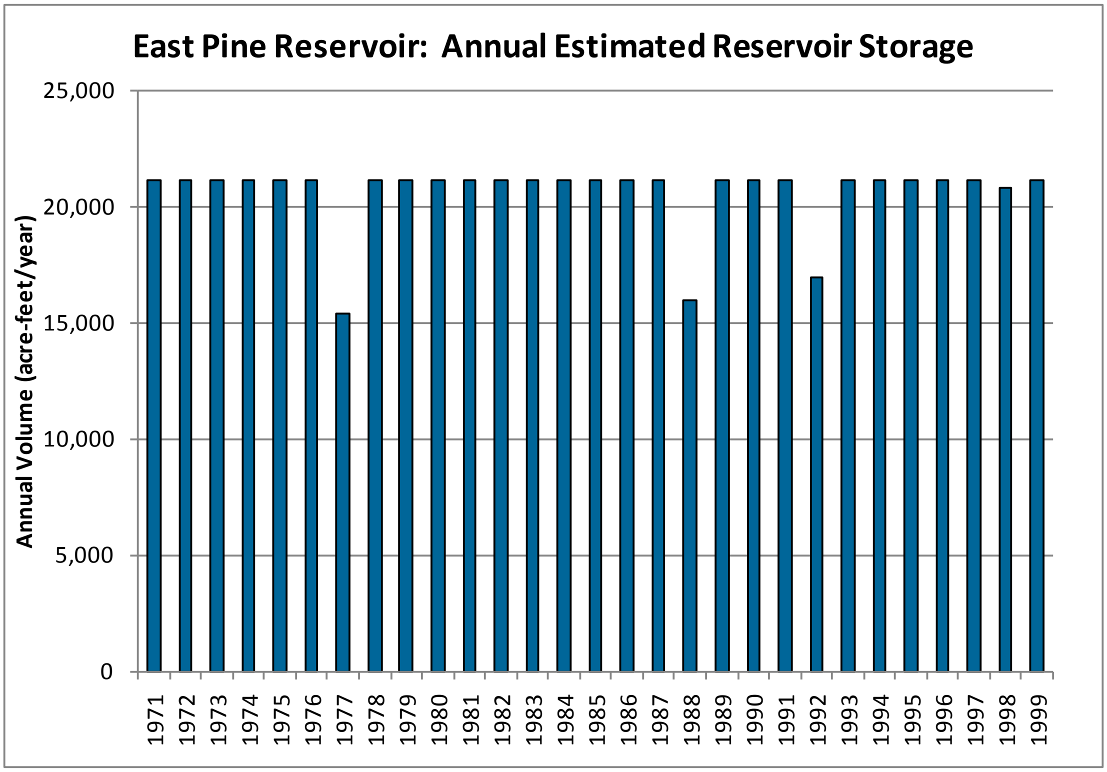

Figure 4-66. Estimated maximum volume of water stored in proposed East Pine reservoir for each water year

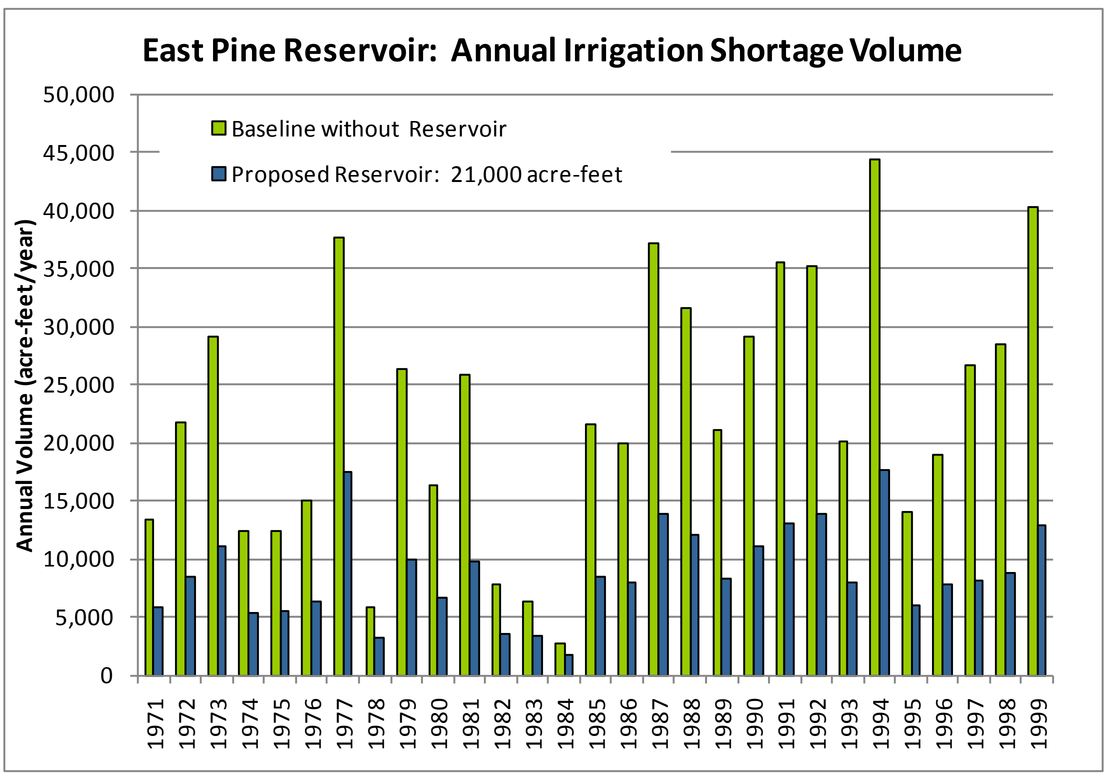

Figure 4-67. Estimated irrigation shortage with and without the proposed East Pine Reservoir

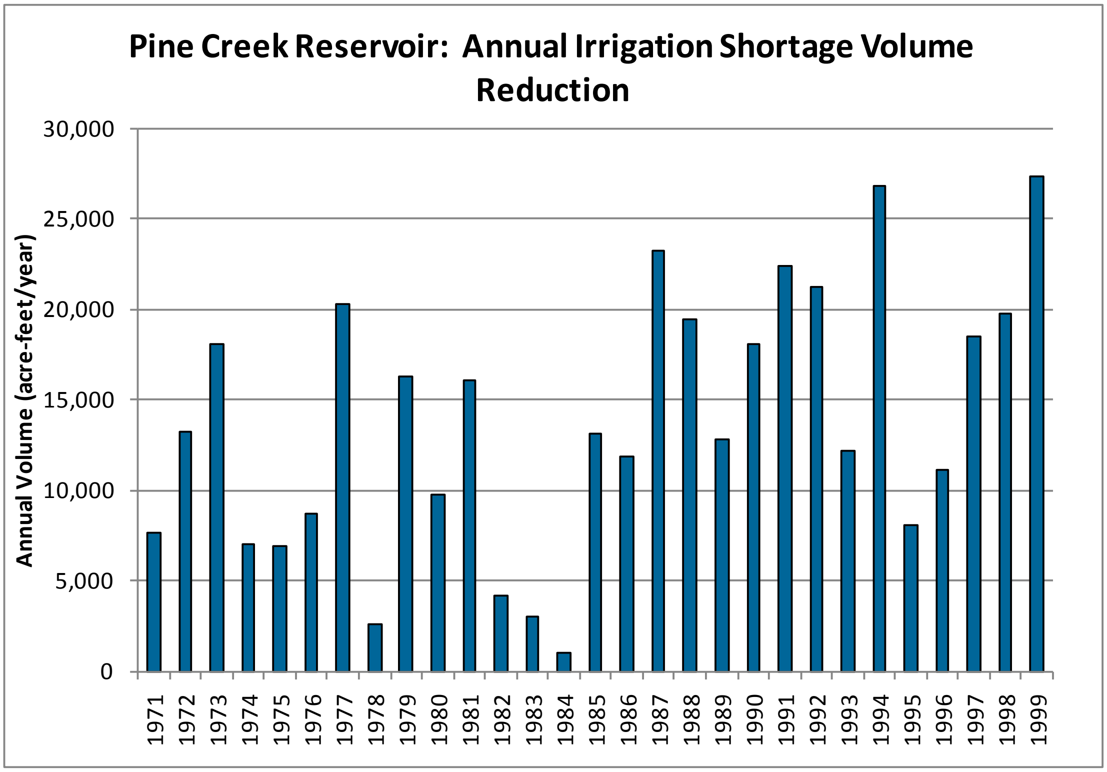

Figure 4-68. Estimated reduction in annual irrigation shortage within the Pine Creek Basin with the proposed East Pine reservoir

It should be noted that in a few years, the irrigation shortage reduction is greater than the 21,000 acre-feet of available storage in the proposed reservoir (Figure 4-68). The additional shortage reduction is an artifact of conceptually locating the conveyance piping upstream of the dam structure to divert water necessary to meet a portion of the basin's irrigation demand. This allows the model to divert water in order to satisfy those irrigation demands in proximity to the reservoir, and if enough water is available, to store the excess within the reservoir to meet the demands downstream of the project. Therefore, based on this concept and configuration in the model, the reduction in irrigation demand shortages exceeded the reservoir capacity of 21,000 acre-feet.

The proposed reservoir results in a change to the hydrograph of the flow downstream of the project (Figure 4-69). Figure 4-70 illustrates the current hydrology pattern and the modeled demand pattern in proximity of this site. This figure also illustrates the timing differences in flow between the run-off pattern and irrigation demand pattern. Downstream flows are lower in October through March for the proposed reservoir condition compared to existing conditions (without the proposed reservoir). The lower flows during this period represent water being stored in the reservoir (Figure 4-71). Conversely, downstream flows are higher in April through September for the proposed reservoir compared with existing conditions. An instream flow right filed by the State was set as a minimum flow target. At this location, the assumed target was 5 cfs. Water stored is released during the irrigation season in response to irrigation demand and the assumed 5 cfs minimum flow target. The assumed 5 cfs minimum release requirement below the reservoir was a target flow condition, set in the MODSIM model. It was satisfied most of the time except for the month of October in most years.

The change in the hydrograph not only occurs below the proposed reservoir, but also changes the flow (to a lesser extent) from Pine Creek to the Snake River. Figure 4-72 shows the average monthly flow in Pine Creek near the confluence with the Snake River.

Overall, the proposed reservoir changes the hydrograph and reduces the shortage for irrigation water demand below the reservoir compared to existing conditions. The 21,000 acre-feet of additional storage in the system reduces the irrigation shortage by approximately 13,800 acre-feet with a net reduction in water volume that reached the Snake River of 8,100 acre-feet between the proposed reservoir model configuration and existing baseline condition (Figure 4-17). This net reduction is the result of the irrigation diversions reusing irrigation return water passing through the system.

While the proposed East Pine Reservoir could provide recreational and environmental benefits, the results of the MODSIM model simulations indicated that there would not be enough water to reliably satisfy additional demands beyond those currently included. The simulation did not assume any significant inactive storage volume that would be reserved in storage for recreational or fisheries benefits. The reservoir could be sized to hold water in inactive storage. However, the result would be either reduced annual water supply benefits or a larger reservoir in order to produce the same benefits.

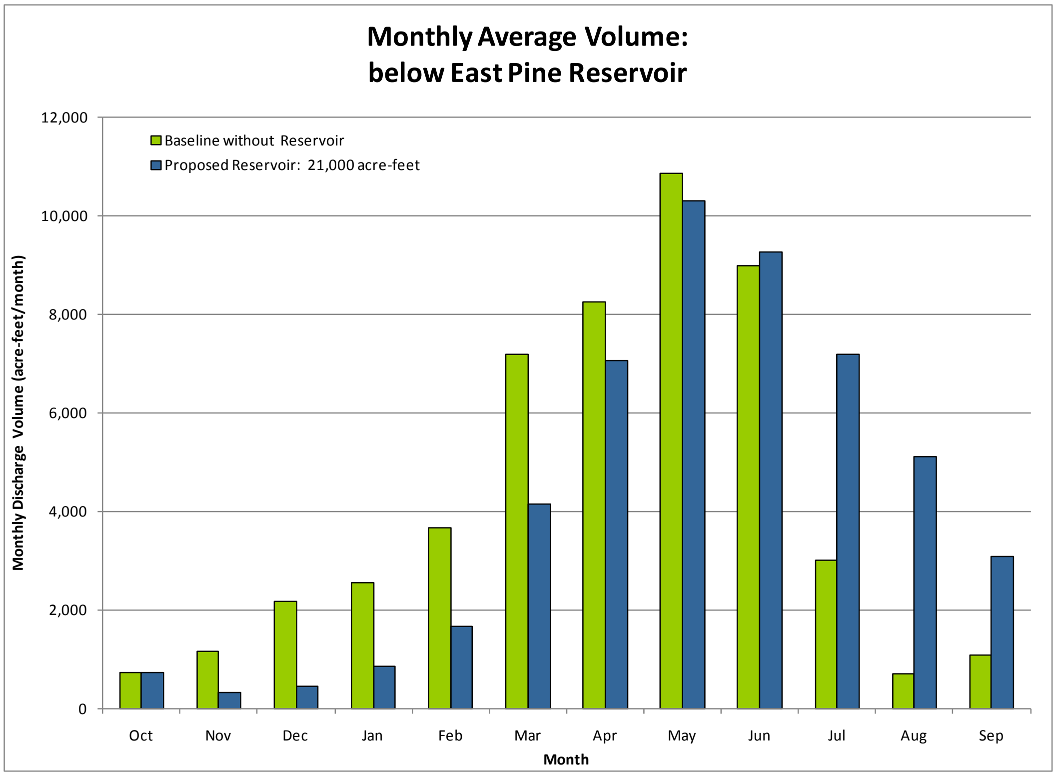

Figure 4-69. Estimated monthly average flow below the proposed East Pine Reservoir

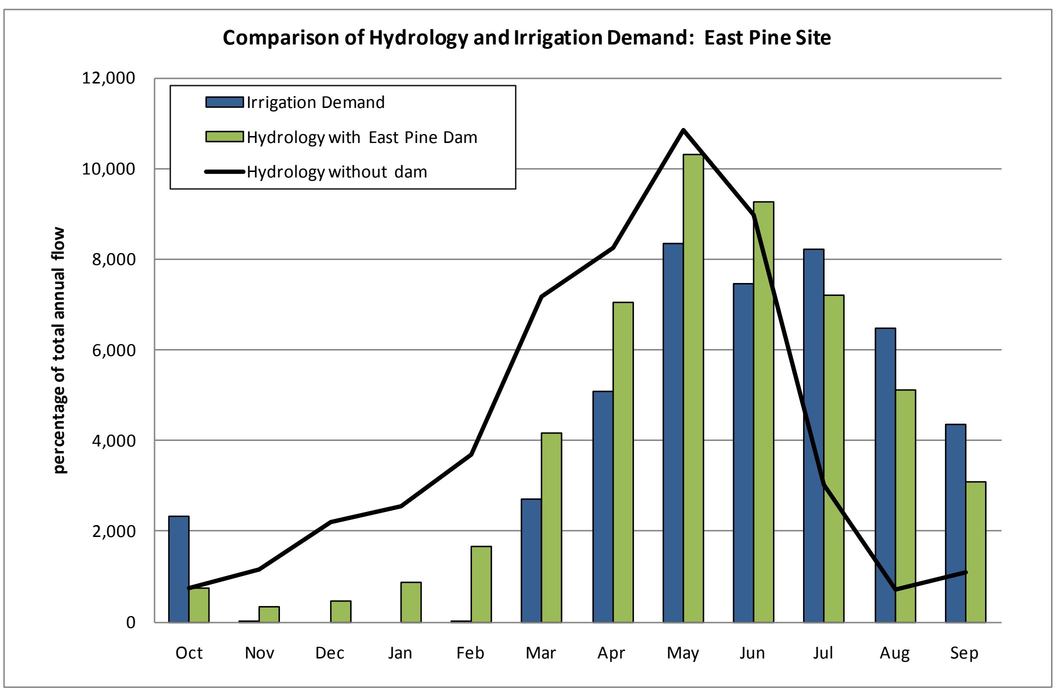

Figure 4-70. Estimated monthly average flow below the project and irrigation demand located below the proposed East Pine Reservoir

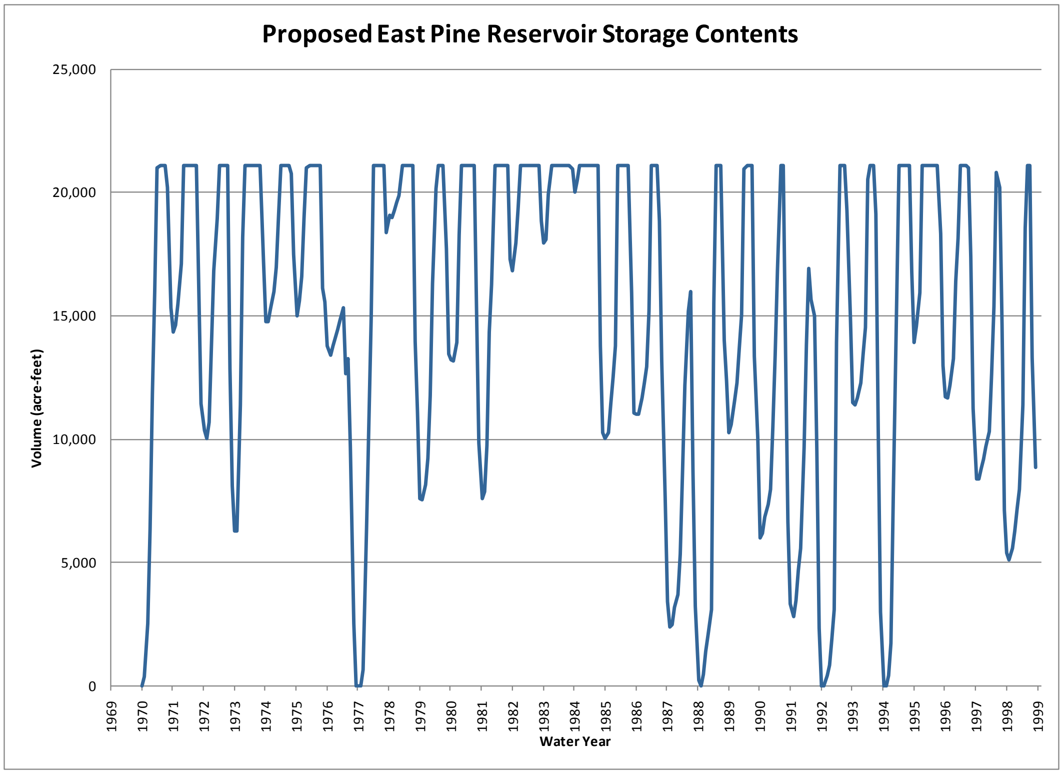

Figure 4-71. Modeled storage contents of proposed East Pine Reservoir

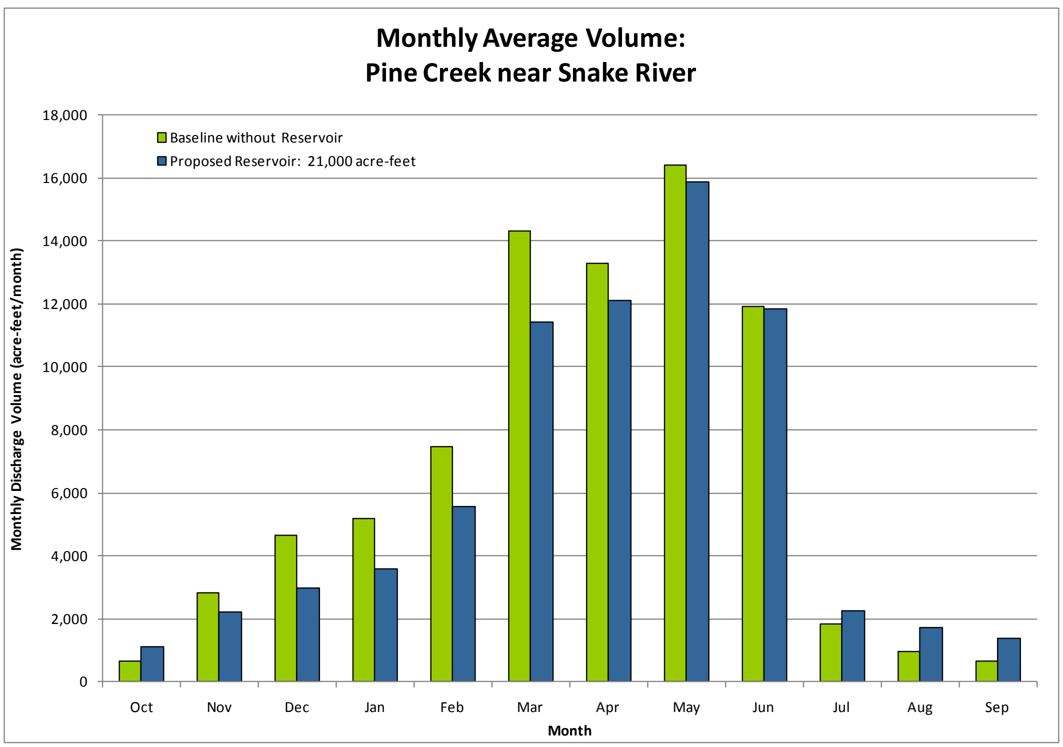

Figure 4-72. Estimated monthly average flow in Pine Creek near Snake River confluence with the proposed East Pine Reservoir

Table 4-17. East Pine Creek Alternative Summary Table

Irrigation Shortages Modeled Water Years: 1971 - 1999:						
Average Annual Irrigation Shortage Baseline Condition (acre-feet/year)						22,652
Average Annual Irrigation Shortage with East Pine Reservoir (acre-feet/year)						8,840
Average Annual Irrigation Shortage Reduction (acre-feet/year)						13,812
	Monthly Average Flow at Reservoir Site Model Water Years: 1971 – 1999			Monthly Average Flow on Pine Creek near Snake River Model Water Years: 1971 – 1999		
Month	Below East Pine Reservoir (acre-feet/month)	Baseline Condition (acre-feet/month)	Difference	With East Pine Reservoir (acre-feet/month)	Baseline Condition (acre-feet/month)	Difference
October	740	735	6	1,096	652	444
November	331	1,172	(842)	2,232	2,845	(613)
December	458	2,188	(1,730)	2,973	4,654	(1,680)
January	870	2,547	(1,677)	3,570	5,198	(1,628)
February	1,679	3,678	(1,999)	5,549	7,457	(1,908)
March	4,159	7,185	(3,027)	11,424	14,306	(2,882)
April	7,053	8,259	(1,206)	12,098	13,282	(1,184)
May	10,313	10,848	(536)	15,881	16,409	(528)
June	9,254	8,987	268	11,831	11,917	(86)
July	7,194	3,011	4,183	2,256	1,823	433
August	5,105	701	4,403	1,725	956	769
September	3,087	1,092	1,996	1,371	640	731
Average Annual Change (acre-feet/year)			(161)			(8,133)

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Chapter 5 COST EVALUATION OF ALTERNATIVES

5.1 General

An appraisal-level engineering analysis was conducted on four proposed reservoir locations selected by the stakeholder work group which met Reclamation's reliability objectives. The analyses included developing conceptual designs for storage and hydropower, developing order of magnitude cost opinions, and identifying environmental implications associated with each proposed facility. The following proposed reservoirs or existing reservoir expansions were analyzed:

- Burnt River basin
  - Hardman Reservoir
- Powder River basin
  - Thief Valley Reservoir enlargement
  - North Powder Reservoir
- Pine Creek basin
  - East Pine Reservoir

5.2 Overview of Cost Evaluation Process

5.2.1 Conceptual Design of Storage Facilities

The conceptual design phase of the appraisal study for the selected storage locations consisted of three steps: review of available literature, a field visit, and selection of the general configuration and layout for the storage structures (e.g., height, slope, material, cross-section, abutments, spillway, outlet works). Following are summaries of each step:

Literature Review:

- Reviewed several past project studies for applicable information, including studies for:
  - Hardman Reservoir, prepared by Reclamation (Reclamation1965) and the U.S. Forest Service (USFS 1967)
  - Thief Valley Reservoir enlargement, prepared by Reclamation (Reclamation 2001a)

  - North Powder Reservoir, prepared by Powder Valley Water Control District (PVWCD 1980), Browne Consulting (Browne 2008), and Baker Valley Soil and Water Control District and Powder Valley Water Control District (BVSCD 1967)
  - East Pine Reservoir, prepared by Pine Valley Soil and Water Conservation District (PVSCD 1976), Eagle Valley Soil and Water Conservation District and Pine Valley Water Control District (EVSCD 1968a) (EVSCD 1968b) (EVSCD 1978)

- Reviewed available USGS topographic maps (USGS 1991) to assist in site assessment of storage capability and selection of potential location and configuration
- Reviewed USGS Interactive Probabilistic Seismic Hazard Maps (USGS 2008) to determine the approximate level of seismic loading for a Maximum Creditable Earthquake for each site
- Reviewed existing conceptual designs to help establish foundation conditions. The five sites all had been assessed in the past and some foundation data were available.
- Reviewed existing conceptual designs to assist in determining location, alignment, and configuration for the dams to be evaluated in this study

Field Visit:

- Visited the selected sites and storage basins
- Identified potential hazards that might make the location unusable or uneconomical
- Selected spillway and outlet works locations based on observed conditions
- Evaluated information on site access, local borrow material, and local availability of construction materials
- Assessed conceptual-level constructability to evaluate whether a project could be safely and economically constructed at each site

Selection of the Configuration and Layout of Structures:

- Selected location of the dam, spillway, and outlet works based on information from the review of available documents and observations made during the site visit
- Selected the maximum height from foundation to crest of potential dams based on available storage elevation curves and basin configuration
- Selected maximum height for each dam
- Selected structural configuration that was considered compatible with observed site conditions and available resources

5.2.2 Conceptual Design of Hydropower Facilities

Simple computations were performed to determine the potential hydropower generation capabilities at the proposed storage sites. Calculations were performed for each of the five alternative scenarios analyzed. Equation 1 was used to compute plant capacity in MW (Table 5-1).

$$P = \frac{\left(62.4\frac{lb_m}{ft^3}\right)\left(32.2\frac{ft}{s^2}\right)(Qh)}{\left(32.2\frac{lb_m \cdot ft}{lb_f \cdot s^2}\right)\left(550\frac{ft \cdot lbf}{hp \cdot s}\right)\left(1{,}341\frac{hp}{MW}\right)}$$

(Equation 1)

Where:

Q = maximum average monthly flow through project (cfs)
h = maximum reservoir water surface elevation at maximum average monthly flow (feet)

The maximum average monthly flow was used in the computations. This assumption was used in an attempt to determine the approximate size of a power plant. Additional daily data are necessary to refine these computations and compute frequency of spill past the powerhouse. However, they represent an order of magnitude approximation applicable to this appraisal analysis.

Table 5-1. Power plant sizing for the Alternative Analysis

Parameter	Hardman	Thief Valley Expansion		North Powder	East Pine
		Alternative 1	Alternative 2		
Maximum h (feet)	92	110	110	169	221
Maximum Q (cfs)	80	1195	1280	360	380
Unit Efficiency (%)	80	80	80	80	80
Calculated Plant Capacity (MW)	**0.5**	**9**	**10**	**4**	**6**

The model output from each scenario provided monthly flow through the project and reservoir water surface elevations. Computations were performed to determine the potential for hydropower generation at the proposed storage sites. Table 5-2 presents the annual total MWh generation for each of the alternative analyses. It should be noted that these calculations do not reflect a specific turbine unit or other design considerations that may change the annual generation values shown in the table.

An overall efficiency of 70 percent was assigned to the hydropower computation to include the total flow passing through the project as generating power as a result of the model's monthly time step. In reality, spill, flow that is not passed through the powerhouse turbines, occurs at hydropower projects. The quantity of spill was not differentiated from the modeled output for this analysis.

As a result, these values should be interpreted as a means of making relative comparisons between the scenarios and in providing an approximate order of magnitude of generation potential of the alternatives based on the physical characteristics of the proposed sites.

The following assumptions were also used in the computations:

- Hours per month = 720
- Overall project efficiency = 70 percent

Table 5-2. Annual generation for the proposed alternative

Water Year	Hardman (MWh)	Thief Valley Expansion		North Powder (MWh)	East Pine (MWh)
		Alternative 1 (MWh)	Alternative 2 (MWh)		
1971	909	14,904	17,110	9,304	9,632
1972	905	16,214	18,516	7,895	10,358
1973	395	5,320	7,354	1,156	6,630
1974	912	14,401	16,831	8,515	13,486
1975	990	16,013	18,320	7,812	8,443
1976	875	11,790	13,982	5,634	8,148
1977	455	3,631	5,603	236	2,886
1978	425	4,212	6,516	3,348	7,247
1979	561	9,684	12,118	5,388	8,314
1980	629	10,261	12,501	6,894	6,703
1981	756	12,146	14,441	6,831	8,019
1982	1,053	21,599	23,880	9,951	9,983
1983	1,324	21,771	24,111	8,160	12,306
1984	1,303	25,124	27,439	9,746	10,075
1985	1,074	12,373	14,659	4,424	8,235
1986	715	10,836	12,833	5,352	8,817
1987	493	3,814	5,932	549	5,190
1988	264	1,985	2,839	398	3,086
1989	728	5,183	7,624	3,427	6,286
1990	464	3,141	5,112	574	6,489
1991	350	2,396	3,941	2,032	4,758
1992	196	1,735	2,766	92	3,619
1993	666	5,099	7,533	4,803	6,558
1994	281	3,246	5,018	790	5,766
1995	568	5,295	7,701	3,571	8,579
1996	815	14,026	16,248	7,173	11,708

Water		Thief Valley Expansion		North	East Pine
1997	997	16,211	18,626	7,533	5,461
1998	932	12,782	15,048	5,785	3,329
1999	874	13,782	16,023	5,285	4,465
Annual Average	**721**	**10,309**	**12,435**	**4,919**	**7,399**

The calculated, annual average energy required for the Alternative 2 pumping plant, located downstream of the expanded Thief Valley reservoir, for the period of record modeled was approximately 3,500 MWh. This value was based on the following assumptions to satisfy the approximately 30,000 acre-feet/year of existing irrigation demand located upstream of the reservoir:

- Pump lift required = 150 feet
- Pump efficiency = 80 percent

Interestingly, the additional annual generation through Thief Valley as a result of delivering water to the downstream pumping plant does not compensate for the energy necessary to deliver the irrigation water to upstream demands. The difference between Alternative 1 and Alternative 2 is, on average, 2,045 MWh per year.

The effect of the proposed reservoir to the system-wide power generation was not analyzed in detail as part of this appraisal-level study. A detailed valuation of the foregone generation was not performed; however, a general order of magnitude assessment of annual lost energy potential for the Snake River projects is presented.

The following Table 5-3 presents the general generation capabilities for the dams located on the Snake and Columbia Rivers. In addition, the potential change in generation for each of these projects is presented for each analyzed alternatives. This table is designed to represent the overall average annual difference in potential power generation between the alternatives and the existing Snake and Columbia River dams.

Assumptions used to compute generating capacity at the Hells Canyon Complex are listed below (Idaho Power 2003):

- Brownlee Reservoir Elevation: 2050 feet above mean sea level
- Hells Canyon Reservoir Elevation: 1688 feet above mean sea level
- Hells Canyon Tailrace: 1475 feet above mean sea level
- Overall Plant Efficiencies: 80 percent

Table 5-3. Generation Comparison

Estimated Annual Generation		Thief Valley Expansion		North Powder	Hardman	East Pine
		Alternative 1	Alternative 2			
Water Volume Change to Snake River with Alternatives (acre-feet/year)		(20,100)	(20,300)	(2,600)	(1,000)	(8,100)
Potential Generation of Alternatives		**10,309 MWh/year**	**12,435 MWh/year**	**4,919 MWh/year**	**721 MWh/year**	**7,399 MWh/year**
Snake and Columbia River Projects	kW/cfs	MWh /year	MWh /year	MWh /year	MWh /year	MWh /year
Hells Canyon Complex	39.6	(9,631)	(9,727)	(1,246)	(479)	
Hells Canyon Dam only	14.4					(1,411)
Lower Granite Dam	7.3	(1,775)	(1,793)	(230)	(88)	(715)
Little Goose Dam	7.2	(1,751)	(1,769)	(227)	(87)	(706)
Ice Harbor Dam	7.4	(1,800)	(1,818)	(233)	(90)	(725)
Lower Monumental Dam	7.2	(1,751)	(1,769)	(227)	(87)	(706)
McNary Dam	5.2	(1,265)	(1,277)	(164)	(63)	(510)
John Day Dam	7.7	(1,873)	(1,891)	(242)	(93)	(755)
The Dalles Dam	6.3	(1,532)	(1,547)	(198)	(76)	(617)
Bonneville Dam	4.4	(1,070)	(1,081)	(138)	(53)	(431)
Total Change in Snake and Columbia Rivers Generation Potential (MWh/year)		**(22,400)**	**(22,700)**	**(2,900)**	**(1,100)**	**(6,600)**
Overall System Change in Gross Generation between Alternatives and the Snake and Columbia River Projects (MWh/year)		**(12,100)**	**(10,200)**	**2,000**	**(400)**	**800**

It should be noted that Pine Creek enters the Hells Canyon Complex at Hells Canyon Reservoir. Therefore, the change in volume reaching the Snake River only affects the Hells Canyon Project and not the other upstream reservoirs within the complex.

The modeled results show that the proposed projects have the potential to change the quantity and timing of flows reaching the hydropower projects located on the Snake and Columbia Rivers. Modeling also suggests that some of the alternatives demonstrate a potential net increase to overall power production.

This perceived energy surplus must be studied further in order to demonstrate that the computed local benefit does not negatively impact the overall stability and reliability of the rest of the system. Operational constraints of the existing projects, located on the Snake and Columbia Rivers, were not considered in this analysis. The change in monthly timing and quantity of flow from the alternatives may ultimately impact regional generation such that a net loss in overall power generation results. It should be noted that this appraisal level analysis provides a gross approximation of generation capabilities for comparative purposes and requires further evaluation to quantify regional power impacts in more detail.

The proposed reservoirs are shown with their spatial relationship to main transmission lines (Figure 5-1). The location of these transmission lines were obtained from available maps and are approximate. A transmission line (not shown in Figure 5-1) is proposed to be added by others within close proximity to the existing Thief Valley reservoir. This proposed line was used for cost calculations. Hookup requires a formal application process as a generator requesting interconnection with the local utility.

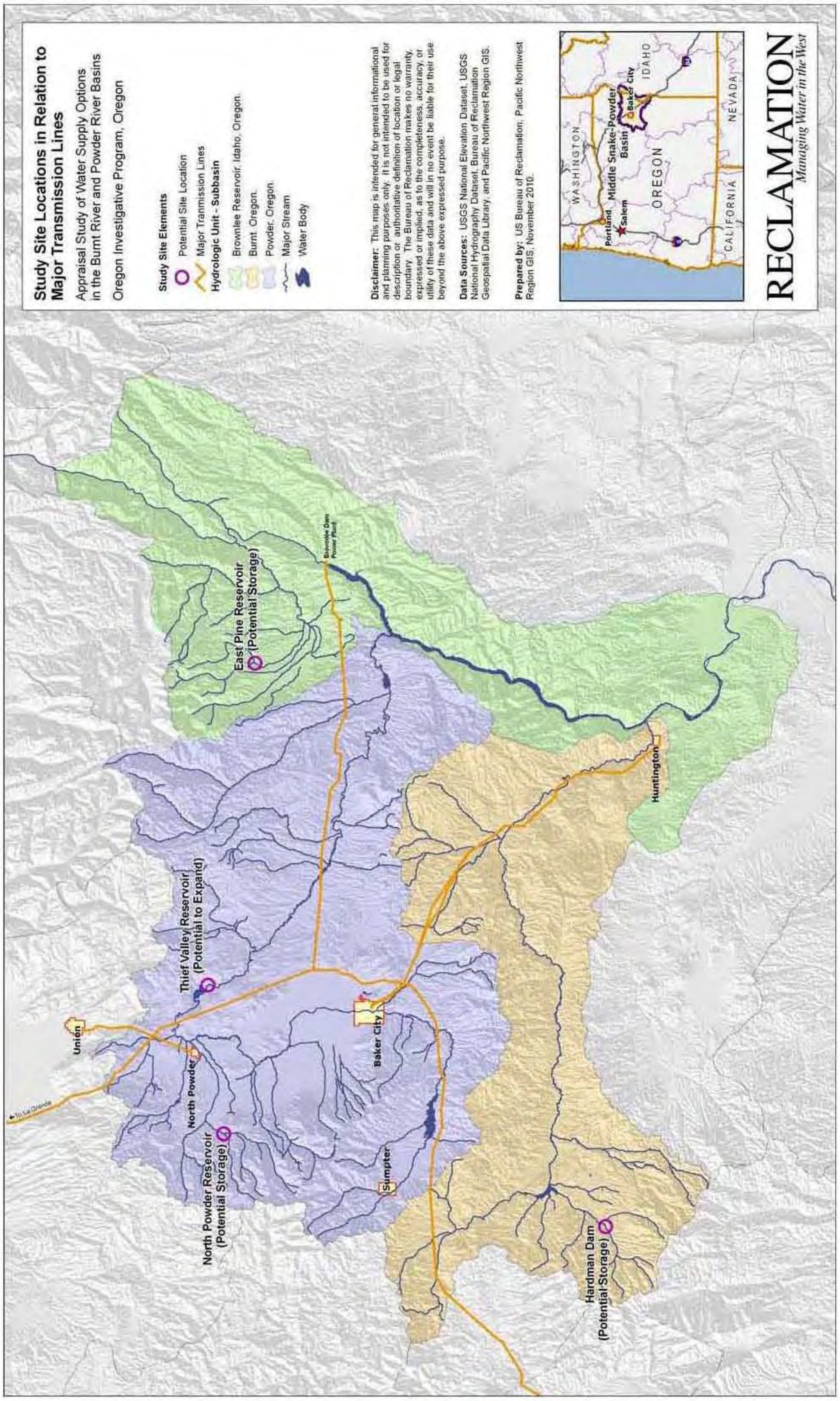

Figure 5-1. Existing transmission lines within study area

5.2.3 Cost Estimation

The total appraisal-level construction cost estimate is the estimated direct cost for a contractor to provide materials, equipment, and labor to build the proposed project, plus indirect costs for the necessary non-construction actions needed before construction can proceed. These indirect costs include site exploration, permitting, engineering design, preparation of plans and specifications, construction supervision, mitigation, contingencies, and indirect/noncontract costs discussed below.

An appraisal-level direct cost estimate for each of the four sites was developed using unit costs where quantities could be easily calculated, and using lump-sum costs for features that would have required significant design effort, such as intake structures, spillways, hydropower, and pumping plants.

Unit and lump-sum direct-cost values were developed from recent estimates for similar projects such as the proposed Mill Creek Dam (HDR 2009), and from available unit costs from the Oregon Department of Transportation database (ODOT 2008). These were also compared with values developed for the proposed North Powder Project prepared by CH2M-Hill and the U.S. Soil Conservation Service for the Powder Valley Water Control District in 1980 (PVWCD 1980). All 1980 costs were indexed to 2009 dollars for comparison to current costs.

Indirect costs were based on U.S. Army Corps of Engineers (USACE) projects and other estimates for similar projects. Indirect costs are estimated to be 32 percent of the direct construction cost (HDR 2009, USACE 2006, and USACE 2008). The indirect cost estimate of 32 percent includes:

- Additional studies (3 percent) – Hydrologic, fish and wildlife, water quality and related data collection to provide more detailed information for future studies and designs; and feasibility studies
- Environmental permitting (9 percent) – Meet National Environmental Policy Act (NEPA) and ESA requirements, secure work in waterways permits and required state and local permits (stormwater management, historical preservation)
- Design (13 percent) – Geologic explorations to better define foundation and material borrow sites; topographic and boundary surveying, pre-design and final design costs and specifications
- Construction management (7 percent) – Construction oversight and inspection

The cost estimates do not include land acquisition costs which, based on projects in the reference materials, were the responsibility of the project sponsors. In this analysis, they were considered as a small part of the direct cost contingency of 30 percent, since much of the underlying land was already owned by the Federal government or irrigation districts, and most of the water rights have been acquired.

The cost development detail is outlined below, with additional information provided in Appendix C:

- A spreadsheet was developed for each location to compute earthwork material quantities for each zone in the dam at selected elevations. The quantities of each item needed to construct each zone at the selected elevation are computed. These quantities are multiplied by the unit cost for each item. These values are summed to provide a total cost to construct the dam to that elevation. The spreadsheet with equations and supporting information is provided in Appendix C.

- Unit costs for embankment materials were developed as discussed above and indexed to 2009 dollars. Adjustments were made based on experience and information obtained during the site visit.

- Unit costs for concrete and roller-compacted concrete were developed based on recent estimates prepared for Mill Creek Dam (HDR 2009) and modified as needed to reflect the location and availability of material.

- Grout curtain cost was based on the unit cost for grouting originally developed by Reclamation for the proposed North Powder Dam foundation (PVWCD 1980) and indexed to 2009 dollars. This cost per linear foot was applied to each proposed project based on the estimated depth and length for each proposed dam.

- Costs for lump-sum construction items at the proposed Hardman and East Pine reservoirs were estimated to be similar to those in an existing conceptual plan for the proposed North Powder Dam (Browne 2008). These costs and similarities apply to the spillway and outlet works, the area to be cleared, and the foundation dewatering plan. The cost estimates for these features on the proposed projects were based on the existing North Powder Project cost estimates and indexed to 2009 dollars.

- Costs for hydropower and related facilities were estimated based on costs prepared by Idaho National Laboratories for similar facilities (INEL 1996).

- Costs for transmission lines were based upon recent costs from the construction of facilities in association with Arrowrock Dam by the Boise Project (Reclamation 2009).

- Relocation costs for roads, highways, utilities, and other facilities at East Pine, Hardman, and Thief Valley were based on a cost of $45 per foot of required relocation, multiplied by the estimated length of the facility being relocated. The costs for relocations of the Anthony Lakes Highway around the proposed North Powder Reservoir were based on Reclamation's original North Powder cost estimate (Browne 2008), indexed to 2009 dollars.

- Fish passage costs are based on feasibility cost estimates for a similar proposed project, Mill Creek Dam (HDR 2009).

- Mobilization and demobilization costs were estimated to be 9 percent of the direct construction cost based on cost estimates for a similar project, Mill Creek Dam (HDR 2009).

- A cost contingency of 30 percent of the direct costs was added to account for uncertainties in unit cost changes, uncertainty of material quantities, and design changes from appraisal estimates that may occur during final design and construction, along with other unexpected items. These contingencies are based on cost variations from similar projects at this level of design (HDR 2008).

In summary, the total project capital cost equals the direct cost, plus indirect costs, where:

- Direct costs include:
  - Construction cost of embankment, spillway, outlet works, grout curtains, relocations, fish passage, conveyance (Pine Creek and Thief Valley only), hydropower facilities and transmission lines, and mobilization/demobilization
  - A contingency of 30 percent of the construction cost, as noted above
- Indirect costs (equal to 32 percent of direct cost) include:
  - Additional technical data collection and feasibility study
  - Environmental permits
  - Design
  - Construction management

Operation, maintenance, replacement, and power (OMR&P) costs were calculated for inclusion in the economic analysis. Information for existing dam and irrigation system OMR&P was used to estimate future costs associated with proposed dam and related structure OMR&P (Reclamation 2011). Costs for hydropower-related OMR&P were obtained from Idaho National Laboratory data (INEL 1996).

5.3 Proposed Hardman Reservoir – Burnt River

5.3.1 Project Description

Location

The proposed Hardman Reservoir site is located on the South Fork of the Burnt River approximately 8 miles upstream (southwest) from Unity Reservoir and 5 miles west of the community of Unity, Oregon. The proposed dam and reservoir are located on land owned by the Burnt River Irrigation District and the U.S. Forest Service (Figure 5-2). The estimated inundation area is determined from the storable volume of the reservoir as presented in Chapter 4.4.1, the dam height (discussed below), and contours of the natural topography.

Topography

The proposed Hardman Reservoir is in a relatively narrow section of the river where a rock ridge protrudes into the river valley. At river level the valley is approximately 150 feet wide. The abutment slopes are very steep at approximately 1:2 vertical to horizontal. Rock is exposed on much of the slopes on both sides and, based on the field visit and a Reclamation geotechnical report (Reclamation 1965); it appears that rock is relatively close to the surface on the valley walls and in the river bottom. The valley bottom at the dam site is approximately 4,240 feet in elevation based on the USGS quadrangle map (Rail Gulch).

Abutment

The right abutment ridge is relatively low and limits the height of the dam to about 4,400 feet elevation (about 160 feet vertical from streambed to crest) unless saddle dams are constructed in the low areas of the right abutment ridge. If constructed to an elevation of 4,400 feet, a relatively inexpensive spillway could be constructed in a saddle located more than 1,000 feet upstream of the dam. Upstream of the proposed dam site the valley widens and flattens, forming a large meadow and increasing the potential storage volume by providing relatively large amounts of storage for incremental height increases.

Foundation

Foundation materials at the proposed dam site are igneous rock. Basalts were observed on the right abutment and its upper slopes. Material on the left abutment appeared similar. Based on the field visit, it appeared that the proposed dam site has been investigated, and records of borings are available (Reclamation 1965). No samples were taken during this field visit. A drawing from the 1965 report (Reclamation 1965) shows basalts, breccias, and agglomerate and tuff units. Access to the location is by a gravel county/U.S. Forest Service road that follows the South Fork of the Burnt River, then, at the dam site, crosses over the right abutment ridge about 1,500 feet south of the proposed location.

Proposed Structure

The proposed Hardman dam and reservoir would include a rock-filled and gravel-filled dam with a central impervious core. Filter zones would be placed upstream and downstream of the impervious zone between the shell and the core material. It was assumed that the upstream embankment would have a slope of 1 vertical to 2.5 horizontal (1V:2.5H) and that the downstream shell would have a slope of 1V:2H (see Figure 5-3). The impervious core was assumed to have upstream and downstream slopes of 1V:0.5H and would extend to rock. The filter zones would be 10 feet wide. A grout curtain would likely be required because of the potential porous nature of the rock.

The intake tower and outlet conduit was assumed to be located on the southeast side of the valley in a rock excavation. The outlet culvert would serve as the diversion during embankment construction. The spillway would be located on the right abutment or in the saddle south of the embankment.

Availability of Materials

It was assumed that the rock fill would come from construction of the spillway and from an on-site quarry; gravel and impervious core material would come from the area upstream of the dam site; and filter materials and concrete would be imported.

Relocations

The existing road would be impacted and would only require relocation where it enters the pool. The U.S. Forest Service South Fork Campground would probably have to be relocated. An irrigation canal that traverses the right abutment would also need to be addressed. A conceptual design for fish passage was not developed for this study. The cost based on estimates for a trap-and-haul at a similar site (HDR 2009).

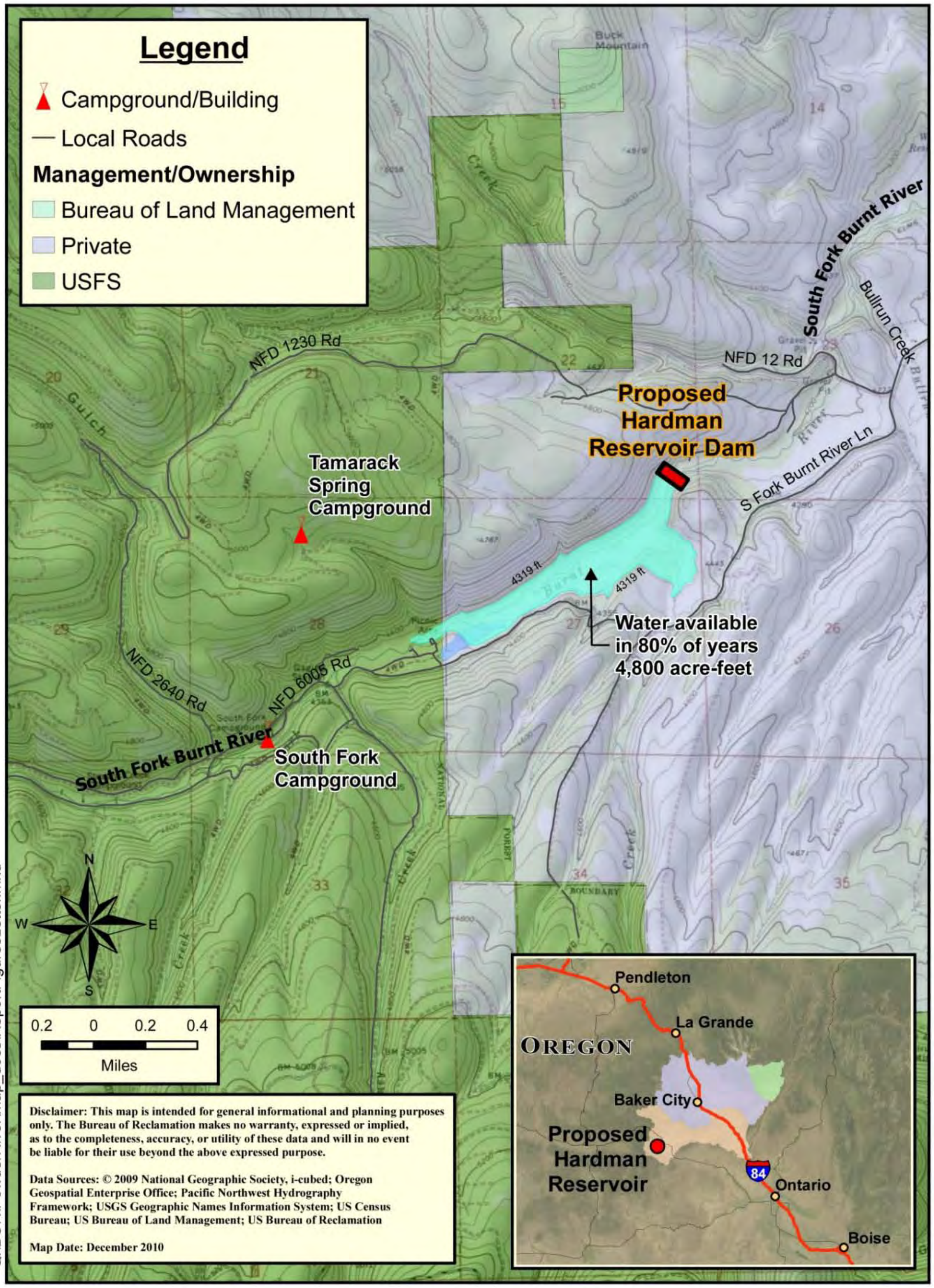

Figure 5-2. Proposed Hardman Reservoir Location Map

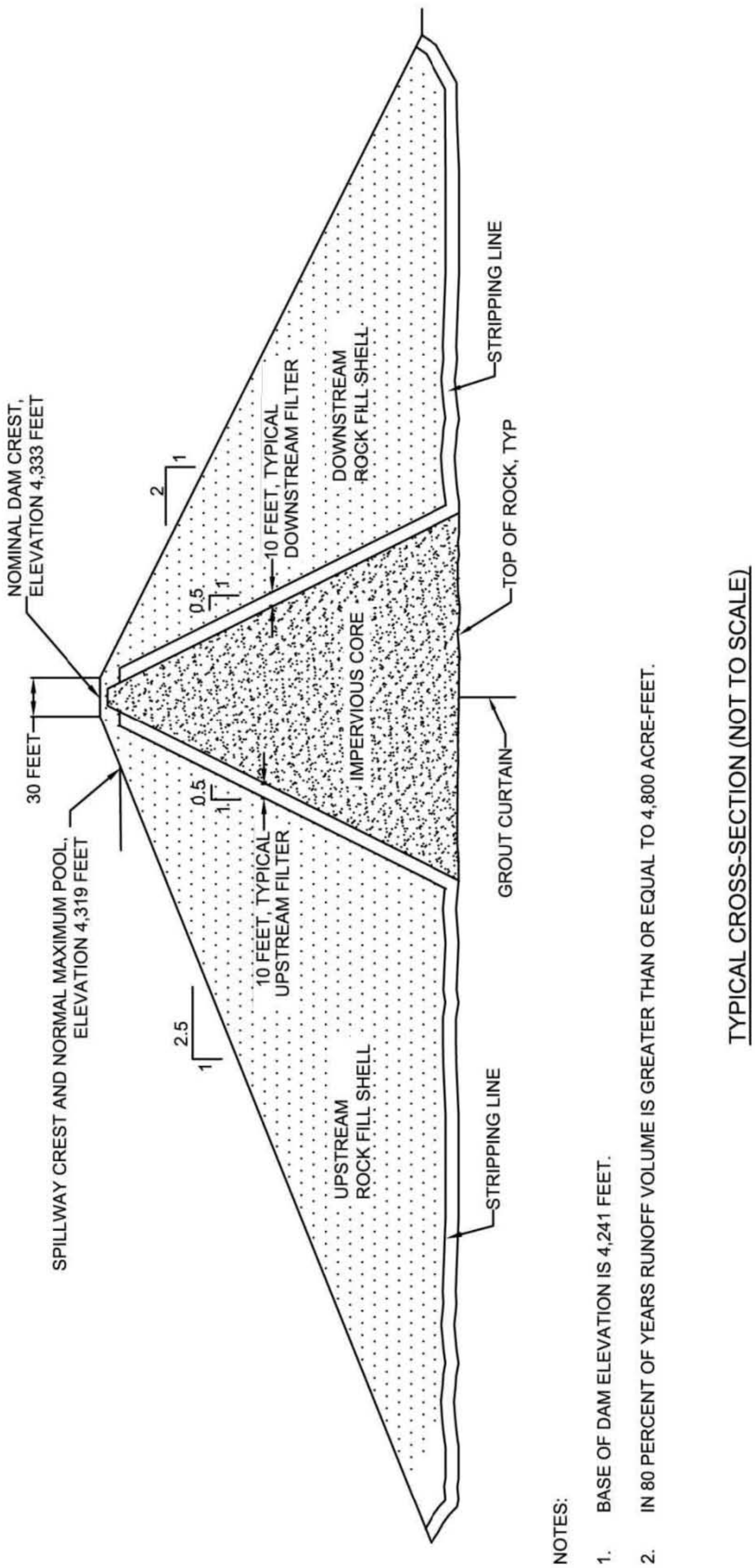

Figure 5-3. Cross-Section of Proposed Hardman Reservoir

5.3.2 Estimated Costs

The estimated cost for the proposed 4,800 acre-foot Hardman Reservoir is about $50 million, as shown in Table 5-4. This estimate includes both the direct and the indirect costs of construction. It does not include the cost for construction of potential hydropower facilities. Table 5-4 also includes costs for a range of different storage levels.

Table 5-4. Proposed Hardman Reservoir Estimated Costs

Crest Elevation	Height above Foundation (feet)	Spillway Elev.	Direct Cost	Direct Cost + Indirect @ 32%	Reservoir Storage (Acre Feet)
4,261	20	4,247	$23,400,000	$30,800,000	-
4,281	40	4,267	$26,400,000	$34,900,000	200
4,301	60	4,287	$30,800,000	$40,600,000	1,200
4,321	80	4,307	$36,200,000	$47,800,000	3,200
4,333	**92**	**4,319**	**$38,100,000**	**$50,300,000**	**4,800**
4,341	120	4,327	$48,600,000	$64,200,000	5,900
4,361	130	4,347	$52,000,000	$68,600,000	9,530
4,371	143	4,357	$57,000,000	$75,600,000	12,400
4,384	160	4,370	$64,100,000	$84,600,000	14,000

Construction of a hydropower facility associated with the 4,800 acre-foot reservoir is estimated to be $1,738,000 in 2010 dollars (INEL 1996) and transmission lines to be $1,360,000 (Reclamation 2011).

Annual OMR&P costs for the proposed dam and related structures are estimated to be $161,040 (Reclamation 2011). Annual OMR&P costs for the hydropower facilities are estimated to be $5,047 and $6,800 for transmission lines (INEL 1996).

5.4 Proposed Thief Valley Reservoir Enlargement – Powder River

5.4.1 Project Description

Location

The existing Thief Valley Dam is located on the Powder River approximately 7 miles east of the community of North Powder, Oregon. The project is owned by Reclamation and operated by the Lower Powder River Irrigation District. The proposed reservoir enlargement is located on land owned by Reclamation and on privately owned land (Figure 5-4). The estimated inundation area was determined from the storable volume of the reservoir as described in Chapter 4.4.2, the dam height (discussed below), and contours of the natural topography.

Topography

At the existing Thief Valley dam site, the river enters a narrow and steep-sided valley (1V:2H) with hard basalt bedrock located close to the surface on the sidewalls of the valley and valley floor. The storage volume is currently estimated to be 13,300 acre-feet, which has been reduced by sedimentation from the original capacity of 17,400 acre-feet. The elevation of the Powder River where it leaves the North Powder River Valley is about 3,190 feet. Water levels at elevation 3,200 feet would begin to encroach on State Highway 237 and the Union Pacific Railroad line, and at approximately elevation 3,225 feet would impact the North Powder sewage treatment ponds.

Abutments

Abutments of hard basalt extend from the valley floor up to about elevation 3,300 feet before flattening, which would allow the dam to be extended to above an elevation of 3,200 feet with no significant changes in configuration. Available information shows the existing structure to be resting against the abutment rock.

Foundation

The existing structure foundation is hard basalt bedrock located close to the surface on the side walls of the valley and valley floor.

Proposed Structure

The existing dam is a 73-foot-high, 420-foot-long concrete slab and buttress structure built in the 1930s. The spillway crest is at elevation 3,133 feet (48 feet above the base of the dam) and is 268 feet wide. The reservoir currently provides about 685 acres of water surface and 10 miles of shoreline when full. The existing site is proposed for use as the core of the proposed enlarged structure, as it highly cost-effective to use the existing facility when compared to construction of an entirely new facility. The proposed reservoir enlargement would raise the dam by constructing a new section of roller-compacted concrete (RCC) on the existing downstream face and dam crest, with the spillway crest at elevation 3,178 feet and the abutments at 3,188 feet, reconstructing the spillway and outlet works stilling basin, and extending the abutment sections using RCC (see Figure 5-5). The existing regulating outlet would be retained and extended downstream. The voids between the buttresses and the new RCC section would be backfilled with a low-strength, flowable controlled-density fill to provide additional stability. The proposed spillway would look similar to the existing spillway. The existing grout curtain would be extended on both abutments and a new road would be built to access the dam.

Pumping plant and conveyance

Two alternatives for a pumping facility with associated conveyance were prepared for analysis, as described in Section 4.4.2 and depicted in Figure 5-6. Alternative 2, which places the pumping facility downstream of the dam, was carried forward in cost and economic analyses. This alternative has a shorter conveyance route and generally more favorable hydroelectric generation potential. However, this routing may have greater potential for environmental impacts that would require mitigation (e.g., wetlands).

Availability of Materials

There are no significant sources of concrete aggregate at the proposed dam site. It is assumed that the RCC and low-strength, flowable controlled-density backfill would be manufactured off site and transported to the dam site.

Relocations

The reservoir is accessed by a gravel county road that leads to a small camping and boating facility operated by Union County 1.5 miles upstream from the dam. Access to the dam is by a four-wheel drive road along the northeast abutment. All these facilities would need to be relocated.

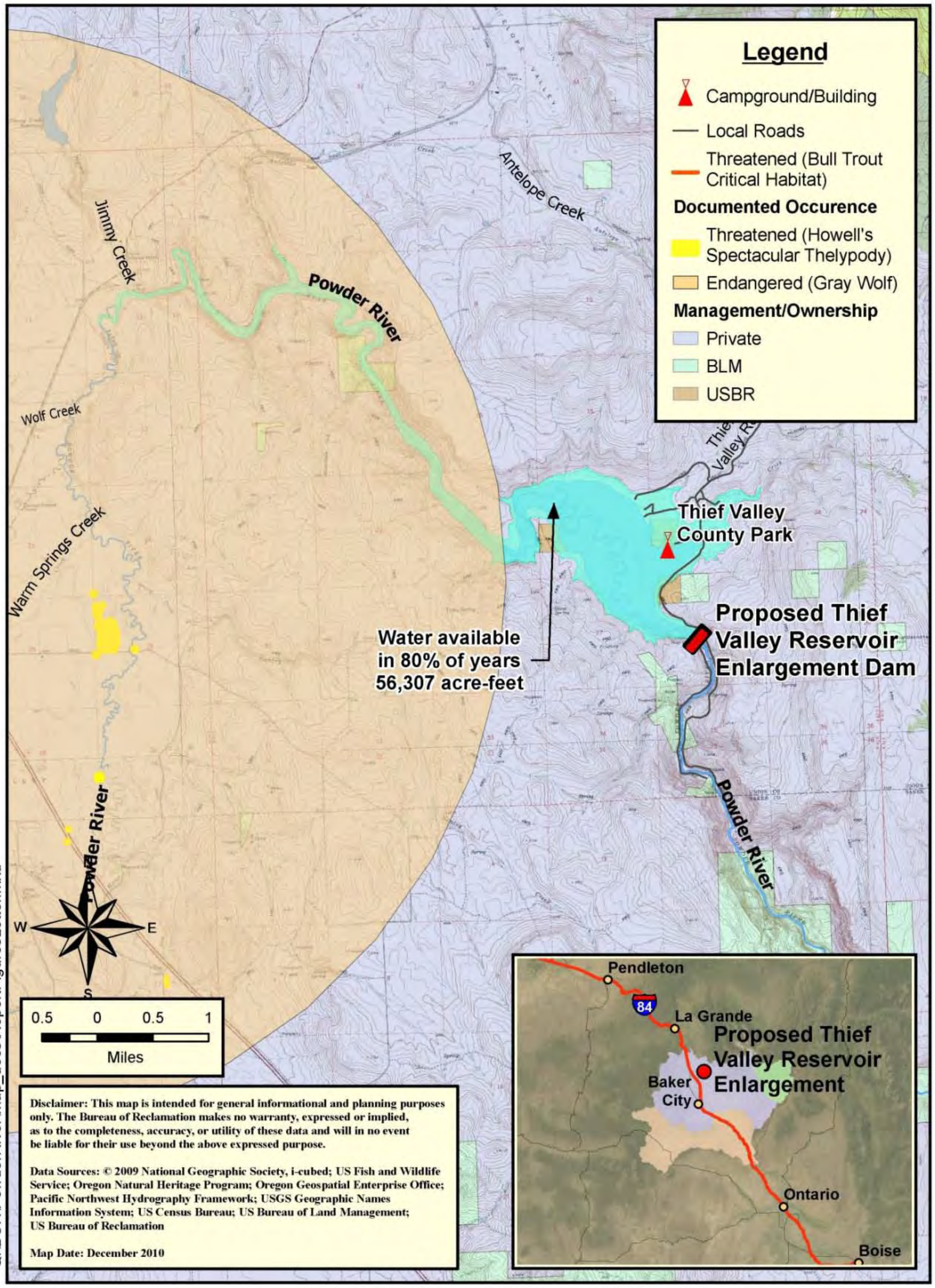

Figure 5-4. Proposed Thief Valley Reservoir Enlargement Location Map

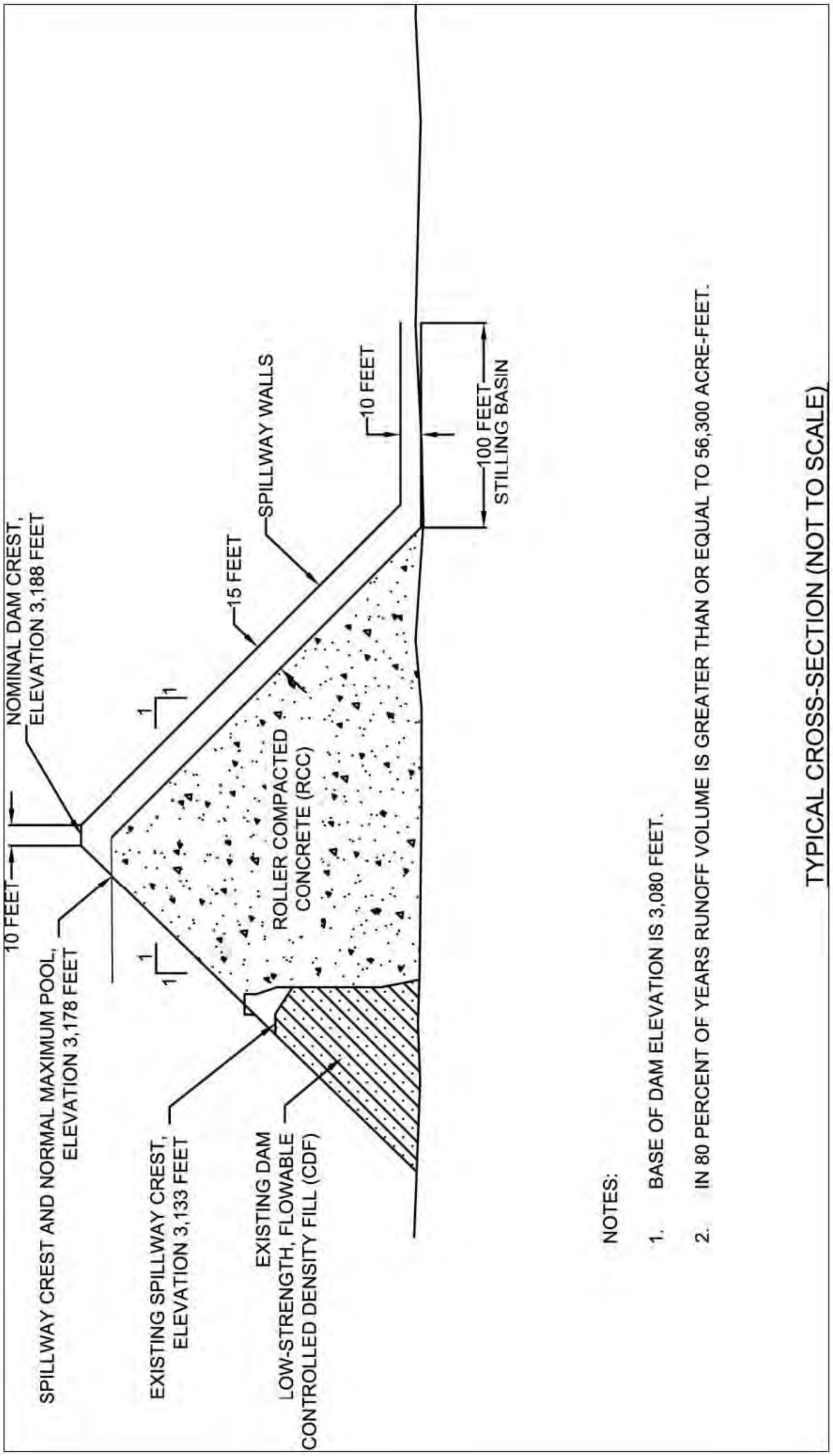

Figure 5-5. Proposed Thief Valley Reservoir Cross-Section

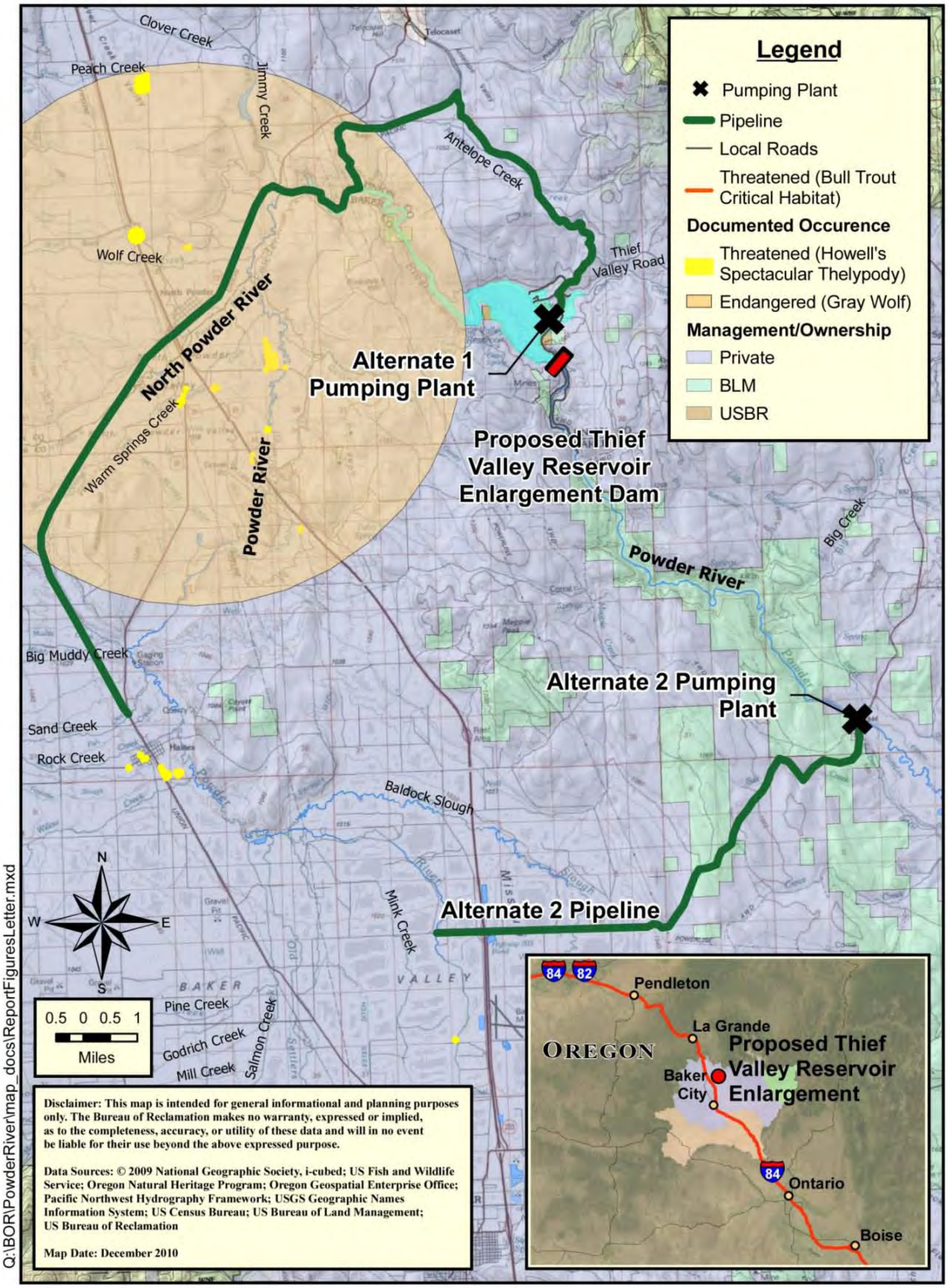

Figure 5-6. Proposed Thief Valley Reservoir Enlargement Pumps and Pipelines Location Map

5.4.2 Estimated Costs

The estimated cost for the proposed Thief Valley Reservoir enlargement is about $62 million as shown for the 56,400 acre-foot storage level in Table 5-5. This estimate includes both direct and the indirect costs of construction to enlarge the storage at this reservoir by 43,000 acre-feet. It does not include any costs for potential hydroelectric facilities or a pump station and conveyance to supply water to upstream irrigated areas as proposed for this project. The cost estimates include both the direct cost of construction and the indirect costs for embankment heights between elevation 3,133 and 3,180 at 5-foot intervals.

Table 5-5. Proposed Thief Valley Reservoir Enlargement Estimated Costs

Dam Crest Elevation (feet)	Height above Foundation (feet)	Direct Cost	Direct Cost + Indirect @ 32%	Reservoir Storage (acre Feet)	Storage Increase (acre-feet)
3,142	53	-	-	13,300	0
3,144	55	$18,500,000	$24,400,000	14,700	1,400
3,149	60	$20,900,000	$27,500,000	18,400	5,100
3,154	65	$23,600,000	$31,100,000	22,400	9,100
3,159	70	$26,400,000	$34,800,000	26,700	13,400
3,164	75	$29,600,000	$39,000,000	31,300	18,000
3,169	80	$32,800,000	$43,300,000	36,100	22,800
3,174	85	$36,400,000	$48,100,000	41,300	28,000
3,179	90	$40,100,000	$53,000,000	46,900	33,600
3,184	95	$44,100,000	$58,200,000	52,700	39,400
3,188	**98**	**$46,900,000**	**$62,000,000**	**56,400**	**43,100**
3,190	100	$48,400,000	$63,900,000	58,800	45,500

Additional costs are associated with the Alternative 2 pumping plant and conveyance to discharge into the Powder River upstream near Haines, Oregon, to obtain the calculated total 56,400 acre-feet of storage. The total cost (direct plus indirect) for the pumping plant and conveyance is estimated to be $122,000,000 using current values (Reclamation 2011). Thus, total direct plus indirect costs for construction of enlarged reservoir storage and the Alternative 2 pump plant and conveyance is $184,000,000.

Construction of a hydropower facility associated with the 56,400 acre-foot reservoir is estimated to be $63,900,000 in 2010 dollars (INEL 1996) and transmission lines to be $20,000 (Reclamation 2011). Transmission line locations are assumed to be in close proximity to the facility, using proposed Idaho Power facilities as a basis for calculation.

Annual OMR&P costs for the proposed dam and related structures are estimated to be $279,500 and $390,400 for the pumping plant and conveyance (Reclamation 2011). Annual OMR&P costs for the hydropower facilities are estimated to be $142,900 and $200 for transmission lines (INEL 1996).

5.5 Proposed North Powder Reservoir – Powder River

5.5.1 Project Description

Location

The proposed North Powder Reservoir site is located on the North Powder River in the northeastern part of the Powder River watershed, approximately 20 miles northeast of Baker, Oregon and 9 miles east of North Powder, Oregon. The proposed dam and reservoir is located on land owned privately and land owned by the U.S. Forest Service (see Figure 5-7). The estimated inundation area is determined from the storable volume of the reservoir as presented in Chapter 4.4.3, the dam height (discussed below), and contours of the natural topography.

Topography

The dam site is located in a narrow reach of the river about three-quarters of a mile upstream from where the river flows into the North Powder Valley. The valley widens immediately upstream of the potential dam site where Anthony Creek and North Powder River converge. Previous explorations at the location show bedrock to be near the surface. The height of the dam is not constrained by location conditions.

Abutments

Based on available drawings (PVWCD 1980) and the site visit (HDR 2009), the abutments are steep (1V:2H), with bedrock exposed in several places. The rock appeared to be a hard, competent rock but with fractures less than a foot apart. The rock is mapped as a partly metamorphosed sedimentary and volcanic rock (USGS 1991). Grouting of the abutments would be required to a depth that would be determined by explorations and permeability testing.

Foundation

Foundation rock described above appears to extend across the valley floor with rock close to the surface across the bottom of the valley, and would form the foundation for the structure. The narrowest point at the valley bottom is less than about 100 feet wide, but rapidly widens both upstream and downstream. The foundation would need to be stripped and shaped for both abutments and the valley section, and a grout curtain would be required for the full length of the dam and across the spillway.

Proposed structure

The North Powder dam structure concept is based on a 1980 investigation of the location by the U.S. Soil Conservation Service (PVWCD 1980), which included subsurface explorations, drawings, and a cost estimate. The dam would be an earth- and rock-fill structure with an impervious core upstream of the centerline of the dam, with upstream and downstream filter zones and rock-fill zones forming the outer zones both upstream and downstream. It was assumed that the upstream embankment would have a slope of 1V:2.25H and that the downstream shell would have a slope of 1V:2H and a top of dam elevation of 3,959 feet (see Figure 5-8).

An uncontrolled spillway with a crest elevation of 3,942 feet would be constructed into the right abutment (looking downstream). The regulating outlet and outlet conduit would be cut into the right abutment through the low portion of the ridge which forms the lower portion of the right abutment. The original project proposed a diversion conduit through a tunnel in the right abutment, but a cut and fill with a conduit appears feasible and lower cost.

Availability of materials

Material from the spillway excavation and upstream borrow sources would be used to construct the dam. Significant quantities of good quality sand and gravel were observed downstream of the proposed dam site and are potentially available for borrow material.

Relocations

The Anthony Lakes Highway is a paved two-lane highway located about 80 feet above the valley bottom on the left abutment and continues into the proposed reservoir area. The cost of road relocation would be relatively expensive due to the local topography. The Rocky Ford Campground just upstream and would need to be relocated.

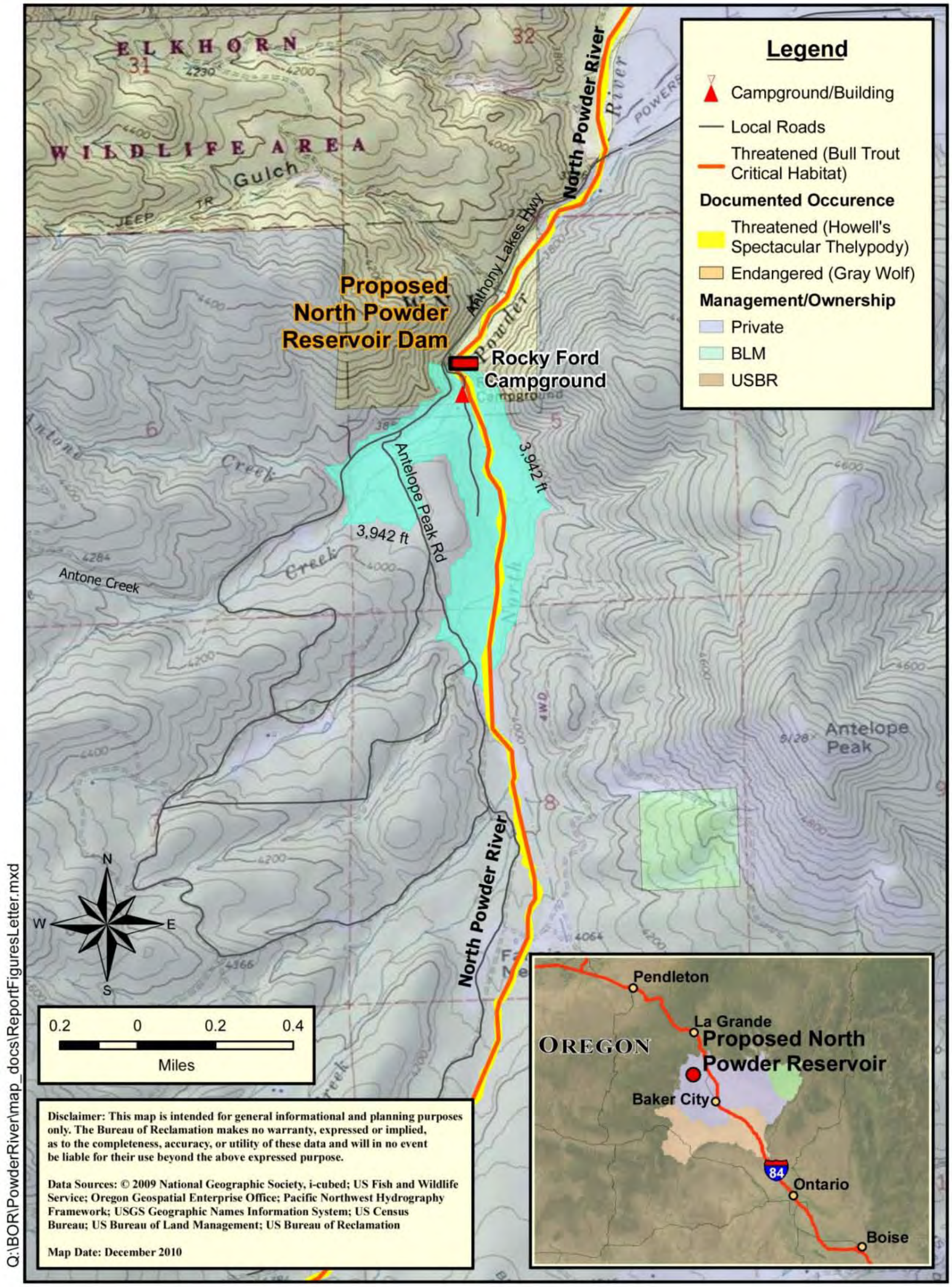

Figure 5-7. Proposed North Powder Reservoir Location Map

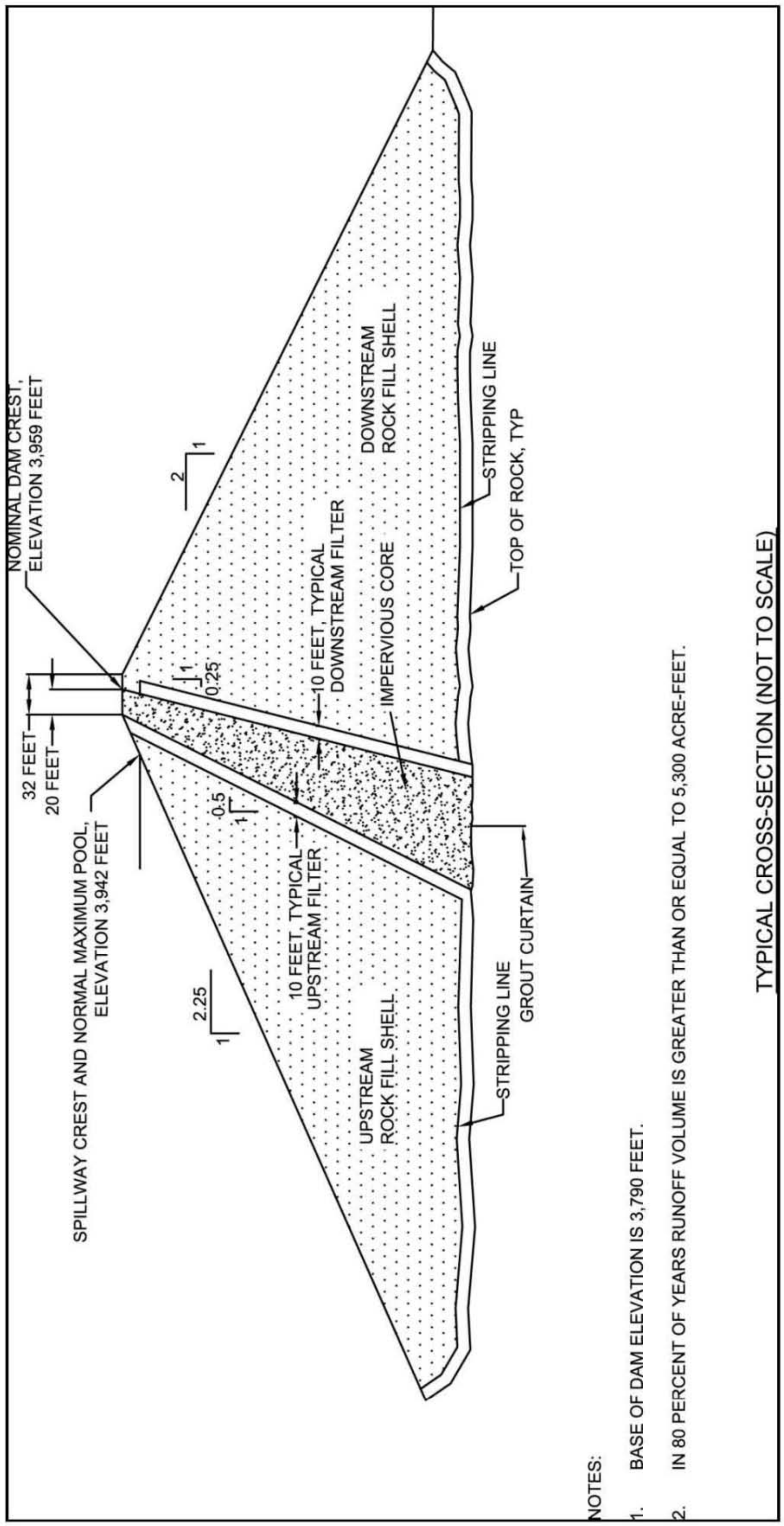

Figure 5-8. Proposed North Powder Reservoir Cross-Section

5.5.2 Estimated Costs

The estimated cost for the proposed 5,300 acre-foot North Powder Reservoir is about $113 million, as shown in Table 5-6. This estimate includes both the direct and the indirect costs of construction. It does not include any costs for potential hydroelectric facilities. Table 5-6 also includes costs for a range of different storage levels.

Table 5-6. Proposed North Powder Reservoir Estimated Costs

Dam Crest Elevation (feet)	Height above Foundation (feet)	Direct Cost	Direct Cost + Indirect @ 32%	Reservoir Storage (acre Feet)
3,850	60	$32,100,000	$42,400,000	-
3,870	80	$35,200,000	$46,400,000	300
3,890	100	$48,700,000	$64,300,000	750
3,910	120	$57,900,000	$76,500,000	1,500
3,920	130	$64,300,000	$84,900,000	2,000
3,950	160	$81,800,000	$107,900,000	4,200
3,959	**169**	**$85,900,000**	**$113,405,134**	**5,300**
3,970	180	$97,200,000	$128,400,000	6,800
3,990	200	$113,500,000	$149,800,000	9,600
4,010	220	$127,700,000	$168,600,000	16,650
4,013	223	$129,000,000	$170,300,000	20,000
4,030	240	$144,400,000	$190,600,000	25,800
4,050	260	$163,000,000	$215,200,000	30,375
4,070	280	$183,700,000	$242,500,000	34,950
4,090	300	$207,200,000	$273,500,000	39,525

Construction of a hydropower facility associated with the 5,300 acre-foot reservoir is estimated to be $14,100,000 in 2010 dollars (INEL 1996) and transmission lines to be $720,000 (Reclamation 2011).

Annual OMR&P costs for the proposed dam and related structures are estimated to be $162,200 (Reclamation 2011). Annual OMR&P costs for the hydropower facilities are estimated to be $45,300 and $5,500 for transmission lines (INEL 1996).

5.6 Proposed East Pine Reservoir – Pine Creek

5.6.1 Project Description

Location

The proposed East Pine Reservoir site is located approximately 4.5 miles north of Halfway, Oregon. The proposed dam and reservoir are located on land owned privately and land managed by the U.S. Forest Service (Figure 5-9). The proposed reservoir would receive runoff from Clear Creek and East Pine Creek. Clear Creek does not intersect the inundation area and would need to be diverted to the proposed reservoir. The estimated inundation area is determined from the storable volume of the reservoir as presented in Chapter 4.4.6, the dam height (discussed below), and contours of the natural topography.

Topography

The proposed reservoir site, which is in the northwestern part of the Pine Creek watershed, is in a reach of the stream that is only about 150 feet wide at the bottom, with relatively steep sides (1V:1.7H to 1V:2H). Upstream of the location, the valley bottom opens to about 600 feet, with much flatter side slopes and several small drainages coming in from the north. A saddle on the south side, at elevation 3,440 feet, limits the height of a dam to about 440 feet.

Abutments

Bedrock is exposed on both abutments. A geologic section in a report prepared by Shannon & Wilson (EVSCD 1978) shows rock close to the surface on the abutments. The abutments have a relatively regular slope that should not require extensive shaping.

Foundation

The abutment foundation would require stripping of about 10 feet of loose and weathered rock to reach a sound foundation. About 20 feet of alluvium in the valley bottom will also require stripping. Foundation rock will require grouting for the full length of the dam section and spillway section.

Proposed structure

The proposed East Pine Creek dam and reservoir would be at the same location investigated by Shannon and Wilson (EVSCD 1978). The structure would be a rock- and gravel-filled dam with a central impervious core. Filter zones would be located upstream and downstream of the impervious core. The upstream face of the dam would be at 1V:2.75H and the downstream face would be 1V:2H (see Figure 5-10). A grout curtain would be constructed for the full width of the dam. The spillway would be excavated into the left abutment. Rock from the spillway excavation would be incorporated into the rock fill in the dam. It was assumed that the regulating outlet and outlet conduit would be constructed on the left side of the valley and sized to serve as a diversion during construction. This project would require a relatively small diversion to the northwest on Clear Creek and a new conveyance to transfer flows to the proposed reservoir. Borrow material would be obtained from upstream of the dam.

Availability of materials

Based on observations made during a site visit and information on available explorations (EVSCD 1978), it appears that impervious materials and sand and gravel are available in the upstream reservoir area. Rock fill would be available from construction of the spillway. Material for the filter zones and concrete would be imported from off-site.

Relocations

Access to the East Pine Reservoir location is by a gravel-surfaced U.S. Forest Service road that follows the creek. The road is located about 50 feet above the creek at the proposed dam site and would need to be relocated. Access to the East Pine Reservoir location is by a gravel-surfaced U.S. Forest Service road that follows East Pine Creek. The road is located about 50 feet above East Pine Creek at the proposed dam site and about 4 miles of the road near the reservoir location would need to be relocated.

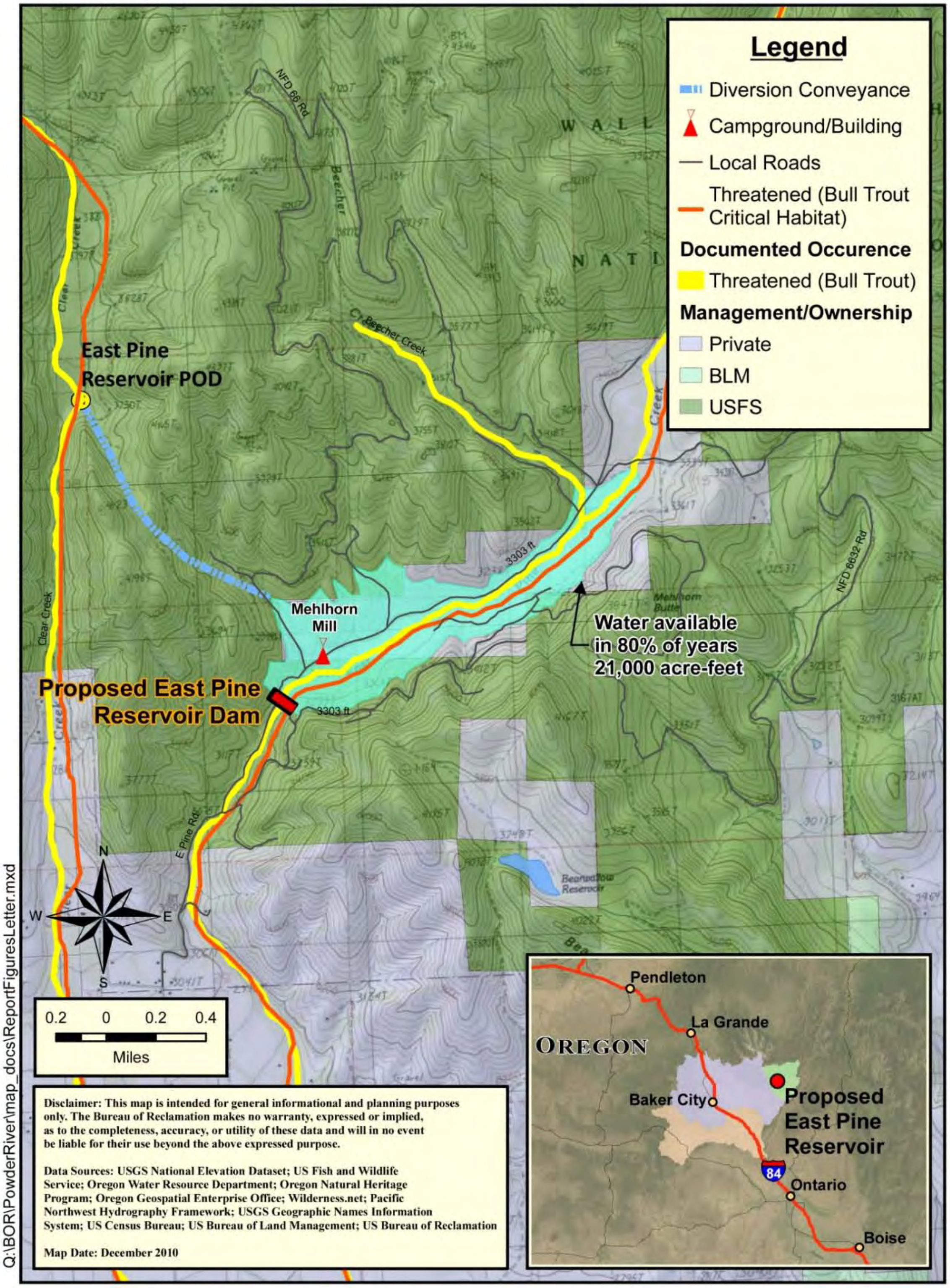

Figure 5-9. Proposed East Pine Reservoir Location Map

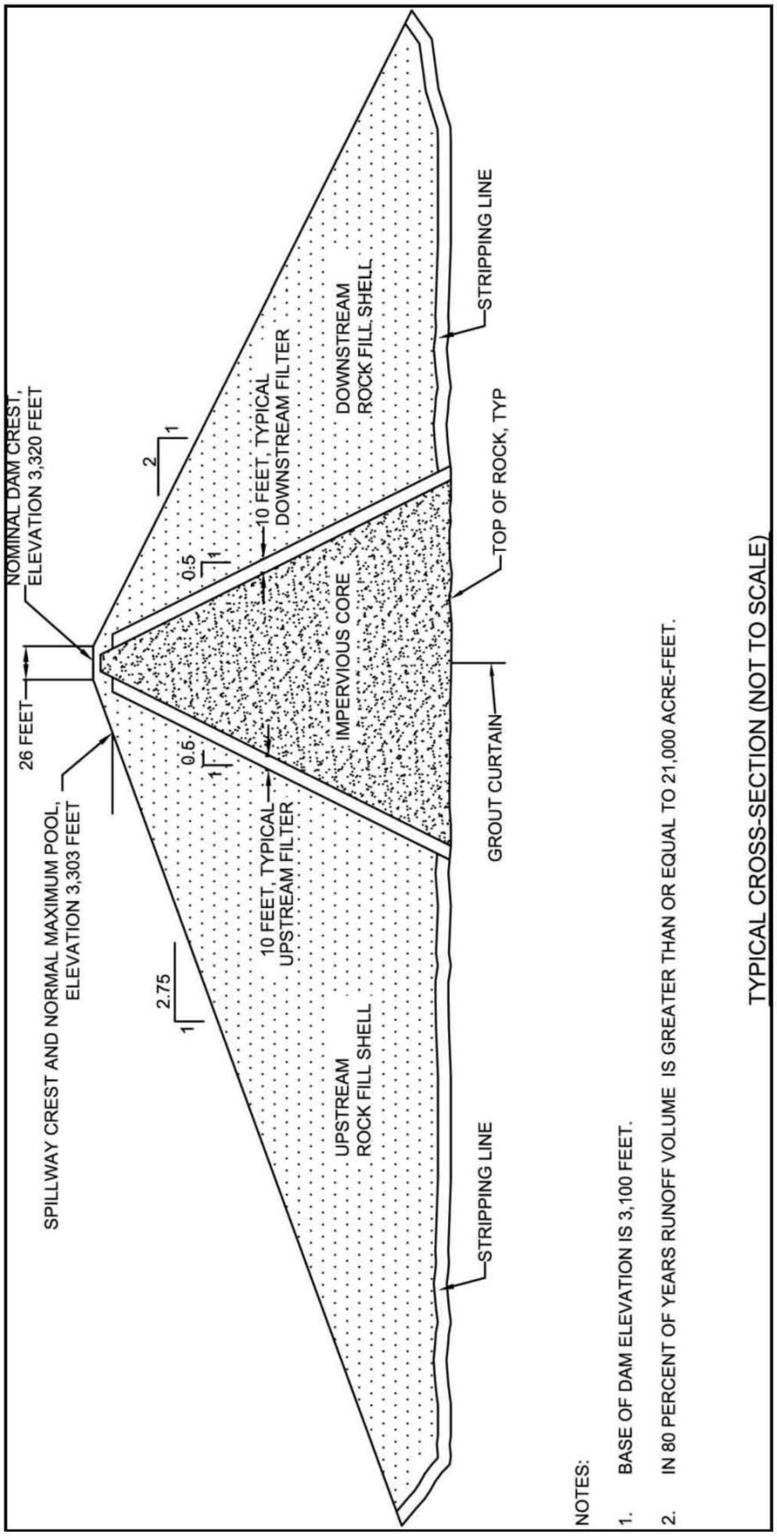

Figure 5-10. Proposed East Pine Reservoir Cross-Section

5.6.2 Estimated Costs

The estimated cost for the proposed 21,000 acre-foot East Pine Reservoir is about $133 million, as shown in Table 5-7. This estimate includes both the direct and the indirect costs of construction. Table 5-7 also includes costs for a range of different storage levels.

Table 5-7. Proposed East Pine Reservoir Estimated Costs

Dam Crest Elevation (feet)	Height above Foundation (feet)	Direct Cost	Direct Cost + Indirect @ 32%	Reservoir Storage (acre Feet)
3,120	20	$23,400,000	$30,800,000	-
3,140	40	$26,300,000	$34,800,000	50
3,160	60	$30,700,000	$40,500,000	500
3,180	80	$36,800,000	$48,600,000	1,100
3,200	100	$43,100,000	$56,800,000	3,000
3,220	120	$48,700,000	$64,200,000	4,800
3,230	130	$52,000,000	$68,700,000	6,200
3,260	160	$64,100,000	$84,600,000	10,100
3,280	180	$74,300,000	$98,400,000	14,900
3,293	193	$82,000,000	$108,100,000	17,200
3,300	200	$87,000,000	$114,800,000	19,000
3,320	**220**	**$101,100,000**	**$133,400,000**	**21,000**
3,340	240	$118,100,000	$155,800,000	25,000

Additional costs are associated with a proposed diversion dam on Clear Creek and conveyance from that diversion dam to the proposed East Pine Reservoir to obtain the calculated 21,000 acre-feet of storage. The total cost is estimated to be $133,400,000 using the 1968 costs adjusted to current values.

Construction of a hydropower facility associated with the 21,000 acre-foot reservoir is estimated to be $15,600,000 in 2010 dollars (INEL 1996) and transmission lines to be $680,000 (Reclamation 2011).

Annual OMR&P costs for the proposed dam and related structures are estimated to be $198,300 (Reclamation 2011). Annual OMR&P costs for the hydropower facilities are estimated to be $47,100 and $5,200 for transmission lines (INEL 1996).

5.7 Summary of Alternatives for Economic Evaluation

Table 5-8 summarizes parameters estimated for the proposed storage reservoirs at their 80 percent reliability levels of water supply. The construction cost is the direct and indirect cost for each proposed storage reservoir as discussed earlier in this section. The storable volume at 80 percent reliability is essentially the volume of storage proposed to store and release water. The estimated average annual supply is the amount of average annual additional water supply made available to reduce irrigation shortages by the proposed storage. These values in Table 5-8 are provided only for the purpose of comparison of the selected reservoir locations. Table 5-9 provides comparisons for construction of hydropower generation and transmission facilities, using only Alternative 2 information for Thief Valley.

Table 5-8. Summary of Storage Associated with Proposed Storage Reservoirs at 80 Percent Reliability Levels of Water Supply

No.	Proposed Storage Reservoir	Reservoir Construction Cost	Storable Volume at 80 percent Reliability (acre-feet)	Estimated Average Annual Supply (acre-feet/yr)
83	Hardman Reservoir	$50,000,000	4,800	1,500
30	Thief Valley Reservoir Enlargement	$62,000,000 ($184,000,000 with pumping and conveyance)	43,000	29,000
40	North Powder Reservoir	$113,000,000	5,300	4,500
6	East Pine Reservoir	$133,000,000	21,000	13,700

Table 5-9. Summary of Hydropower Potential Associated with Proposed Hydropower Facilities at 80 Percent Reliability Levels of Water Supply

No.	Proposed Hydropower Facilities	Hydropower and Transmission Construction Cost	Generation Potential at 80 percent Storage Reliability (MWh)	Preliminary Estimated Impacts on Snake River system (MWh/yr)
83	Hardman Reservoir	$3,100,000	721	(110)
30	Thief Valley Reservoir Enlargement	$64,000,000	12,435	(4,440)
40	North Powder Reservoir	$14,700,000	4,919	2,758
6	East Pine Reservoir	$16,300,000	7,399	3,136

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Chapter 6 ECONOMIC ANALYSIS OF ALTERNATIVES

A benefit-cost analysis was conducted on the proposed alternatives being considered in this study. Benefits and costs associated with each proposed alternative are compared to the No Action (baseline) alternative. Benefit categories evaluated for this analysis include agriculture and hydropower. Other benefit categories such as flood control, recreation, fisheries were not evaluated due to a lack of available data. Cost categories include construction of dams, pumping plants and conveyance systems, hydropower plants, power transmission lines and annual OMR&P costs. Interest during construction (IDC), based on the current FY2011 federal water resource agency planning rate of 4.125 percent, was charged on each construction element annually through the end of the construction period. The construction period was assumed at 3 years for all alternatives (2012-2014). The period of analysis for benefits and OMR&P costs was assumed at 100 years from the end of the construction period (2015-2114).

All benefits and costs are measured in current (2009/2010) dollars. In some cases, costs were initially based on previously developed estimates. These costs were indexed to reflect current dollars. In addition, all benefits and costs were converted to a common point in time (when benefits begin to accrue). It was assumed that IDC provides the conversion of construction costs to the end of the construction period. The 100-year stream of agricultural and hydropower benefits and OMR&P costs were discounted (present valued) back to the end of the construction period using the 4.125 percent planning rate.

6.1 Methodology

The methodology discussion for the economic benefit-cost analysis is presented separately for each of the benefit and cost categories.

6.1.1 Benefits

The benefit components evaluated for the benefit-cost analysis include agriculture and hydropower.

Agriculture

Agricultural benefits evaluate economic costs and returns related to irrigated agriculture. The purpose of using economic costs and returns to farming is to assess, from a national standpoint, whether the economic viability of investing in a proposed irrigation project is the most efficient use of investment capital over a long-term planning horizon. A farm budget methodology estimates how valuable an irrigation water supply is to crops by using the residual net farm income of a representative farm in the project area under “with” and “without” project conditions.

A farm budget application, developed by Reclamation, evaluates the economic costs and returns associated with irrigated agriculture. The purpose of Reclamation's benefits budgets differs from University Extension budgets such as those published by Oregon State University. Extension budgets present a short-term financial analysis of the annual costs and returns of farming. This type of information is useful in making short-term managerial decisions such as how many acres to plant, which crops will receive irrigation water in water-short years, and how much funding will be needed for the year. Reclamation's benefits budgets measure the long term economic costs and returns related to irrigated agriculture, which represent the opportunity costs to the Nation.

Even though the purposes of economic and financial analyses differ, the base data for both types of analyses are strongly correlated and the two types of budgets look very similar if placed side-by-side. For example, both types of analyses use the same crop inputs such as pre-planting, planting, and harvesting operations (cultural practices), seed, fertilizers, agricultural chemicals applied, farm size, improvements, and buildings. The difference in the two types of budgets is due to the different purpose of each budget.

Reclamation's benefit budget is measuring an opportunity cost according to economic theory. A long-term planning rate is used in the budget as an interest rate. This long-term interest rate is appropriate for measuring economic costs and returns over a 100-year planning horizon. All capital is assumed to be borrowed. When all the capital is borrowed, the analysis can focus on whether investing the capital in this irrigation project is the best use of this capital from a national standpoint. Prices received for crop sales are market-clearing prices exclusive of farm subsidies. Each budget provides a fair return to land, labor, and capital. These assumptions are necessary to measure the long-term economic costs and returns versus short-term accounting costs and returns. The P&Gs provide a framework for governmental agencies to follow that allows irrigation benefit analyses to satisfy their purpose.

The net farm incomes generated under the "without" project condition for this study was compared to the net farm income resulting from the "with" project conditions. The "without" project condition assumed that irrigated acres had a stable, partial water supply going into the future. The current available water supply is not sufficient to provide a full supply of water to all the irrigated acres and irrigation ceases in late July on average.

The "with" project condition assumed that a full supply of irrigation water would be delivered to the irrigated acres within the area. Modeling described in Chapter 4 indicated that varying degrees of irrigation water shortages would exist. However, assignment of these variable shortages is beyond the scope of an appraisal level effort. Thus, it is understood that this assumption within the economic agricultural benefit analysis produces a slight overestimation of benefits.

The net farm income remaining after subtracting production costs and an allowance for management and labor from the gross farm income is referred to as residual income. Agricultural benefits are calculated by estimating the residual net farm income for the "with" and "without" project farms. After estimating the residual net farm income for both conditions, the difference between the two residual net farm incomes is calculated; this difference is the agricultural benefit.

The agricultural benefits analysis for this study are based on 1) changes in the crop mix expected to occur under the "with" and "without" conditions, 2) increases in yield coming from an increase in the amount of irrigation water, and 3) the subsequent differences in residual net farm income under the "with" and "without" conditions.

Enterprise budgets for six crops were developed: grass hay, alfalfa, winter wheat, spring wheat, potatoes, and pasture. Current county-average yields were obtained from the Oregon Agricultural Information Network (OAIN). Normalized prices, published by the USDA-Economic Research Service, were used if available for each crop.

Gross revenue for the farm was calculated using the county-average yields and normalized crop prices. Variable and fixed production costs were subtracted from the gross revenue to find net farm revenue. Residual net farm income was derived by subtracting an allowance for a return to management and labor from net farm revenues. The residual net farm income was divided by the total number of irrigated acres in the farm plus the number of acres in the farmstead to derive a per-acre value. The difference between the "with" project residual net farm income and the "without" project residual net farm income for each representative farm is the estimate of agricultural irrigation benefits.

In this analysis, the primary driver for agricultural benefits comes from a change in yield due to an increase in water deliveries. A secondary driver for agricultural benefits comes from an incremental change in the number of acres of potato production, a relatively higher value crop, that displaces a like number of acres of wheat production, a relatively lower value crop.

Hydropower

The hydropower analysis considered both the effects on generation at the new hydropower facilities associated with each proposed alternative (local effects) and existing downstream Snake River hydropower facilities (Hells Canyon Complex, Lower Granite Dam, Little Goose Dam, Ice Harbor Dam, Lower Monumental Dam) and Lower Columbia River hydropower facilities (McNary, John Day, The Dalles, Bonneville).

Table 6-1 displays the average annual forecasted wholesale hydropower prices from 2011-2030 for the Mid-Columbia area as obtained from the "Sixth Northwest Conservation and Electric Plan" (Northwest Power and Conservation Council [NPCC], 2010). For the remainder of the period of analysis, from 2031-2114, the average annual price was assumed equal to the 2030 value. Since these prices were in 2006 dollars, they were indexed up to 2010 dollars using the national Gross Domestic Product Implicit Price Deflator.

Table 6-1. Forecasted Wholesale Mid-Columbia Average Annual Prices

Year #	Year	Original Price [1] 2006 ($/MWh)	Indexed Price [2] 2010 ($/MWh)
1	2015	54	58
2	2016	57	61
3	2017	59	63
4	2018	60	64
5	2019	62	66
6	2020	63	68
7	2021	65	70
8	2022	66	71
9	2023	68	73
10	2024	69	74
11	2025	70	75
12	2026	71	76
13	2027	72	77
14	2028	73	78
15	2029	73	78
16	2030	74	79
17-100	2031-2114	74	79

(1) Source: Sixth Northwest Conservation and Electric Plan (Northwest Power and Conservation Council [NPCC], 2010)

(2) Gross Domestic Product Implicit Price Deflator: 2006 value: 103.257, 2010 value: 110.662, Expansion Factor: 1.0717

The forecasted annual prices were multiplied by the average change in local and downstream generation for each alternative (Table 5-4). The change in local generation and value was added to the decrease in downstream generation and value to develop the net effect. The 100-year stream of changes in net hydropower value associated with each alternative was then discounted back to the end of the construction period.

6.1.2 Costs

Costs for the four proposed alternatives were broken down into construction and IDC costs and annual OMR&P costs. Construction and IDC costs are incurred upfront during the 3-year construction period (2012-2014). OMR&P costs are incurred annually across the 100-year period of analysis (2015-2114).

Construction and Interest during Construction (IDC)

Construction costs vary by alternative and include the costs of dams, pumping plants and conveyance systems (Thief Valley alternative only), hydropower plants, power transmission lines, and the Clear Creek Diversion (East Pine alternative only). The dams, pumping plants and conveyance structures, and power transmission lines were all estimated in current dollars (2009 or 2010). Hydropower and Clear Creek Diversion costs were pulled from previous cost estimates (1996 and 1967 dollars respectively). To convert these older cost estimates to current dollars, the Reclamation Construction Cost Index was used. Table 6-2 presents the cost indexes used in the analyses. The indexed cost estimates are presented below under each alternative section.

Table 6-2. Reclamation Construction and O&M Cost Indexes

Feature	1996 or 1967 Index Value	2010 Index Value	Expansion Factors (2010/1996 or 1967)
I. Construction Cost Index			
Hydropower Plant	219 (1996 value)	330	1.50685
Clear Creek Diversion	47 (1967 value)	336	7.14894
II. O&M Cost Index			
All O&M Costs	2.77 (1996 value)	4.20	1.51625

For calculating IDC, total construction costs for each alternative had to be allocated across the 3-year construction period associated with each alternative. IDC is charged annually on the cumulative amount of construction cost associated with each construction period year based on the current planning rate of 4.125 percent. Annual construction costs and IDC are summed to reflect total construction costs as of the end of the construction period.

Annual OMR&P Costs

Reclamation developed estimates of average annual OMR&P costs for each alternative. These OMR&P costs were based on the same facilities as discussed above in the Construction and Interest during Construction section. While OMR&P costs for the dam and pumping plant and conveyance structures elements were measured in 2010 dollars, the costs for the hydropower plant and transmission lines were measured in 1996 dollars. The hydropower plant and transmission line OMR&P costs were indexed up to 2010 dollars using Reclamation's O&M Cost Index (see Table 6-2).

The estimate of average annual OMR&P costs for each alternative was assumed to occur each year of the 100-year period of analysis. This 100-year stream of OMR&P costs for each alternative was discounted back to the end of the construction period. The discounted OMR&P costs were combined with construction and IDC costs to estimate the total cost for each alternative.

6.2 Benefit-Cost Results by Alternative

This section presents the benefit-cost results separately for each of the four proposed alternatives. Benefit-cost results are presented in terms of net benefits (total benefits minus total costs) and benefit-cost ratios (total benefits divided by total costs). When benefits equal costs, the net benefit is zero and the benefit-cost ratio equals 1.0. Background information is also presented for the No Action alternative. Since the No Action alternative is the baseline from which the proposed alternatives are compared, benefit-cost results are not provided for the No Action alternative.

6.2.1 No Action Alternative

The No Action alternative represents the baseline from which all of the proposed alternatives are compared. While starting with current conditions, the No Action alternative projects conditions through the end of the 100-year period of analysis based on expected operations of the system without any of the proposed alternatives. It is possible that system changes could be anticipated over time unrelated to the proposed alternatives (e.g., due to the impact of biological opinions, climate change, etc.). Since no significant system changes are anticipated, the No Action alternative is based on the current configuration and operation of the system.

Agricultural Benefits

All agricultural irrigation benefits associated with the action alternatives were measured as changes from the No Action alternative. To start the agricultural benefits calculation, the “without” project annual net farm income was calculated by estimating the economic net revenues for each of the six crops in the analysis and multiplying that by the number of acres for each of the crops. It was assumed that a stable water supply would allow the current cropping pattern to continue into the future. No changes in the cropping pattern were estimated for future years.

There are 165,000 acres in the study area currently irrigated with natural flow and storage water. The study area is split into four subareas that correspond to the alternatives: the Hardman alternative, the Thief Valley enlargement alternative with the downstream pumping plant, the Powder River alternative, and the East Pine alternative. The total number of acres served with irrigation water at each site was estimated by Reclamation.

The crops represented by the NED benefits budgets include irrigated potatoes, winter and spring-planted wheat, alfalfa, grass hay, and pasture. Information about crops grown in the study area came are provided in Table 4-1 and Table 4-2.

Table 6-3 shows the number of acres of crops for each site for the No Action alternative.

Table 6-3. No Action Alternative Cropping Pattern

	Without Project Cropping Pattern							
Site	Grass hay	Alfalfa	Winter grain	Spring grain	Potatoes	Corn	Pasture	Total Acres
Hardman	6,754	6,723	1,365	883	258	93	5,923	22,000
Thief Valley Enlargement	29,948	29,812	6,054	3,916	1,146	413	26,266	97,555
North Powder	8,425	8,387	1,703	1,102	322	116	7,389	27,445
East Pine	5,526	5,501	1,117	723	211	76	4,846	18,000
Totals	50,653	50,422	10,240	6,624	1,939	698	44,425	165,000

County-average yields were obtained from the USDA National Agricultural Statistics Service (NASS). Five-year averages for Union and Baker counties, Oregon were used. The "without" project yields were grass hay (2.2 tons/acre of hay plus 0.5 tons/acre aftermath grazing), alfalfa (3.9 tons/acre), winter wheat (98.5 bushels/acre), spring wheat (75 bushels/acre), potatoes (506 cwt/acre), and pasture (18 AUMS/acre). Corn represented less than 1 percent of the total acreage and an extension budget was not available, so corn was not included in this analysis.

Prices received were obtained from the USDA Economic Research Service (ERS). Normalized prices were used in the analysis except for pasture. Pasture prices were obtained from NASS and a three-year average price was used. Grass and alfalfa hay prices were $144.68/ton, wheat price was $5.36/bushel, potato price was $7.12/cwt, and pasture price was $13.53/AUM.

Published extension budgets were obtained from the Oregon State University Extension Service and indexed to a 2008 basis. The extension budgets provided the cultural practices such as plowing, disking, planting; inputs used such as fertilizer and chemicals; machinery used; and improvements such as buildings, sheds, and irrigation equipment.

The 2010 planning rate, 4.125 percent, was used as the interest rate on all borrowed capital and as the depreciation rate for machinery and buildings. All capital was assumed to be borrowed. Each enterprise budget estimated gross revenue by multiplying price and yield together. Then, variable costs, fixed costs, and a return to the farm family were subtracted from the gross revenue, which gave the residual net farm income. The residual net farm income was divided by the sum of irrigated acres and the farmstead, roads, ditches, and waste acres.

This is an economic analysis, not a financial analysis. Therefore, the farm budget methodology estimates, from a national standpoint, the economic viability of investing in the proposed irrigation project by comparing the residual net returns from the No Action alternative to the residual net farm returns under each of the action alternatives. The residual net returns from the No Action alternative represent the "without" project portion of a benefit calculation. They do not represent the financial gains or losses from crop production in a year.

Table 6-4 presents the price and yield assumptions used in the benefits budgets and the residual net farm income by crop. The same "without" project residual net farm income is used for all four regions.

Table 6-4. No Action Alternative Net Farm Income by Crop

Crop	Yield	Unit	Price	Net Income/Acre*
Alfalfa Hay	3.9	Tons	$144.68	$23.92
Grass Hay and	2.2	Tons	$144.68	
Aftermath Grazing	0.5	AUMs	$13.53	$87.09
Potatoes	506	Cwt	$7.12	$629.43
Spring Wheat	75	Bushel	$5.36	-$135.17
Winter Wheat	98.5	Bushel	$5.36	$22.28
Pasture	18	AUMs	$13.53	-$35.80

* The farm budget net farm incomes, from a national standpoint, help to measure the economic viability of investing in the proposed irrigation project and represent "without" project portion of a benefit calculation.

The total net farm incomes for the four sites (Hardman, Thief Valley enlargement, North Powder, and East Pine) is calculated by multiplying the per-acre residual net farm income (from Table 6-4) by the number of acres of each crop grown (from Table 6-4) at each of the sites. Table 6-5 presents the total residual net farm income by site. Neither the total income for each crop across all four sites nor the total income for all crops for each site is added up. The total income for each crop at each site will be compared to the "with" project income to find an annual benefit derived from the Action alternatives. For example, the total income for grass hay for the Hardman No Action alternative ("without" project) will be subtracted from the total income for the Hardman alternative ("with" project) to find the annual benefit for grass hay for the Hardman alternative. The Hardman alternative economic analysis will be discussed later in this document.

Table 6-5. No Action Residual Net Farm Income by Crop and Site

Site	Grass Hay	Alfalfa	Winter Grain	Spring grain	Potatoes	Corn	Pasture
Hardman	$588,179	$160,813	$30,418	($119,376)	$162,708	-	($212,057)
Thief Valley Enlargement	$2,608,175	$713,097	$134,884	($529,353)	$721,497	-	($940,329)
North Powder	$733,754	$200,614	$37,947	($148,922)	$202,978	-	($264,541)
East Pine	$481,238	$131,574	$24,888	($97,672)	$133,124	-	($173,501)

Hydropower Benefits

There are no known hydropower facilities within the existing system. Therefore, there are no hydropower benefits included under the No Action alternative.

Construction Costs and IDC Costs

The No Action alternative has no construction or IDC components.

Annual OMR&P Costs

Average OMR&P costs for the existing Thief Valley dam and related structures were estimated by Reclamation at $75,740 annually.

6.2.2 Hardman Alternative

Benefits

Agricultural Benefits

All agricultural irrigation benefits associated with the action alternatives were measured as changes from the No Action alternative. To start the agricultural benefits calculation, the "without" project annual net farm income was calculated by estimating the economic net revenues for each of the six crops in the analysis and multiplying that by the number of acres for each of the crops. This was presented in the No Action alternative description.

There are 22,000 acres in the Hardman site currently irrigated with natural flow and storage water. The crops represented by the NED benefits budgets include irrigated potatoes, winter and spring-planted wheat, alfalfa, grass hay, and pasture.

Table 6-6 presents the price and yield assumptions used in the "with" project benefits budgets and the residual net farm income by crop. An increase in yield for alfalfa, grass hay, winter and spring wheat, and pasture was assumed for the "with" project conditions. The size of yield increases were derived from a combination of personal communications (Browne Consulting 2011) and published Extension budgets from Oregon State University where yield data were available through the OAIN. A published yield increase for spring wheat was not available, so a proxy yield increase was estimated by determining the percentage increase in winter wheat (21.83 percent) and applying that percentage increase to spring wheat yields. Thus, spring wheat yields increased 21.83 percent, going from 75 to 91 bushels per acre. Alfalfa hay yield increased to 6 tons/acre, grass hay increased to 2.5 tons/acre and the amount of aftermath grazing increased to 1 AUMs/acre. There was no increase in potato yields, but spring wheat yields increased to 91 bushels/acre as described, winter wheat yields increased to 120 bushels/acre, and pasture yields increased to 20 AUMs/acre.

No change in crop acres was assumed for any of the crops except potatoes, spring wheat, and winter wheat. Over the entire basin, it was assumed that an increase in potato acreage would occur (Browne Consulting 2011). This analysis assumed a constant percentage increase in potato acreage for the acres served by each alternative. The increase in potato acreage for each alternative was offset by a reduction in the numbers of acres of winter and spring wheat.

The reduction was split evenly between winter and spring wheat acres. With the exception of potato, spring and winter wheat, no change in crop acres was assumed. Potato acres are assumed to increase slightly (90 acres) at the expense of the spring and winter wheat acreages in the Hardman alternative.

Table 6-6. Hardman Alternative Net Farm Income by Crop

Crop	Yield	Unit	Price	Net Income/Acre
Alfalfa Hay	6	Tons	$144.68	$189.97
Grass Hay and	2.5	Tons	$144.68	
Aftermath Grazing	1.0	AUMs	$13.53	$132.06
Potatoes	506	Cwt	$7.12	$629.43
Spring Wheat	91	Bushel	$5.36	-$57.59
Winter Wheat	120	Bushel	$5.36	$127.82
Pasture	20	AUMs	$13.53	-$11.20

Once the changes in yields and the change in potato and wheat acreages had been identified, the residual net farm income for the crops was estimated and then compared to the No Action alternative acreages and residual net farm income. The difference in net farm income between the No Action and Hardman alternatives is an estimate of an annual benefit coming from implementing this alternative. The annual benefit is assumed to occur for each of the next 100 years. This 100-year benefit stream is then present valued to arrive at a total net benefit value in 2010 dollars. The future benefit stream was discounted using the 2010 planning rate of 4.125 percent. The annual benefit stream came to $1,831,932; the present value is $43,630,700. This is presented in Table 6-7.

Table 6-7. Hardman Alternative Crop Acres and Total Residual Net Farm Income

	Grass hay	Alfalfa	Winter grain	Spring grain	Potatoes	Corn	Pasture	Total
With Project								
Acres	6,754	6,723	1,320	838	349	93	5,923	22,000
Net Farm Income	$891,893	$1,277,161	$168,748	-$48,266	$219,423	$0	($66,342)	
Without Project								
Acres	6,754	6,723	1,365	883	258	93	5,923	22,000
Net Farm Income	$588,179	$160,813	$30,418	($119,376)	$162,708	-	($212,057)	
Difference in:								
Acres	-	-	(45)	(45)	90	-	-	(0)
Net Farm Income	$303,714	$1,116,348	$138,330	$71,110	$56,716	-	$145,715	$1,831,932
Annual Benefit								$1,831,932
Net Present Value of Benefit*								$43,630,700

* Benefit Stream of 100 years, discount rate of 4.125 percent

Hydropower Benefits

The 100-year discounted stream of local hydropower benefits for this alternative was estimated at $1.28 million. The 100-year discounted stream of downstream hydropower losses for this alternative was estimated at -$1.98 million. Combining the positive local effect with the negative downstream effect results in an overall negative hydropower effect of -$701.6 thousand.

The discounted 100-year stream of agriculture and hydropower benefits for this alternative totals $42.9 million.

Costs

As shown in Table 6-8, construction and IDC costs for this alternative total $56.3 million.

Table 6-8. Hardman Alternative Total Costs (Millions $)

Cost Element	Original Estimate	Indexed Estimate (2010 $)	Year 1	Year 2	Year 3
Dam & Related Structures	50.27	50.3	13.0	14.0	23.3
Hydropower Plant	1.15	1.74	.579	.579	.580
Power Transmission Lines	1.36	1.36	.453	.453	.454
Subtotal		53.40	14.03	15.03	24.33
Interest During Construction		2.94	.289	.901	1.750
Total Construction Costs		56.34	14.32	15.93	26.08
Average Annual OMR&P Costs	.179				
Discounted 100 Year Stream of Average Annual OMR&P Costs:		4.26			
Total Construction, IDC, and OMR&P Costs		60.60			

Construction Costs

Construction elements for this alternative include a dam, hydropower plant, and hydropower transmission lines. Construction costs for these three elements, indexed to 2010 dollars, total $53.4 million. Adding $2.94 million of IDC results in a total construction cost of $56.3 million.

Annual OMR&P Costs

Average annual OMR&P costs, indexed to 2010 dollars, were estimated at $179.0 thousand. The 100-year stream of average annual OMR&P costs discounted to the end of the construction period totals $4.26 million.

Adding $4.26 million of discounted average annual OMR&P costs spread across the 100-year period of analysis brings the total cost for this alternative to $60.6 million.

Combining the discounted agricultural and hydropower benefits ($42.9 million) with the total project construction and annual OMR&P costs ($60.6 million) results in a negative net benefit of -$17.7 million. This corresponds to the benefit cost ratio of 0.71.

6.2.3 Thief Valley Enlargement Alternative

Benefits

Agricultural Benefits

All agricultural irrigation benefits associated with the action alternatives were measured as changes from the No Action alternative. To start the agricultural benefits calculation, the “without” project annual net farm income was calculated by estimating the economic net revenues for each of the six crops in the analysis and multiplying that by the number of acres for each of the crops. This was presented in the No Action alternative description.

There are 97,555 acres in the Thief Valley enlargement site currently irrigated with natural flow and storage water. The crops represented by the NED benefits budgets include irrigated potatoes, winter and spring-planted wheat, alfalfa, grass hay, and pasture.

Table 6-9 presents the price and yield assumptions used in the “with” project benefits budgets and the residual net farm income by crop. An increase in yield was assumed for the “with” project conditions. Alfalfa hay yield increased to 6 tons/acre, grass hay increased to 2.5 tons/acre and the amount of aftermath grazing increased to 1 AUMs/acre. There was no increase in potato yields, but spring wheat yields increased to 91 bushels/acre, winter wheat yields increased to 120 bushels/acre, and pasture yields increased to 20 AUMs/acre. With the exception of potato, spring and winter wheat, no change in crop acres was assumed. Potato acres are assumed to increase by 400 acres at the expense of the spring and winter wheat acreages.

Table 6-9. Thief Valley Enlargement Alternative Net Farm Income by Crop

Crop	Yield	Unit	Price	Net Income/Acre
Alfalfa Hay	6	Tons	$144.68	$189.97
Grass Hay and	2.5	Tons	$144.68	
Aftermath Grazing	1.0	AUMs	$13.53	$132.06
Potatoes	506	Cwt	$7.12	$629.43
Spring Wheat	91	Bushel	$5.36	-$57.59
Winter Wheat	120	Bushel	$5.36	$127.82
Pasture	20	AUMs	$13.53	-$11.20

Once the changes in yields and the change in potato and wheat acreages had been identified, the residual net farm income for the crops was estimated and then compared to the No Action alternative acreages and residual net farm income. The difference in net farm income between the No Action and Thief Valley enlargement alternatives is an estimate of an annual benefit coming from implementing this alternative. The annual benefit is assumed to occur for each of the next 100 years. This 100-year benefit stream is then present valued to arrive at a total net benefit value in 2010 dollars. The future benefit stream was discounted using the 2010 planning rate of 4.125 percent. The annual benefit stream came to $8,123,372; the present value is $193,472,300. This is presented in Table 6-10.

Table 6-10. Thief Valley Alternative Crop Acres and Total Residual Net Farm Income

	Grass hay	Alfalfa	Winter grain	Spring grain	Potatoes	Corn	Pasture	Total
With Project								
Acres	29,948	29,812	5,854	3,716	1,546	413	26,266	97,555
Net Farm Income	$3,954,938	$5,663,338	$748,282	-$214,027	$972,992	$0	($294,181)	
Without Project								
Acres	29,948	29,812	6,054	3,916	1,146	413	26,266	97,555
Net Farm Income	$2,608,175	$713,097	$134,884	($529,353)	$721,497	-	($940,329)	
Difference in:								
Acres	-	-	(200)	(200)	400	-	-	(0)
Net Farm Income	1,346,763	4,950,241	613,398	315,326	251,495	-	$646,148	$8,123,372
Annual Benefit								$8,123,372
Net Present Value								$193,472,300

Hydropower Benefits

The 100-year discounted stream of local hydropower benefits for this alternative was estimated at $22.03 million. The 100-year discounted stream of downstream hydropower losses for this alternative was estimated at -$40.2 million. Combining the positive local effect with the negative downstream effect results in an overall negative hydropower effect of -$18.1 million.

The discounted 100-year stream of agriculture and hydropower benefits for this alternative total $175.3 million.

Costs

As shown in Table 6-11, construction and IDC costs for this alternative total $262.7 million.

Table 6-11. Thief Valley Enlargement Alternative Total Costs (Millions $)

Cost Element	Original Estimate ($1M)	Indexed Estimate 2010 ($1M)	Year 1 ($1M)	Year 2 ($1M)	Year 3 ($1M)
Dam & Related Structures	61.0	61.0	4.5	56.5	0
Pumping Plant & Conveyance	122.0	122.0	40.6	40.6	40.8
Hydropower Plant	42.4	63.9	21.3	21.3	21.3
Power Transmission Lines	0.02	0.02	0	0	.02
Subtotal		246.9	66.4	118.4	62.1
Interest During Construction		15.78	1.37	5.24	9.18
Total Construction Costs		262.7	67.77	123.64	71.29
Average Annual OMR&P Costs	.7373				
Discounted 100 Year Stream of Average Annual OMR&P Costs		17.56			
Total Construction, IDC, and OMR&P Costs		280.26			

Construction Costs

Construction elements for this alternative include a dam, downstream pumping plant and conveyance system, hydropower plant, and hydropower transmission lines. Construction costs for these four elements, indexed to 2010 dollars, total $246.9 million. Adding $15.8 million of IDC results in a total construction cost of $262.7 million.

Annual OMR&P Costs

Average annual OMR&P costs, indexed to 2010 dollars, were estimated at $737.3 thousand. The 100-year stream of average annual OMR&P costs discounted to the end of the construction period totals $17.6 million.

Adding $17.6 million of average annual OMR&P costs spread across the 100-year period of analysis brings the total cost for this alternative to $280.3 million.

Combining the discounted agricultural and hydropower benefits ($175.36 million) with the total project construction and annual OMR&P costs ($280.3 million) results in a negative net benefit of -$104.9 million. This corresponds to a benefit cost ratio of 0.63.

6.2.4 North Powder Alternative

Benefits

Agricultural Benefits

All agricultural irrigation benefits associated with the action alternatives were measured as changes from the No Action alternative. To start the agricultural benefits calculation, the “without” project annual net farm income was calculated by estimating the economic net revenues for each of the six crops in the analysis and multiplying that by the number of acres for each of the crops. This was presented in the No Action alternative description.

There are 67,789 acres in the North Powder site currently irrigated with natural flow and storage water. The crops represented by the NED benefits budgets include irrigated potatoes, winter and spring-planted wheat, alfalfa, grass hay, and pasture.

Table 6-12 presents the price and yield assumptions used in the “with” project benefits budgets and the residual net farm income by crop. An increase in yield was assumed for the “with” project conditions. Alfalfa hay yield increased to 6 tons/acre, grass hay increased to 2.5 tons/acre and the amount of aftermath grazing increased to 1 AUMs/acre. There was no increase in potato yields, but spring wheat yields increased to 91 bushels/acre, winter wheat yields increased to 120 bushels/acre, and pasture yields increased to 20 AUMs/acre. With the exception of potato, spring and winter wheat, no change in crop acres was assumed. Potato acres are assumed to increase by 112 acres at the expense of the spring and winter wheat acreages.

Table 6-12. North Powder Alternative Net Farm Income by Crop

Crop	Yield	Unit	Price	Net Income/Acre
Alfalfa Hay	6	Tons	$144.68	$189.97
Grass Hay and	2.5	Tons	$144.68	
Aftermath Grazing	1.0	AUMs	$13.53	$132.06
Potatoes	506	Cwt	$7.12	$629.43
Spring Wheat	91	Bushel	$5.36	-$57.59
Winter Wheat	120	Bushel	$5.36	$127.82
Pasture	20	AUMs	$13.53	-$11.20

Once the changes in yields and the change in potato and wheat acreages had been identified, the residual net farm income for the crops was estimated and then compared to the No Action alternative acreages and residual net farm income. The difference in net farm income between the No Action and North Powder alternatives is an estimate of an annual benefit coming from implementing this alternative. The annual benefit is assumed to occur for each of the next 100 years. This 100-year benefit stream is then present valued to arrive at a total net benefit value in 2010 dollars. The future benefit stream was discounted using the 2010 planning rate of 4.125 percent. The annual benefit stream came to $2,285,336; the present value is $54,429,300. This is presented in Table 6-13.

Table 6-13. North Powder Alternative Crop Acres and Total Residual Net Farm Income

	Grass		Winter	Spring				
Item	Hay	Alfalfa	grain	Grain	Potatoes	Corn	Pasture	Total
With Project								
Acres	8,425	8,387	1,647	1,046	435	116	7,389	27,445
Net Farm Income	$1,112,637	$1,593,258	$210,513	-$60,212	$273,730	$0	-$82,762	
Without Project								
Acres	8,425	8,387	1,703	1,102	322	116	7,389	27,445
Net Farm Income	$733,754	$200,614	$37,947	-$148,922	$202,978	$0	-$264,541	
Difference in								
Acres	-	-	(56)	(56)	112	-	-	(0)
Net Farm Income	378,883	1,392,644	172,566	88,710	70,753	-	181,780	2,285,336
Annual Benefit								$2,285,336
Net Present Value								$54,429,300

* Benefit Stream of 100 years, discount rate of 4.125 percent

Hydropower Benefits

The 100-year discounted stream of local hydropower benefits for this alternative was estimated at $8.72 million. The 100-year discounted stream of downstream hydropower losses for this alternative was estimated at -$5.15 million. Combining the positive local effect with the negative downstream effect results in an overall positive hydropower effect of $3.57 million.

The discounted 100-year stream of agriculture and hydropower benefits for this alternative totals $58.0 million.

Costs

As shown in Table 6-14, construction and IDC costs for this alternative total $136.1 million.

Table 6-14. North Powder Alternative Total Costs (Millions $)

Cost Element	Original Estimate	Indexed Estimate (2010 $)	Year 1	Year 2	Year 3
Dam & Related Structures	113.4	113.4	36.8	33.9	42.7
Hydropower Plant	9.36	14.1	4.7	4.7	4.7
Power Transmission Lines	0.72	0.72	.24	.24	.24
Subtotal		128.22	41.74	38.84	47.64
Interest During Construction		7.87	.86	2.56	4.45
Total Construction Costs		136.09	42.6	41.4	52.09
Average Annual OMR&P Costs	.213				
Discounted 100 Year Stream of Average Annual OMR&P Costs		5.07			
Total Construction, IDC, and OMR&P Costs		141.16			

Construction Costs

Construction elements for this alternative include a dam, hydropower plant, and hydropower transmission lines. Construction costs for these three elements, indexed to 2010 dollars, total $128.2 million. Adding $7.9 million of IDC results in a total construction cost of $136.1 million.

Annual OMR&P Costs

Average annual OMR&P costs, indexed to 2010 dollars, were estimated at $213.0 thousand. The 100-year stream of average annual OMR&P costs discounted to the end of the construction period totals $5.1 million.

Adding $5.1 million of average annual OMR&P costs spread across the 100-year period of analysis brings the total cost for this alternative to $141.2 million.

Combining the discounted agricultural and hydropower benefits ($58.0 million) with the total project construction and annual OMR&P costs ($141.2 million) results in a negative net benefit of -$83.2 million. This corresponds to a benefit cost ratio of 0.41.

6.2.5 East Pine Alternative

Benefits

Agricultural Benefits

All agricultural irrigation benefits associated with the action alternatives were measured as changes from the No Action alternative. To start the agricultural benefits calculation, the “without” project annual net farm income was calculated by estimating the economic net revenues for each of the six crops in the analysis and multiplying that by the number of acres for each of the crops. This was presented in the No Action alternative description.

There are 18,000 acres in the East Pine site currently irrigated with natural flow and storage water. The crops represented by the NED benefits budgets include irrigated potatoes, winter and spring-planted wheat, alfalfa, grass hay, and pasture.

Table 6-15 presents the price and yield assumptions used in the "with" project benefits budgets and the residual net farm income by crop. An increase in yield was assumed for the "with" project conditions. Alfalfa hay yield increased to 6 tons/acre, grass hay increased to 2.5 tons/acre and the amount of aftermath grazing increased to 1 AUMs/acre. There was no increase in potato yields, but spring wheat yields increased to 91 bushels/acre, winter wheat yields increased to 120 bushels/acre, and pasture yields increased to 20 AUMs/acre. With the exception of potato, spring and winter wheat, no change in crop acres was assumed. Potato acres are assumed to increase by 74 acres at the expense of the spring and winter wheat acreages.

Table 6-15. East Pine Alternative Net Farm Income by Crop

Crop	Yield	Unit	Price	Net Income/Acre
Alfalfa Hay	6	Tons	$144.68	$189.97
Grass Hay and	2.5	Tons	$144.68	
Aftermath Grazing	1.0	AUMs	$13.53	$132.06
Potatoes	506	Cwt	$7.12	$629.43
Spring Wheat	91	Bushel	$5.36	-$57.59
Winter Wheat	120	Bushel	$5.36	$127.82
Pasture	20	AUMs	$13.53	-$11.20

Once the changes in yields and the change in potato and wheat acreages had been identified, the residual net farm income for the crops was estimated and then compared to the No Action alternative acreages and residual net farm income. The difference in net farm income between the No Action and East Pine alternatives is an estimate of an annual benefit coming from implementing this alternative. The annual benefit is assumed to occur for each of the next 100 years. This 100-year benefit stream is then present valued to arrive at a total net benefit value in 2010 dollars. The future benefit stream was discounted using the 2010 planning rate of 4.125 percent. The annual benefit stream came to $1,498,854; the present value is $35,697,800. This is presented in Table 6-16.

Table 6-16. East Pine Alternative Crop Acres and Total Residual Net Farm Income

Item	Grass hay	Alfalfa	Winter grain	Spring grain	Potatoes	Corn	Pasture	Total
With Project								
Acres	5,526	5,501	1,080	686	285	76	4,846	18,000
Net Farm Income	729,731	1,044,950	138,066	(39,490)	179,528	-	(54,280)	

	Grass		Winter	Spring				
Without Project								
Acres	5,526	5,501	1,117	723	211	76	4,846	18,000
Net Farm Income	481,238	131,574	24,888	(97,672)	133,124	-	(173,501)	
Difference in								
Acres	-	-	(37)	(37)	74	-	-	(0)
Net Farm Income	248,493	913,375	113,179	58,181	46,404	-	119,222	1,498,854
Annual Benefit								$1,498,854
Net Present Value*								$35,697,800

Hydropower Benefits

The 100-year discounted stream of local hydropower benefits for this alternative was estimated at $13.11 million. The 100-year discounted stream of downstream hydropower losses for this alternative was estimated at -$11.65 million. Combining the positive local effect with the negative downstream effect results in an overall positive hydropower effect of $1.46 million.

The discounted 100-year stream of agriculture and hydropower benefits for this alternative total $37.2 million.

Costs

As shown in Table 6-17, construction and IDC costs for this alternative total $158.1 million.

Table 6-17. East Pine Alternative Total Costs (Millions $)

Cost Element	Original Estimate	Indexed Estimate (2010 $)	Year 1	Year 2	Year 3
Dam & Related Structures	133.4	133.4	23.0	53.7	56.7
Hydropower Plant	10.33	15.6	5.2	5.2	5.2
Power Transmission Lines	0.68	0.68	.23	.22	.23
Clear Creek Diversion	0.055	0.4	0	0.4	0
Subtotal		150.1	28.4	59.5	62.1
Interest During Construction		8.04	.59	2.42	5.03
Total Construction Costs		158.1	29.0	61.9	67.2
Average Annual OMR&P Costs	.251				
Discounted 100 Year Stream of Average Annual OMR&P Costs		5.97			
Total Construction, IDC, and OMR&P Costs		164.1			

Construction Costs

Construction elements for this alternative include a dam, hydropower plant, hydropower transmission lines, and the Clear Creek Diversion. Construction costs for these four elements, indexed to 2010 dollars, total $150.1 million. Adding $8.0 million of IDC results in a total construction cost of $158.1 million.

Annual OMR&P Costs

Average annual OMR&P costs, indexed to 2010 dollars, were estimated at $250.6 thousand. The 100-year stream of average annual OMR&P costs discounted to the end of the construction period totals $6.0 million.

Adding $6.0 million of average annual OMR&P costs spread across the 100-year period of analysis brings the total cost for this alternative to $164.1 million.

Combining the discounted agricultural and hydropower benefits ($37.2 million) with the total project construction and annual OMR&P costs ($164.1 million) results in a negative net benefit of -$126.9 million. This corresponds to a benefit cost ratio of 0.23.

6.3 Benefit-Cost Comparison across Alternatives

Table 6-18 presents the results of the benefit-cost analysis across all four proposed alternatives. While the Hardman alternative generates the highest ratio overall, none of the alternatives result in positive net benefits or benefit-cost ratios greater than 1.0. Individual alternatives do generate net positive benefits with inclusion of hydropower generation; however, these alternatives were conceptually designed for agricultural benefits with the additional water storage, and were not evaluated with hydropower generation as the primary function. Further study is necessary to confirm these results that the net positive hydropower benefits within the context of the overall regional power system are valid. Hydropower-specific and other economic analyses were outside of the scope of this appraisal level study and were not undertaken.

Table 6-18. Benefit-Cost Analysis Results for each Alternative (Millions $)

Benefit-Cost Components	Hardman Alternative	Thief Valley Enlargement Alternative	North Powder Alternative	East Pine Alternative
Total Benefits	**42.9**	**175.3**	**58.0**	**37.2**
Agriculture	43.6	193.5	54.4	35.7
-Hydropower	-0.7	-18.1	3.6	1.5
Total Costs	**60.6**	**280.3**	**141.2**	**164.1**
Construction & IDC	56.3	262.7	136.1	158.1
OMR&P	4.3	17.6	5.1	6.0
Net Benefits	**-17.7**	**-104.9**	**-83.2**	**-126.9**
Benefit-Cost Ratio	**.71**	**.63**	**.41**	**.23**

Chapter 7 CONCLUSIONS AND RECOMMENDATIONS

Reclamation is authorized to conduct feasibility studies on water optimization by the Burnt, Malheur, Owyhee, and Powder River Basin Water Optimization Study Act of 2002 (P.L. 107-237). However, the decision to proceed to a feasibility study of one or more of the potential storage sites analyzed requires that at least one alternative meets the objectives stated in Chapter 1.

The Federal objective is to contribute to NED consistent with protecting the Nation's environment. An NED benefit-cost analysis compares the benefits of a proposed project to its costs. Total costs of the project are subtracted from the total benefits to quantify potential net benefits. The calculated benefits associated with the action alternatives are defined as changes from the No Action alternative.

Overall project benefit and cost ratios of the proposed alternatives were presented. Ratios are advantageous in determining an "accept" or "reject" decision. For example, when benefits of a project equal its costs, the net benefit of that project is zero, and the benefit-cost ratio equals 1.0. To demonstrate an increase in the net value of goods or services to satisfy the Federal objectives set forth in the P&Gs and project justification in this appraisal level analysis, the calculated benefit-cost ratio of an alternative must be equal to or greater than 1.0.

The results of this appraisal level study indicate that a Federal objective does not exist that would recommend at least one alternative be carried forward into a feasibility study that would be consistent with the original objectives of this study, Reclamation policies, laws, costs, benefits, and environmental impacts due to the cost/benefit requirement. The appraisal analyses performed for all four screened alternatives resulted in benefit to cost ratios of less than 1.0.

The results of this appraisal level study also demonstrate that the No Action alternative does not meet water users' water delivery needs. These needs are not being met either currently or through the study's 40-year planning horizon for existing Reclamation projects.

The appraisal study alternatives focused on supplying water to current and future agricultural needs in addition to considering additional benefits resulting from multi-purpose uses. While the benefit to cost ratio of this appraisal level study resulted in a values less than 1.0, opportunities exist for the stakeholders to evaluate alternatives focused on hydropower generation benefits related to energy production within the region using the study area's water resources. Analyses of the various alternatives, using available hydrologic information indicated storage potential that could be assessed for hydropower generation capabilities.

Conclusions reached by this study could not have been achieved without extensive research and assimilation of hydrologic data and water right information. Improvements to this understanding and future analyses would be realized through better measurement of existing water supply and use.

This appraisal study process has identified alternatives that may be implemented without Federal involvement, should stakeholders wish to pursue them. Four sites had been identified through the screening process involving stakeholders. In concert with the WASH Initiative's mission statement, other long term water management plans could be developed.

The following recommendations are provided by Reclamation to the project stakeholders as a result of the Eastern Oregon Water Storage Appraisal Study:

- None of the alternatives analyzed as water storage projects for irrigation should be considered for further study.

- Stakeholders should pursue water optimization studies and implementation through grant and loan programs supported by Reclamation and others. Consideration of non-structural actions would assist irrigators in achieving the water users' water delivery needs. Watershed management or water conservation measures, such as those identified in the WASH objectives and listed under current activities (Section 1.4) should be pursued.

- Stakeholders could consider studies focused on hydropower generation potential within the basin.

- To support the above recommendations, stakeholders should pursue means to collect additional long-term hydrologic and water use data within the study area. This would enable the stakeholders to enhance their knowledge of the basin's water resources.

Chapter 8 Literature Cited

Parenthetical Reference Bibliographic Citation

Parenthetical Reference	Bibliographic Citation
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Cocks 2009	Cocks, Michael. 2009. Industry Economist – Marketing and Pricing. Bonneville Power Administration. November.
EVSWCD 1968a	Eagle Valley Soil and Water Conservation District and Pine Valley Water Control District, East Pine Impact Study, Baker County, Oregon, December 1968.
EVSWCD 1968b	Eagle Valley Soil and Water Conservation District, Pine Valley Water Control District, Watershed Work Plan, Pine Valley, Baker County, Oregon, December 1968.
EVSWCD 1978	Eagle Valley Soil and Water Conservation District and Pine Valley Water Control District, Pine Valley Watershed Protection and Flood Prevention Project, Baker County, Oregon, Plans for the Construction of East Pine Creek Dam, July 1978.
FEMA 1988	Federal Emergency Management Agency. June 3, 1988. Flood Insurance Rate Maps, Baker County, Oregon and Incorporated Areas.
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HUD 1978	U.S. Department of Housing and Urban Development. September 29, 1978. Flood Insurance Rate Map, City of North Powder, Oregon, Union County.
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NPCC 2010	Northwest Power and Conservation Council. 2010. Sixth Northwest Conservation and Electric Power Plan. Council Document 2010-09. February 2010.
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PVWCD 1980	Powder Valley Water Control District (Prepared by CH2M-Hill under contract to USDA Soil Conservation Service), North Powder Watershed Protection and Flood Prevention Project, Baker County, Oregon, Plans for the Construction of North Powder Reservoir, April 1980.
Reclamation 1965	Larson C. E., US Dept of Interior, Bureau of Reclamation, Geologic Report for Feasibility Design Request, Hardman Damsite, Burnt River Project, Oregon, Dark Canyon Division, Jan 1965.
Reclamation 2001	Bureau of Reclamation. 2001. *Burnt River Basin Water Temperature Modeling, Final Report.* Technical Service Center, Water Quality and Land Suitability Group (Mangelson, K.A.), Denver, CO.
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Reclamation 2009a	Bureau of Reclamation. 2009. Technical Memorandum 86-68210-091. Literature Synthesis on Climate Change Implications for Reclamation's Water Resources. Technical Service Center. Water Resources Planning and Operations Support Group, Water and Environmental Resources Division. U.S. Bureau of Reclamation.
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Reclamation 2010	Reclamation: Programs & Activities, PN Region Storage Study." Bureau of Reclamation Homepage. Web. 15 Dec. 2010. <http://www.usbr.gov/pn/programs/srao_misc/storagestudy/index.html>
USACE 2006	U.S. Army Corps of Engineers 2006, The Dalles Lock and Dam Juvenile Behavioral Guidance System Columbia River, Oregon-Washington.
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USFS 1967	USDA, Forest Service, Impact Survey Report (Hardman Dam), June 1967.
USFWS 2010	U.S. Fish and Wildlife Service. Boise, Idaho. Final Critical Habitat Rule. September 30, 2010 <http://www.fws.gov/pacific/bulltrout/CriticalHabitat.html>.
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Wallowa Whitman National Forest 1999	Wallowa Whitman National Forest. 1999. Powder River Haines, North Powder River, Wolf Creek watershed analysis. Wallowa Whitman National Forest, Baker Ranger District.
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Glossary

acre-feet (acre-feet) – One acre-foot is the volume of water that would cover an acre of land to a depth of 1 foot (43,560 cubic feet, or 325,851 gallons).

active storage – The volume of water storage in a reservoir between its minimum and maximum content that is normally available for release; usually expressed in units of acre-feet.

average annual discharge (runoff) -- For a specified area, the average value of annual runoff amounts calculated for a selected period of record that represents average hydrologic conditions.

average annual (safe) yield – The quantity of water that can be annually collected for a given use from surface or ground water sources of supply without depleting the source beyond it ability to be replenished naturally.

certificate/water right certificate – A document issued by the state or Oregon and held by the Oregon Water Resources Department that describes the source, rate, use, and place of use for water, and the conditions required by law.

cfs (cubic feet per second) – A measurement of the flow of water equal to 7.48 gallons of water flowing each second.

consumptive water use – Total amount of water used by vegetation, human activity, and evaporation of surface water. Irrigation is a primary consumptive use in this study.

date of priority – The date when a water right certificate was issued, which also describes the seniority of the use of water from a specific source.

dead storage (dead capacity) – The reservoir capacity that cannot be evacuated by gravity.

diversion – A structure built to divert the flow of water from a stream channel.

diversion rate – The maximum, instantaneous quantity of water allowed to be diverted from a water source as described on a state-issued water right certificate.

instream water right – A water right for flow that is to remain in a stream for the purpose of fish and aquatic habitat.

non-consumptive water use – A use of water that either does not remove the water from the available water supply system or returns it to the system in total after its use. Hydropower production is an example of non-consumptive use. Some commercial and municipal uses are non-consumptive if diverted volumes are fully returned to the source.

subject to forfeit – If a certified water right has not been put to beneficial use in 5 or more consecutive years, the water right is subject to cancelation (forfeit) by the Oregon Water Resources Department. Cancelation requires a legal proceeding to determine whether or not the period of non-use has occurred.

surplus flow – A volume of water that is in excess of an identified need such as a water right for irrigation or instream flow.

water year -- Period of time beginning October 1 of one year and ending September 30 of the following year and designated by the calendar year in which it ends. A calendar year used for water calculations.

303 (d) water quality limitations – water bodies that do not meet applicable clean water standards are place on a list that identifies the location and nature of the limitation. The list for this study area is maintained by the Oregon Department of Environmental Quality. The "303 (d)" is a reference to the pertinent section of the Clean Water Act.

APPENDIX A

Water and Stream Health Steering Committee

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IN THE BOARD OF COUNTY COMMISSIONERS OF THE STATE OF OREGON
FOR THE COUNTY OF BAKER

IN THE MATTER OF APPOINTING MEMBERS TO WATER AND STREAM HEALTH STEERING COMMITTEE	)))))	ORDER NO. 2009-143

NOW AT THIS TIME, this 20th day of May, 2009, and the above entitled matter coming on for consideration by the Board of Commissioners, and it appearing to the Board of Commissioners that members to the Water and Stream Health Steering Committee be appointed; and

NOW, THEREFORE, it is hereby ORDERED and ADJUDGED that the following are hereby appointed to serve as members of the Water and Stream Health Steering Committee:

Name	Term Expiration
Marion Crow	May 1, 2011
Cal Foster	May 1, 2011
Jerry Franke	May 1, 2011
Tom (Mac) Kerns	May 1, 2011
Rick Lusk	May 1, 2011
Michael McNamara	May 1, 2011
Gary Miller	May 1, 2011
Darrell Dyke	May 1, 2011
Aaron Umpleby	May 1, 2011
Clair Pickard	May 1, 2011
Phil George	May 1, 2011
Tim Bailey	May 1, 2011

Done and dated this 20th day of May, 2009.

BAKER COUNTY BOARD OF COMMISSIONERS

Fred Warner Jr.

Fred Warner Jr., Commission Chair

Tim L. Kerns

Tim L. Kerns, Commissioner

Carl E. Stiff

Carl E. Stiff, M.D., Commissioner

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APPENDIX B

Water Rights Summaries

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Appendix B – Water Rights Summaries

The enclosed water right summaries were used to estimate current and future needs in the respective watersheds. Tables B-1 through B-11 contain the certified municipal, industrial, and instream water rights for the Burnt River, Powder River, and Pine Creek basins. The enclosed population data was used to estimate future municipal needs in their respective watersheds.

Figures B-1, B-2, and B-3 provide the locations of certain instream water rights held by the Oregon Department of Water Resources (ODWR) and Oregon Department of Fish and Wildlife for fish benefits. Those water rights are designated as “I” in the figures. Detailed information on the certificated instream water rights is provided in Tables B-4, B-8, and B-11 below.

Locations with pending water right applications are designed as “IS” on the figures. Information on those applications can be found on the ODWR Water Rights Database.

Discussion on the inclusion of instream water rights in the MODSIM modeling analysis

The tables below show a significant number of instream water rights that could potentially affect the diversion of water to storage and the operation of the proposed reservoir projects described in this study. These instream rights were not included in the hydrologic analysis or the MODSIM modeling conducted to estimate the storable water and the effect of the proposed projects on reducing water supply shortages and providing instream flow benefits. The instream rights were not included for the following reasons:

- Many of the instream rights are upstream of the proposed water development sites, and would not affect the operations of the proposed reservoirs and reservoir enlargements.
- Including the instream rights in the analysis would have complicated the operational analysis beyond the level of detail typically included in an appraisal-level evaluation.
- Details of existing reservoir operations were not included in the analysis, and these reservoirs may be partially operated to meet the instream rights or may be otherwise affected by them.
- The priorities of the instream rights with respect to the priorities of the proposed reservoirs are not clear.

A sensitivity analysis was conducted using the largest instream right with the greatest potential to affect the proposed reservoirs and proposed enlargements (the 50-cfs instream water right immediately below Thief Valley Reservoir). In this analysis, it was assumed that the instream right needed to be satisfied at all times before water could be stored in the proposed enlarged Thief Valley Reservoir.

The results of the analysis showed that the ability of the proposed enlarged reservoir to reduce the Powder River basin water supply shortages was decreased from an average of 30,500 acre-feet per year, to an average of 29,000 acre-feet per year. In addition, the 50-cfs instream flow right below Thief Valley Reservoir was satisfied almost 98 percent of the time, as opposed to only about 85 percent of the time under existing conditions.

This sensitivity analysis indicates that, at least in the case of the proposed Thief Valley Reservoir enlargement, the instream water rights would probably not significantly decrease the potential water supply benefits associated with the proposed project. Additionally, the proposed enlargement could provide water to meet the instream right a higher percentage of the time. This could provide additional flow benefits below the proposed reservoir enlargement that would be greater than those estimated in the results documented in this report. Additional research and evaluation would be required if any of the proposed reservoirs are advanced to the next phase after this study.

Burnt River

Table B-1. Municipal Water Rights: Burnt River Basin			
Community	**Source**	**Maximum Rate[1]**	**Certificate Number[1]**
Unity	Job Creek (groundwater well)	70 gpm (0.015 cfs)	G-11444
Unity	Job Creek (groundwater well)	40 gpm (0.089 cfs)	G-12107
Huntington	Burnt River (groundwater well)	1.11 cfs	54985
Burnt River Subbasin Total		**1.21 cfs**	

[1]Water right certificates obtained from Oregon Department of Water Resources Water Rights Database at http://apps2.wrd.state.or.us/apps/wr/wrinfo/.

Table B-2. Population Data: Burnt River Basin				
Community	**Current Population[1]**	**Low-growth Scenario (0.3-Percent/Year) 2050[2]**	**Medium-growth Scenario (1.25-Percent/Year) 2050[3]**	**High-growth Scenario (2.0-Percent/Year) 2050[4]**
Unity	122	138	203	275
Huntington	470	534	801	1,101
TOTAL	**592**	**672**	**1004**	**1,376**

[1] Unity 2009 population and Huntington 2007 population obtained from www.city-data.com.

[2, 3, 4] Growth rates were adapted from Figure 2-4 of "City of Baker City, Water Facilities Plan" by Anderson Perry & Associates, Inc. Growth rates of 0.3-Percent, 1.25-Percent, and 2-Percent per year used in Baker City forecast were applied to Huntington.

Table B-3. Industrial Water Rights: Burnt River Basin		
Diversion Location	**Maximum Rate**	**Certificate Number[1]**
Gimlet Creek and Jackknife Creek	0.220 cfs	60829
Spring, Tributary to Burnt River	0.010 cfs	60878
Burnt River	0.967 cfs	12052
Total	**1.197 cfs**	

[1]Water right certificates obtained from Oregon Department of Water Resources Water Rights Database at http://apps2.wrd.state.or.us/apps/wr/wrinfo/.

NOTE: Unity Reservoir, 25,220 acre-feet (cert-51709) listed irrigation, domestic, manufacturing, and industrial as usage categories. This water right has already been accounted for as irrigation water rights (TSC Flow Report) therefore not reported in industrial table separately.

Table B-4. Certificated Instream Water Rights – Burnt River Basin

Stream	Study Site	Maximum Flow Rate (cfs)[1]	Certificate Number[1]	Priority Date
East Camp Creek – unknown tributary at Sec.5NENE to mouth	Camp Creek	8.2	73332	1/29/92
West Camp Creek – North Fork to mouth	Camp Creek	3.0	73324	1/29/92
South Fork Burnt River – headwaters to Elk Creek	South Fork Burnt River, Hardman, Whited, and Unity	8.3	72658	1/29/92
Elk Creek – headwaters to mouth	South Fork Burnt River, Hardman, Whited, and Unity	3.0	72660	1/29/92
*South Fork Burnt River – Elk Creek to river mile 9.8	South Fork Burnt River, Hardman, Whited, and Unity	10.0	73323	1/29/92
North Fork Burnt River – river mile 28.5 to Camp Creek	North Fork Burnt River, Ricco, Upper, Middle, and Lower North Fork Burnt River, and Unity	5.0	72662	1/29/92

[1]Water right certificates obtained from Oregon Department of Water Resources Water Rights Database at http://apps2.wrd.state.or.us/apps/wr/wrinfo/.

Powder River

Table B-5. Municipal Water Rights: Powder River Basin			
Community	**Source**	**Maximum Rate**	**Certificate Number[1]**
Baker City	Goodrich Creek	6.250 cfs	80496
Baker City	Marble Creek	5.000 cfs	80496
	Baker City Total	**11.250 cfs**	
Haines	Rock Creek	0.025 cfs	4186
	Haines Total	**0.025 cfs**	
North Powder	North Powder River (groundwater well)	2.200 cfs	65088
North Powder	North Powder River (groundwater well)	0.390 cfs	40599
	North Powder Total	**2.590 cfs**	
Richland	Eagle Creek	2.000 cfs	Permit 50156
Richland	Eagle Creek	1.000 cfs	46537
	Richland Total	**3.000 cfs**	
Sumpter	Cracker Creek	0.330 cfs	60826
Sumpter Total		**0.330 cfs**	
	Powder River Subbasin Total	**17.195 cfs**	

[1]Water right certificates obtained from Oregon Department of Water Resources Water Rights Database at http://apps2.wrd.state.or.us/apps/wr/wrinfo/.

Table B-6. Population Data: Powder River Basin				
Community	**Current Population[1]**	**Low-growth Scenario (0.3-Percent/Year) 2050[2]**	**Medium-growth Scenario (1.25-Percent/Year) 2050[3]**	**High-growth Scenario (2.0-Percent/Year) 2050[4]**
Baker City	10,035	11,380	16,909	23,053
Haines	390	444	665	914
North Powder	487	554	831	1,141
Richland	134	152	229	314
Sumpter	191	177	226	366
Total	**11,237**	**12,707**	**18,860**	**25,788**

[1]Baker City 2008 population obtained from Michelle Owen, Public Works Director. Haines, North Powder, Richland, and Sumpter 2007 population obtained from www.city-data.com.

[2, 3, 4]Growth rates were adapted from Figure 2-4 of "City of Baker City, Water Facilities Plan" by Anderson Perry & Associates, Inc. 2000. The growth rates of 0.3-Percent, 1.25-Percent, and 2-Percent per year were also applied to the other Powder River Basin cities listed.

Table B-7. Industrial Water Rights: Powder River Basin		
Diversion Location	Max Rate or Volume	Certificate Number[1]
Parker Spring, tributary to Wolf Creek	0.223 cfs	83616
Parker Spring, tributary to Wolf Creek	0.075 cfs	83617
Tributary to Powder River – T9S R40E Sec10SESW	9.20 ac-ft	73511
Radium Hot Springs	0.280 cfs	29067
Total	**0.578 cfs / 9.2 acre-feet**	

[1]Water right certificates obtained from Oregon Department of Water Resources Water Rights Database at http://apps2.wrd.state.or.us/apps/wr/wrinfo/.

Table B-8. Certificated Instream Water Rights – Powder River Basin				
Stream	**Study Site**	**Maximum Flow Rate (cfs)[1]**	**Certificate Number[1]**	**Priority Date**
Cracker Creek – Sardine Gulch to mouth	Mason	3.3	72659	1/29/92
Deer Creek – Sheep Creek to mouth	Mason	6.0	73329	1/29/92
McCully Fork – headwaters to mouth	Mason	1.8	72661	1/29/92
Powder River – Cracker Creek to Phillips Lake	Mason	5.6	73336	1/29/92
Rock Creek – Rock Creek Lake to power plant diversion	Rock Creek	2.0	73322	1/29/92
Dutch Flat Creek – lake to mouth	Twin Peak and North Powder	3.0	73331	1/29/92
Antone Creek – headwaters to mouth	North Powder	4.0	73327	1/29/92
North Powder River – North Fork to Antone Creek	North Powder	8.0	73321	6/7/91
Anthony Fork – Anthony Lake to Indian Creek	Warm Springs	7.5	73325	1/29/92
North Fork Anthony Fork – headwaters to mouth	Warm Springs	2.5	73334	1/29/92
Anthony Fork – Indian Creek to mouth	Warm Springs	10.0	73326	1/29/92

Table B-8. Certificated Instream Water Rights – Powder River Basin				
Stream	Study Site	Maximum Flow Rate (cfs)[1]	Certificate Number[1]	Priority Date
Clear Creek – east and west forks to mouth	Wolf Creek	1.8	73328	1/29/92
Big Creek – Lick Creek to mouth	None	9.0	76593	1/29/92
Powder River – Thief Valley Reservoir to Goose Creek	None	50.0	72663	1/29/92
Powder River – Goose Creek to Brownlee Reservoir	None	60.0	72664	1/29/92
West Eagle Creek – east fork to mouth	Echo Lake and West Eagle	10.0	72657	6/7/91
East Eagle Creek and tributaries – headwaters to mouth	None	45.0	59530	6/26/70
Eagle Creek and tributaries – headwaters to USGS gage 13-2882	None	80.0	59531	6/26/70
Eagle Creek and tributaries – headwaters to East Fork Eagle Creek	None	50.0	59532	6/26/70
Eagle Creek and tributaries – headwaters to West Fork Eagle Creek	None	40.0	59533	6/26/70
West Eagle Creek and tributaries – headwaters to mouth	None	5.0	59535	6/26/70
West Eagle Creek and tributaries – headwaters to Trout Creek	Goose Creek POD	10.0	59536	6/26/70
Powder River – below Mason Dam to Smith Diversion Dam	Mason	10.0	59543	6/26/70

[1]Water right certificates obtained from Oregon Department of Water Resources Water Rights Database at http://apps2.wrd.state.or.us/apps/wr/wrinfo/.

Pine Creek

Table B-9. Municipal Water Rights: Pine Creek Basin (Halfway)			
Community	**Source**	**Maximum Rate**	**Certificate Number[1]**
Halfway	Pine Creek (groundwater well)	0.25 cfs	39255
	Pine Creek Subbasin Total	**0.25 cfs**	

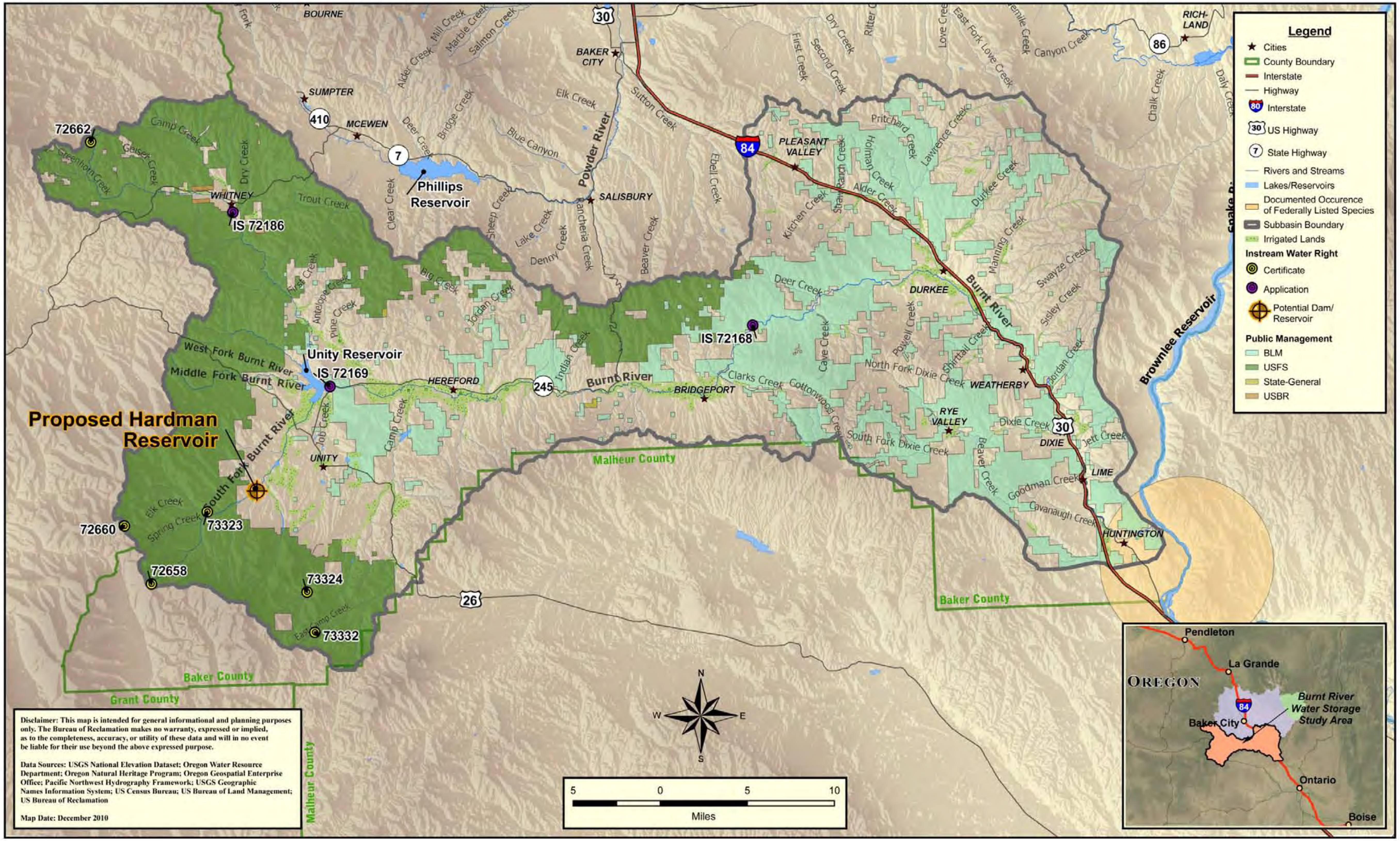
[1]Water right certificates obtained from Oregon Department of Water Resources Water Rights Database at http://apps2.wrd.state.or.us/apps/wr/wrinfo/.

Table B-10. Population Data: Pine Creek Basin (Halfway)			
Current Population[1]	**Low-growth Scenario (0.3-Percent/Year) 2050[2]**	**Medium-growth Scenario (1.25-Percent/Year) 2050[3]**	**High-growth Scenario (2.0-Percent/Year) 2050[4]**
337	383	575	790

[1]Halfway 2007 population obtained from www.halfwayoregon.com. No population data was found for Cornucopia.
[2, 3, 4] Growth rates were adapted from Figure 2-4 of "City of Baker City, Water Facilities Plan" by Anderson Perry & Associates, Inc. The growth rates of 0.3-Percent, 1.25-Percent, and 2-Percent per year used for Baker City were also used for Cornucopia and Halfway.

Table B-11. Certificated Instream Water Rights – Pine Creek Basin				
Stream	**Study Site**	**Maximum Flow Rate (cfs)[1]**	**Certificate Number[1]**	**Priority Date**
Pine Creek – Long Branch Creek to mouth	None	60.0	73335	1/29/92
*East Pine Creek – Trinity Creek to Beecher Creek	East Pine	0.6	73319	11/8/90
Little Elk Creek – headwaters to mouth	None	2.0	73333	1/29/92
Elk Creek – Big Elk Creek to mouth	None	3.0	73320	11/8/90
Duck Creek – headwaters to mouth	None	3.0	73330	1/29/92
North Pine Creek and tributaries – headwaters to mouth	None	45.0	59534	6/26/70
Clear Creek and tributaries – headwaters to 0.75 miles above Twin Bridge Creek	East Pine POD	25.0	59540	6/26/70
East Pine Creek and tributaries – headwaters to 0.5 miles above Beecher Creek	East Pine	10.0	59541	6/26/70

[1]Water right certificates obtained from Oregon Department of Water Resources Water Rights Database at http://apps2.wrd.state.or.us/apps/wr/wrinfo/.



Legend
Cities
County Boundary
Interstate
Highway
Interstate
US Highway
State Highway
Rivers and Streams
Lakes/Reservoirs
Documented Occurence of Federally Listed Species
Subbasin Boundary
Irrigated Lands
Instream Water Right
Certificate
Application
Potential Dam/ Reservoir
Public Management
BLM
USFS
State-General
USBR
Proposed Hardman Reservoir
Unity Reservoir
Phillips Reservoir
Brownlee Reservoir
IS 72186
IS 72169
IS 72168
72662
72660
72658
73323
73324
73332
BOURNE
SUMPTER
MCEWEN
WHITNEY
BAKER CITY
SALISBURY
PLEASANT VALLEY
DURKEE
WEATHERBY
RYE VALLEY
DIXIE
LIME
HUNTINGTON
HEREFORD
BRIDGEPORT
UNITY
RICH-LAND
Powder River
Burnt River
West Fork Burnt River
Middle Fork Burnt River
South Fork Burnt River
Malheur County
Baker County
Grant County
Disclaimer: This map is intended for general informational and planning purposes only. The Bureau of Reclamation makes no warranty, expressed or implied, as to the completeness, accuracy, or utility of these data and will in no event be liable for their use beyond the above expressed purpose.
Data Sources: USGS National Elevation Dataset; Oregon Water Resource Department; Oregon Natural Heritage Program; Oregon Geospatial Enterprise Office; Pacific Northwest Hydrography Framework; USGS Geographic Names Information System; US Census Bureau; US Bureau of Land Management; US Bureau of Reclamation
Map Date: December 2010
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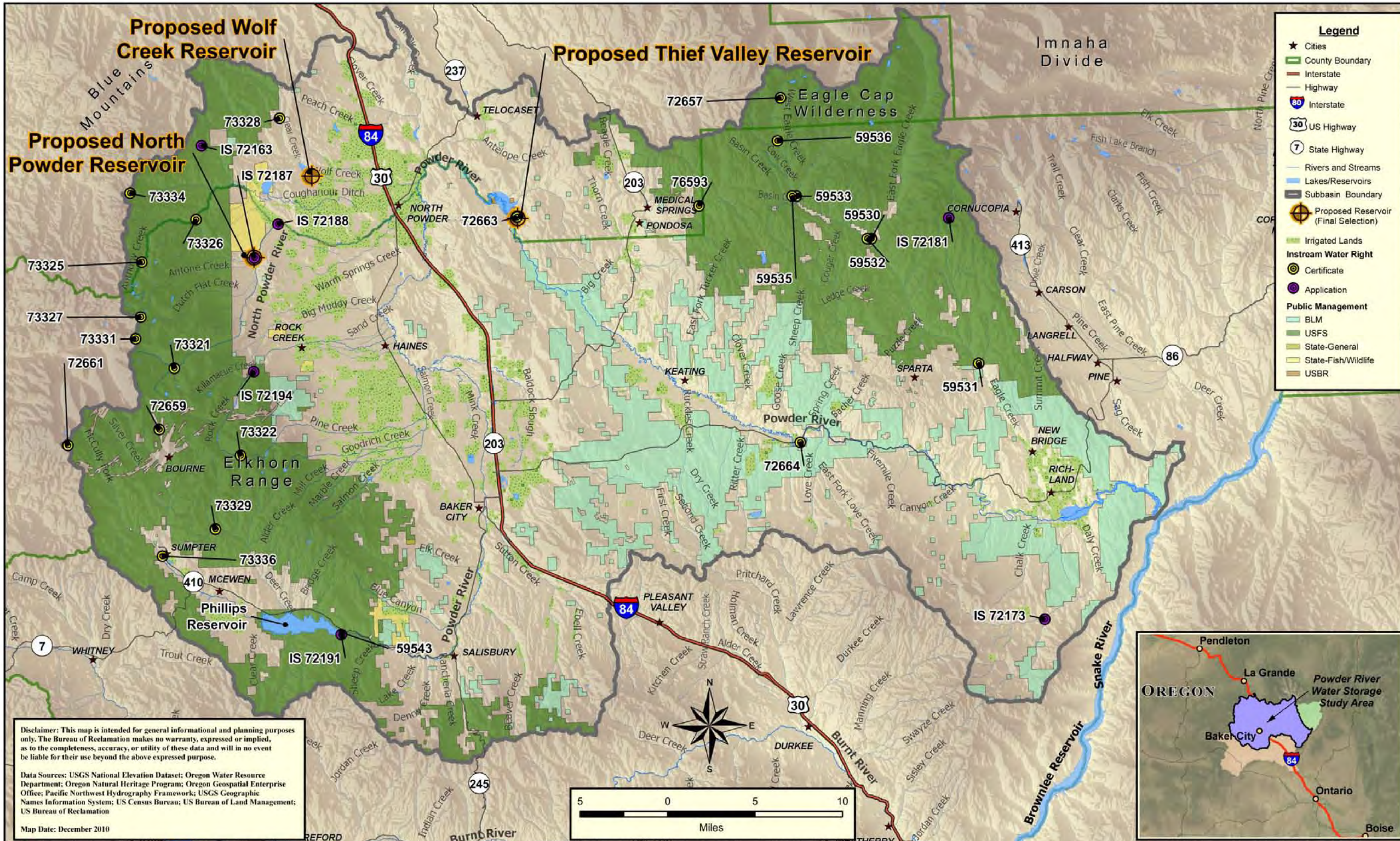
Miles
OREGON
Pendleton
La Grande
Baker City
Ontario
Boise
Burnt River Water Storage Study Area

Figure B-1


Proposed Wolf Creek Reservoir
Proposed Thief Valley Reservoir
Proposed North Powder Reservoir
Blue Mountains
Eagle Cap Wilderness
Imnaha Divide
Elkhorn Range
Legend
Cities
County Boundary
Interstate
Highway
Interstate
US Highway
State Highway
Rivers and Streams
Lakes/Reservoirs
Subbasin Boundary
Proposed Reservoir (Final Selection)
Irrigated Lands
Instream Water Right
Certificate
Application
Public Management
BLM
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State-General
State-Fish/Wildlife
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72663
76593
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IS 72181
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72664
IS 72173
TELOCASET
NORTH POWDER
MEDICAL SPRINGS
PONDOSA
CORNUCOPIA
CARSON
LANGRELL
HALFWAY
PINE
SPARTA
KEATING
NEW BRIDGE
RICHLAND
ROCK CREEK
HAINES
BOURNE
BAKER CITY
SUMPTER
MCEWEN
PLEASANT VALLEY
SALISBURY
WHITNEY
DURKEE
WEATHERBY
BRIDGEPORT
Phillips Reservoir
Powder River
North Powder River
Burnt River
Snake River
Brownlee Reservoir
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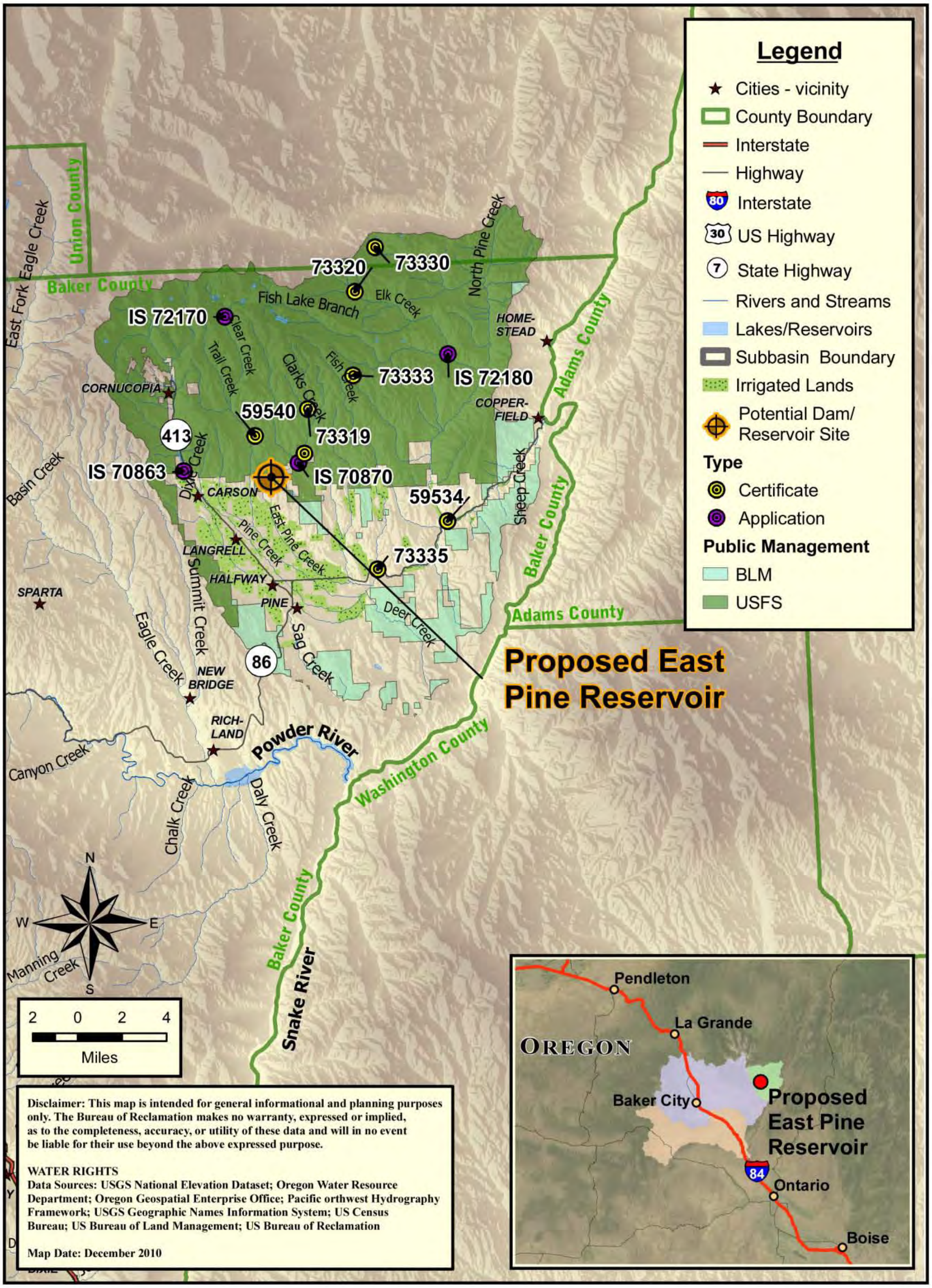
5 0 5 10
Miles
Disclaimer: This map is intended for general informational and planning purposes only. The Bureau of Reclamation makes no warranty, expressed or implied, as to the completeness, accuracy, or utility of these data and will in no event be liable for their use beyond the above expressed purpose.
Data Sources: USGS National Elevation Dataset; Oregon Water Resource Department; Oregon Natural Heritage Program; Oregon Geospatial Enterprise Office; Pacific Northwest Hydrography Framework; USGS Geographic Names Information System; US Census Bureau; US Bureau of Land Management; US Bureau of Reclamation
Map Date: December 2010
OREGON
Pendleton
La Grande
Baker City
Ontario
Boise
Powder River Water Storage Study Area

Figure B-2



Legend
Cities - vicinity
County Boundary
Interstate
Highway
80 Interstate
30 US Highway
7 State Highway
Rivers and Streams
Lakes/Reservoirs
Subbasin Boundary
Irrigated Lands
Potential Dam/ Reservoir Site
Type
Certificate
Application
Public Management
BLM
USFS
Proposed East Pine Reservoir
Union County
Baker County
Adams County
Washington County
73320
73330
IS 72170
73333
IS 72180
59540
73319
IS 70863
IS 70870
59534
73335
HOME-STEAD
CORNUCOPIA
COPPER-FIELD
CARSON
LANGRELL
HALFWAY
PINE
SPARTA
NEW BRIDGE
RICH-LAND
Powder River
Snake River
Fish Lake Branch
Elk Creek
North Pine Creek
Clear Creek
Trail Creek
Clarks Creek
Fish Creek
Sheep Creek
East Pine Creek
Pine Creek
Deer Creek
Sag Creek
Summit Creek
Eagle Creek
East Fork Eagle Creek
Basin Creek
Canyon Creek
Chalk Creek
Daly Creek
Manning Creek
413
86
N
S
E
W
2 0 2 4
Miles
Disclaimer: This map is intended for general informational and planning purposes only. The Bureau of Reclamation makes no warranty, expressed or implied, as to the completeness, accuracy, or utility of these data and will in no event be liable for their use beyond the above expressed purpose.
WATER RIGHTS
Data Sources: USGS National Elevation Dataset; Oregon Water Resource Department; Oregon Geospatial Enterprise Office; Pacific orthwest Hydrography Framework; USGS Geographic Names Information System; US Census Bureau; US Bureau of Land Management; US Bureau of Reclamation
Map Date: December 2010
Pendleton
La Grande
OREGON
Baker City
Proposed East Pine Reservoir
84
Ontario
Boise

Figure B-3

Appendix C

Appraisal Report Calculations

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Calculations for Estimates of Proposed Reservoir Costs

Development of Appraisal-Level Cost Estimate

The appraisal-level cost estimates were developed as tool to estimate project costs for a range of dam heights at each potential storage reservoir and to provide a basis of comparison of proposed projects. Because of the appraisal level of design associated with these estimates, the computed costs should be considered as preliminary. In addition to the construction cost, an estimate has been made of potential indirect costs including additional site explorations, permitting, engineering design, preparation of plans and specifications, construction supervision, mitigation and contingencies. It was assumed that the project sponsor would be responsible for any real-estate cost and therefore real-estate cost are not included. Four different sites were considered in this study (North Powder, East Pine Creek, Hardman, and Thief Valley) and a cost estimate spreadsheet was prepared with supporting information for each proposed reservoir.

Data Sources

Several existing designs and data sources were used to inform these appraisal-level designs and cost estimates. Existing plans, geotechnical information, and cost estimates directly related to the four proposed reservoirs were reviewed for design information (PVWCD 1980, Browne 2008), PVSWCD 1976, Reclamation 1965, and Reclamation 2001). Plans were also considered for a similar proposed project that is being evaluated at a higher feasibility level, Mill Creek Dam, near Colville, Washington (HDR 2009). It provided cost estimates for piping, valves, demolition, concrete and steel, and Roller Compacted Concrete (HDR 2009). Cost information was also available from the Oregon Department of Transportation Unit Cost Database (ODOT 2008) for fundamental unit costs for items such as mass concrete, earthwork, and roadway costs.

Designers evaluated and used those portions of existing design which appeared to meet current design criteria. Cost estimators indexed older cost to the 2009 level.

A field trip was also conducted to gather information used to inform the proposed reservoir designs. The trip memo is attached.

Construction Cost Calculation

The construction cost is made up of two components:

- Direct Costs - The direct costs of materials and services required to construct the projects. These are sometimes referred to as field costs or contract costs as they represent the work to be performed in the field usually by the general contractor constructing the project.

- Indirect Cost - Includes investigations, additional studies, development of plans and specifications, construction engineering and supervision, and environmental compliances. The indirect cost was estimated to be 32 percent of the direct cost for these projects.

Direct Costs

A direct cost was developed for each proposed reservoir which included the contract cost estimate for constructing the proposed dam and reservoir plus a 30 percent contingency to account for the uncertainties inherent in those estimates.

Unit costs were used for quantities that could be easily calculated for items such as earthwork and mass concrete placement. The quantities were priced at unit cost values that were developed from recently developed estimates for similar projects and from available unit cost databases. (HDR 2009, ODOT 2008).

Lump sum costs were based on other existing designs to estimate costs of features requiring significant design effort such as intake structures, outlet works, spillways, and fish passage facilities. Because of the similarities in the project designs for the three proposed storage reservoirs (North Powder, East Pine, and Hardman), the design work previously performed for the North Powder site (PVWCD 1980) was used for the other two sites with almost no modification to the cost for several lump sum items. Cost from the early North Powder project for foundation grouting, regulating outlet design and diversion, spillway and spillway stilling basin, and clearing and dewatering were indexed to 2009 cost. Costs for trap and haul fish facilities and relocation costs were obtained from estimates made for a similar project (HDR 2009).

Mobilization and demobilization cost was established at 9 percent of the estimated total of the unit cost based items and lump sum items based on similar estimates (HDR 2009).

A contingency of 30 percent was added the direct cost subtotal (unit cost items, lump sum items, and mobilization, and demobilization) to obtain the total direct cost. All cost estimates were indexed to 2009 dollars.

Indirect Costs

The indirect or noncontract cost development process is outlined below. Indirect costs were based on a percentage of the direct cost. An indirect cost value of 32 percent of was added to the direct cost which includes its own contingency cost. These indirect costs are also based on the references noted above. The 32 percent value includes:

- Additional studies – additional data collection and studies of hydrologic, water quality, biologic, and other unidentified needs; and feasibility studies (3 percent)
- Environmental permitting – meet NEPA and ESA requirements, secure 404 permits and required state environmental permits, and secure water rights for storage water if necessary (9 percent)
- Design including additional geologic explorations to better define conditions and parameters of the foundation and borrow material sites, surveying, pre-design and final design costs and specifications (13 percent)
- Construction oversight and inspection (7 percent)

Spreadsheet cost estimates

A spreadsheet was developed for each site to compute quantities, apply unit prices, add in lump sum items and factor in contingency and indirect costs. It estimates the total cost as follows:

- Computes the quantity of material for each zone in the dam at the selected elevations
- Multiplies the quantities by the unit cost to obtain a cost for the unit-cost-based items
- Adds in lump sum cost items
- Sums the above into a subtotal direct cost
- Adds 9 percent to direct cost subtotal to include mobilization and demobilization costs
- Adds 30 percent to above for contingencies
- Adds 32 percent to above to include indirect cost
- Displays the information noted above on Cost Estimate Sheets

The cost estimates are provided in the Estimate Worksheet and follow as Tables C-1, C-2, C-3, and C-4. The references in this appendix are located in Section 6 of this report.

Table C-1. Hardman Cost Estimate Worksheets

BUREAU OF RECLAMATION **ESTIMATE WORKSHEET** SHEET 1 OF 4

FEATURE: **Hardman Site Embankment Dam** **Summary Sheet 1 of 1**	**PROJECT:** **Eastern Oregon Water Storage Appraisal Study** **WOID:** **ESTIMATE LEVEL:** Appraisal **REGION:** **UNIT PRICE LEVEL:** July-09 **FILE:**

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		The Hardman Storage Project consists of:					
		92 foot high zoned embankment dam					
		Regulating Outlet and conduit					
		Spillway					
		Relocated Road					
		Trap and Haul Fish Facility					
	1	Shell material U/S and D/S		135,951	CY	$17.00	2,311,173
	2	Filter Zones U/S and D/S		19,284	CY	$30.00	578,516
	3	Impervious Core		56,887	CY	$15.00	853,312
	4	Foundation Excavation		46,114	CY	$9.50	438,079
	5	Foundation Grout Curtain		1	LS	$1,060,734.99	1,060,735
	6	Spillway Construction		1	LS	$8,481,120.00	8,481,120
	7	Regulating Outlet and Stilling Basin		1	LS	$2,500,000.00	2,500,000
	8	Relocations		1	LS	$0.00	0
	9	Fish Passage (Trap and Haul)		1	LS	$7,700,000.00	7,700,000
	10	Clearing grubbing dewatering and miscellaneous foundation work		1	LS	$2,951,600.00	2,951,600
		Subtotal					**26,874,536**
		Mobilization and Demobilization at 9%					2,418,708
		Subtotal Construction Field Costs					**29,293,244**
		Contingency @ 30%					8,787,973
		Total for Construction Field Cost					**38,081,217**
		Indirect @ 32%					12,185,990
		Total Project Cost					**50,267,207**
		SUBTOTAL THIS SHEET					

QUANTITIES				PRICES			
BY	Richard Hannan, HDR Engineering, Inc.	**CHECKED**	Terrance Hsu, HDR Engineering, Inc.	**BY**	Richard Hannan, HDR Engineering, Inc.	**CHECKED**	Shane Cline, HDR Engineering, Inc.
DATE PREPARED	Reformatted from July 2009 estimate	**PEER REVIEW / DATE**		**DATE PREPARED**	**Reformatted from July 2009 estimate**	**PEER REVIEW / DATE**	

BUREAU OF RECLAMATION **ESTIMATE WORKSHEET** SHEET 2 OF 4

FEATURE: **Hardman Site Embankment Dam** **Details 1 of 3**	**PROJECT:** **Eastern Oregon Water Storage Appraisal Study** **WOID:** **ESTIMATE LEVEL:** Appraisal **REGION:** **UNIT PRICE LEVEL:** July-09 **FILE:**

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Information in this spread sheet is from TAB "Hardman"					
	1	Shell material U/S and D/S		135,951	CY	$17.00	$2,311,173
		Excavate, haul, place and compact suitable material from					
		on-site including material from spillway excavation and					
		local borrow areas. Material will be granular and free draining.					
		unit price of $17.00/CY based on (HDR 2009)					
	2	Filter Zones U/S and D/S					
		Material assumed to be manufactured off-site from regional deposits		19,284	CY	$30.00	$578,516
		of sand and gravel to meet filter criteria. Cost covers procurement,					
		hauling, placing, and compaction. A unit price of $30.00/CY based					
		on (HDR 2009)					
	3	Impervious Core		56,887	CY	$15.00	$853,312
		Excavate, haul, place and compact suitable material from					
		on-site borrow located in U/S reservoir area					
		Material will be suitable clay or silt clay mix compacted at appropriate					
		moisture content. Watering is assumed.					
		unit price of $15.00/CY based on (HDR 2009)					
	4	Foundation Excavation		46,114	CY	$9.50	$438,079
		This item assumes that unsuitable foundation material extends to					
		an average depth of 10 feet on abutments and valley section.					
		Unsuitable material would be wasted on site. Suitable material					
		would be stockpiled for use in the embankment. This costs covers					
		excavation, and hauling to disposal or stockpile at Unit Cost					
		of $9.50 (HDR 2009) **SUBTOTAL THIS SHEET**					

QUANTITIES		**PRICES**	
BY Richard Hannan, HDR Engineering, Inc.	**CHECKED** Terrance Hsu, HDR Engineering, Inc.	**BY** Richard Hannan, HDR Engineering, Inc.	**CHECKED** Shane Cline, HDR Engineering, Inc.
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION **ESTIMATE WORKSHEET** SHEET 3 OF 4

FEATURE: **Hardman Site Embankment Dam** **Details 2 of 3**	**PROJECT:** **Eastern Oregon Water Storage Appraisal Study**
	WOID: / **ESTIMATE LEVEL:** Appraisal
	REGION: / **UNIT PRICE LEVEL:** July-09
	FILE:

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Information in this spread sheet is from TAB "Hardman"					
	5	Foundation Grout Curtain		1	LS	$1,060,734.99	$1,060,735
		Cost for construction of the grout curtain was derived from the original CH2M-Hill design and cost estimate for the North Powder Project (PVWCD 1980) indexed to 2009 level and adjusted for the size and configuration at the Hardman Site. The cost is assumed to cover cost of drilling, grouting, and water testing.					
	6	Spillway Construction		1	LS	$8,481,120.00	$8,481,120
		Cost for construction of the Spillway Construction was derived from the original CH2M-Hill design and cost estimate for the North Powder Project (PVWCD 1980) indexed to 2009 level and adjusted for the size and configuration at the Hardman Site. The cost is assumed to cover cost of spillway and stilling basin construction.					
	7	Regulating Outlet and Stilling Basin		1	LS	$2,500,000.00	$2,500,000
		Cost for construction of the Regulating Outlet and Stilling Basin was derived from the original CH2M-Hill design and cost estimate for the North Powder Project (PVWCD 1980) indexed to 2009 level and adjusted for the size and configuration at the Hardman Site.					
		SUBTOTAL THIS SHEET					

QUANTITIES				**PRICES**			
BY	Richard Hannan, HDR Engineering, Inc.	**CHECKED**	Terrance Hsu, HDR Engineering, Inc.	**BY**	Richard Hannan, HDR Engineering, Inc.	**CHECKED**	Shane Cline, HDR Engineering, Inc.
DATE PREPARED		**PEER REVIEW / DATE**		**DATE PREPARED**		**PEER REVIEW / DATE**	

BUREAU OF RECLAMATION **ESTIMATE WORKSHEET** SHEET 4 OF 4

FEATURE: Hardman Site Embankment Dam Detail 3 of 3	**PROJECT:** Eastern Oregon Water Storage Appraisal Study **WOID:** / **ESTIMATE LEVEL:** Appraisal **REGION:** / **UNIT PRICE LEVEL:** July-09 **FILE:**

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	8	Relocations		1	LS	$0	
		Based on the Rail Gulch USGS 7.5 min. quad sheet the existing USFS road lies above the maximum water surface of 4330 feet, and no relocations will be required.					
	9	Fish Passage (Trap and Haul)		1	LS	$7,700,000	7,700,000
		Fish Passage costs are based on conceptual level designs for similar projects. The results were obtained and incorporated into an alternative study at another site (HDR 2009). Since the size of the streams were of the same order of magnitude those cost were used for this project with adjustments for project size.					
	10	Clearing grubbing dewatering and miscellaneous foundation work		1	LS	$2,951,600.00	2,951,600
		Clearing, grubbing, dewatering and miscellaneous cost were taken from the original CH2M-Hill 1980 cost estimate for North Powder and indexed to 2009. No adjustments were made for differences between N.P. and Hardman.					
	11	Mobilization and Demobilization					
		Mobilization and Demobilization was developed by reviewing values used for other project of similar size and complexity. A value of 9% of the Field Construction cost before contingency was found to be a typical. (HDR 2009, USACE 2006, USACE 2008)					
		Contingency					
		A contingency of 30% has been applied to the unit costs and mob and demob. This was selected due to the uncertainties associated with the quantities, uncertainties associated with the final project configuration, and to cover missed work tasks.					
		Indirect Cost					
		Indirect at 32% - See Section 4 or the main report for description.					
		SUBTOTAL THIS SHEET					

QUANTITIES		**PRICES**	
BY Richard Hannan, HDR Engineering, Inc.	**CHECKED** Terrance Hsu, HDR Engineering, Inc.	**BY** Richard Hannan, HDR Engineering, Inc.	**CHECKED** Shane Cline, HDR Engineering, Inc.
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

HARDMAN

Vol U/S and D/S filter = width*ht = 10*h
Vol imp core = (wide of crest+wide of base)/2*h crest width = 13' base width = 13 + 1.0h = (13 + (13+1.0*h))/2*h
Vol D/S shell = (u/s slope*h*h/2) - (10*h)-(.5*h*h/2) = (2*h*h/2) -(10*h)- (0.5*h*h/2)

HEIGHT/PARAMETER DETERMINATION TABLE (based upon existing design						CROSS SECTIONAL AREA BY DAM HEIGHT							HORIZONTAL DISTANCE AT CREST BY DAM HEIGHT			VOLUME BY DAM HEIGHT						
base elev	crest elev	height	U/S slope	D/S Slope	crest width	U/S Shell	U/S Filter	Core	D/S filter	D/S Shell	Found Ex	Total Area	left side	valley section	right side	U/S Shell	U/S Filter	Core	D/S filter	D/S Shell	Found Ex	Total Vol
feet	feet	feet	Horz/1	Horz/1	feet	Sq feet	Sq feet	Sq feet	Sq feet	Sq feet	Sq feet	Sq feet	feet	feet	feet	Cubic Yds	Cubic Yds	Cubic Yds	Cubic Yds	Cubic Yds	Cubic Yds	Cubic Yds
4,241	4,261	20	2.50	2	30	200	200	460	200	100	1,160	2,320	50	90	34	977	977	2,248	977	489	5,669	5,669
4,241	4,281	40	2.50	2	30	1,200	400	1,320	400	800	2,060	6,180	101	90	67	7,729	2,576	8,502	2,576	5,153	13,268	26,536
4,241	4,301	60	2.50	2	30	3,000	600	2,580	600	2,100	2,960	11,840	151	90	101	23,983	4,797	20,626	4,797	16,788	23,664	70,991
4,241	4,321	80	2.50	2	30	5,600	800	4,240	800	4,000	3,860	19,300	201	90	134	53,470	7,639	40,484	7,639	38,193	36,856	147,423
4,241	**4,333**	**92**	**2.50**	**2**	**30**	**7,544**	**920**	**5,428**	**920**	**5,428**	**4,400**	**24,640**	**232**	**90**	**154**	**79,064**	**9,642**	**56,887**	**9,642**	**56,887**	**46,114**	**212,123**
4,241	4,341	100	2.50	2	30	9,000	1,000	6,300	1,000	6,500	4,760	28,560	252	90	168	99,917	11,102	69,942	11,102	72,162	52,845	264,224
4,241	4,361	120	2.50	2	30	13,200	1,200	8,760	1,200	9,600	5,660	39,620	302	90	201	167,053	15,187	110,863	15,187	121,493	71,630	429,783
4,241	4,371	130	2.50	2	30	15,600	1,300	10,140	1,300	11,375	6,110	45,825	327	90	218	209,546	17,462	136,205	17,462	152,794	82,072	533,468
4,241	4,384	143	2.50	2	30	19,019	1,430	12,084	1,430	13,907	6,695	54,564	360	90	240	274,678	20,653	174,514	20,653	200,846	96,691	691,343
4,241	4,401	160	2.50	2	30	24,000	1,600	14,880	1,600	17,600	7,460	67,140	403	90	268	378,311	25,221	234,553	25,221	277,428	117,592	940,734
4,241	4,421	180	2.50	2	30	30,600	1,800	18,540	1,800	22,500	8,360	83,600	453	90	302	529,890	31,170	321,051	31,170	389,625	144,767	1,302,906
4,241	4,441	200	2.50	2	30	38,000	2,000	22,600	2,000	28,000	9,260	101,860	503	90	336	717,074	37,741	426,470	37,741	528,370	174,740	1,747,396

- Embankment cost computed by multiplying Volume of each zone by cost/unit for that material.
- Grout Curtain cost based upon cost/foot of North Powder Dam Spillway * length of dam to be grouted at selected elevation
- Spillway, and regulating Outlet Cost based upon Original Construction Cost estimate inflated to 2009
- Clearing, dewatering, and miscellaneous cost were taken form the original cost estimate and brought to 2009 cost
- Relocation Costs are based on an assumed cost of $45.00 Per foot x computed road relocation requirements.
- Fish Passage Cost based on Cost Chart provided by Jason Kent relating Height vs. Estimated Cost.
- Mob and Demob assumed to be 9% of construction cost
- A contingency of 30% added to total cost to cover unknowns

DAM COST BY HEIGHT

U/S Shell	U/S Filter	Core	D/S filter	D/S Shell	Foundation EX	Grout Curtain	spillway	Regulating Outlet	clearing, dewater, mis	Relocations	Fish Passage	Mob Demob	Subtotal	Contingency	Total Cost	Cost/ft of height
$17.00	$30.00	$15.00	$30.00	$17.00	$9.50							@ 9% cost	Dollars			
Cost /cuyd	Cost /cuyd	Cost /cuyd	Cost /cuyd	Cost /cuyd	Cost /cuyd	Job	Job	Job	Job	Job	job	of construction		30%		
$16,615.93	$29,322.22	$33,720.56	$29,322.22	$8,307.96	$53,855.15	$387,573.68	$8,481,120.00	$2,500,000.00	$2,951,600.00	$0.00	$2,000,000.00	$1,484,229.39	$17,975,667.11	$5,392,700.13	$23,368,367.24	$1,168,418.36
$131,391.11	$77,288.89	$127,526.67	$77,288.89	$87,594.07	$126,045.30	$574,562.93	$8,481,120.00	$2,500,000.00	$2,951,600.00	$0.00	$3,500,000.00	$1,677,097.61	$20,311,515.46	$6,093,454.64	$26,404,970.10	$660,124.25
$407,716.67	$143,900.00	$309,385.00	$143,900.00	$285,401.67	$224,803.78	$761,552.19	$8,481,120.00	$2,500,000.00	$2,951,600.00	$0.00	$5,500,000.00	$1,953,844.14	$23,663,223.43	$7,098,967.03	$30,762,190.46	$512,703.17
$908,983.70	$229,155.56	$607,262.22	$229,155.56	$649,274.07	$350,130.59	$948,541.44	$8,481,120.00	$2,500,000.00	$2,951,600.00	$0.00	$7,700,000.00	$2,299,970.08	$27,855,193.23	$8,356,557.97	$36,211,751.19	$452,646.89
$1,344,086.54	**$289,258.22**	**$853,311.76**	**$289,258.22**	**$967,086.66**	**$438,079.48**	**$1,060,734.99**	**$8,481,120.00**	**$2,500,000.00**	**$2,951,600.00**	**$0.00**	**$7,700,000.00**	**$2,418,708.23**	**$29,293,244.10**	**$8,787,973.23**	**$38,081,217.33**	**$413,926.28**
$1,698,583.33	$333,055.56	$1,049,125.00	$333,055.56	$1,226,754.63	$502,025.74	$1,135,530.69	$8,481,120.00	$2,500,000.00	$2,951,600.00	$500,000.00	$9,700,000.00	$2,736,976.55	$33,147,827.06	$9,944,348.12	$43,092,175.17	$430,921.75
$2,839,906.67	$455,600.00	$1,662,940.00	$455,600.00	$2,065,386.67	$680,489.22	$1,322,519.95	$8,481,120.00	$2,500,000.00	$2,951,600.00	$500,000.00	$10,400,000.00	$3,088,364.63	$37,403,527.13	$11,221,058.14	$48,624,585.27	$405,204.88
$3,562,274.44	$523,863.89	$2,043,069.17	$523,863.89	$2,597,491.78	$779,684.09	$1,416,014.58	$8,481,120.00	$2,500,000.00	$2,951,600.00	$500,000.00	$10,800,000.00	$3,301,108.37	$39,980,090.20	$11,994,027.06	$51,974,117.26	$399,800.90
$4,669,532.55	$619,575.31	$2,617,705.67	$619,575.31	$3,414,376.25	$918,567.33	$2,117,280.00	$8,481,120.00	$2,500,000.00	$2,951,600.00	$500,000.00	$11,300,000.00	$3,663,839.92	$44,373,172.32	$13,311,951.70	$57,685,124.02	$403,392.48
$6,431,288.89	$756,622.22	$3,518,293.33	$756,622.22	$4,716,278.52	$1,117,121.19	$1,696,498.46	$8,481,120.00	$2,500,000.00	$2,951,600.00	$500,000.00	$11,800,000.00	$4,070,290.03	$49,295,734.86	$14,788,720.46	$64,084,455.32	$400,527.85
$9,008,130.00	$935,100.00	$4,815,765.00	$935,100.00	$6,623,625.00	$1,375,289.67	$1,883,487.71	$8,481,120.00	$2,500,000.00	$2,951,600.00	$500,000.00	$12,500,000.00	$4,725,829.56	$57,235,046.94	$17,170,514.08	$74,405,561.03	$413,364.23
$12,190,259.26	$1,132,222.22	$6,397,055.56	$1,132,222.22	$8,982,296.30	$1,660,026.48	$2,070,476.97	$8,481,120.00	$2,500,000.00	$2,951,600.00	$500,000.00	$13,500,000.00	$5,534,755.11	$67,032,034.12	$20,109,610.23	$87,141,644.35	$435,708.22

$26,874,535.87 $29,293,244.10 $38,081,217.33

Table C-2. Thief Valley Cost Estimate Worksheets

BUREAU OF RECLAMATION — **ESTIMATE WORKSHEET** — SHEET 1 OF 4

FEATURE: Thief Valley Dam Raise	**PROJECT:** Eastern Oregon Water Storage Appraisal Study
	WOID: / **ESTIMATE LEVEL:** Appraisal
	REGION: / **UNIT PRICE LEVEL:** July-09
Summary Sheet 1 of 1	**FILE:**

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		The Thief Dam Raise Storage Project consists of:					
		Raising the existing 73 ft high concrete slab and buttress dam					
		by placing an RCC section on the D/S side to raise the spillway					
		crest and abutments to the new spillway crest elevation of 3178 ft.					
		Access road construction and recreations facility relocation would					
		be required and possibly a Trap and Haul Fish Facility.					
	1	Roller Compacted Concrete (RCC)		131,396	CY	$150.00	19,709,326
	2	Spillway Backfill (CDF)		19,000	CY	$70.00	1,330,000
	3	Stilling Basin RCC		1	LS	$925,000.00	925,000
	4	Foundation Excavation		3,907	CY	$70.00	273,481
	5	Foundation Grout Curtain Extension		1	LS	$300,000.00	300,000
	6	Extend Outlets		1	LS	$200,000.00	200,000
	7	Dowels		1	LS	$13,000.00	13,000
	8	Clearing and Dewatering		1	LS	$20,000.00	20,000
	9	Relocations		1	LS	$150,000.00	150,000
	10	Fish Passage (Trap and Haul)		1	LS	$9,700,000.00	9,700,000
		Subtotal					**32,620,807**
		Mobilization and Demobilization at 9%					2,935,873
		Subtotal Construction Field Costs					**35,556,680**
		Contingency @ 30%					10,667,004
		Total for Construction Field Cost					**46,223,684**
		Indirect @ 32%					14,791,579
		Total Project Cost					**61,015,263**
		SUBTOTAL THIS SHEET					

QUANTITIES		PRICES	
BY Richard Hannan, HDR Engineering, Inc.	**CHECKED** Terrance Hsu, HDR Engineering, Inc.	**BY** Richard Hannan, HDR Engineering, Inc.	**CHECKED** Shane Cline, HDR Engineering, Inc.
DATE PREPARED Reformatted from July 2009 estimate	**PEER REVIEW / DATE**	**DATE PREPARED** Reformatted from July 2009 estimate	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION **ESTIMATE WORKSHEET** SHEET 2 OF 4

FEATURE: **Thief Valley Dam Raise** **Details 1 of 3**	**PROJECT:** **Eastern Oregon Water Storage Appraisal Study** **WOID:** **ESTIMATE LEVEL:** Appraisal **REGION:** **UNIT PRICE LEVEL:** July-09 **FILE:**

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Information in this spread sheet is from TAB "Thief V"					
	1	Roller Compacted Concrete (RCC)		131,396	CY	$150.00	$19,709,326
		Assumes construction of a full height spillway section and spillway walls on the D/S side of the existing structure. The existing structure would form the U/S face and serve as a cofferdam. The abutments would be raised and walls placed on both side of the spillway section. $150.00/CY includes the cost of the RCC, hauling, and placing. It is assumed that the RCC will come from off-site. This price was developed for a similar project with similar quantities. (HDR 2009)					
	2	Spillway back fill (low-strength flowable Controlled Density Backfill (CDF))		19,000	CY	$70.00	$1,330,000
		This material would be used to fill the voids in the buttress structure and would be placed concurrent with RCC placement. A cost of $70/CY was assumed based on information from the Oregon State Department of Transportation Unit Price Data Base (ODOT 2008)					
	3	Stilling Basin RCC		1	LS	$925,000.00	$925,000
		It was assumed that a stilling basin would be required for this structure. The size of the stilling basin was assumed independent of the structure height and it's cost was computed as a LS.					
	4	Foundation Excavation		3,907	CY	$70.00	$273,481
		Includes excavation of overburden and loose rock from the foot print of the new structure. Some demolition of the existing structure will be required and is included in this quantity. A cost of $200/CY was assumed due to the amount of sound rock and concrete that would need to be excavated.					
		SUBTOTAL THIS SHEET					

QUANTITIES		**PRICES**	
BY Richard Hannan, HDR Engineering, Inc.	**CHECKED** Terrance Hsu, HDR Engineering, Inc.	**BY** Richard Hannan, HDR Engineering, Inc.	**CHECKED** Shane Cline, HDR Engineering, Inc.
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION **ESTIMATE WORKSHEET** SHEET 3 OF 4

FEATURE: **Thief Valley Dam Raise** **Details 2 of 3**	**PROJECT:** **Eastern Oregon Water Storage Appraisal Study** **WOID:** **ESTIMATE LEVEL:** Appraisal **REGION:** **UNIT PRICE LEVEL:** July-09 **FILE:**

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Information in this spread sheet is from TAB "Thief V"					
	5	Foundation Grout Curtain Extension		1	LS	$300,000.00	$300,000
		Cost for construction of the grout curtain was derived from the					
		original CH2M-Hill design and cost estimate for the North Powder					
		Project (PVWCD 1980) indexed to 2009 level and adjusted for the					
		size and configuration required at Thief Valley. The cost					
		covers drilling, grouting, and water testing.					
	6	Extend Outlets		1	LS	$200,000.00	$200,000
		The outlet pipe and controls would need to be moved downstream					
		to the toe of the new structure. It was assumed that the final					
		configuration would be of a similar design to the existing design.					
		Cost were developed based on similar work that was part of alternatives					
		for Fish water supplies at The Dales Dam (HDR 2008)					
	7	Dowels		1	LS	$13,000.00	$13,000
		Incorporation of the new RCC structure into the existing Concrete					
		will require the drilling and grouting of dowels into the new structure.					
		It was assumed that about 100 dowels would be installed. Each would					
		extend 5' into the existing structure. A cost of $130/dowel was assumed					
	8	Clearing and Dewatering		1	LS	$20,000.00	$20,000
		Limited clearing and relatively inexpensive dewatering was assumed.					
		A value of $20,000 was selected.					
	9	Relocations					
		New access roads would need to be constructed. It was assumed		1	LS	$150,000.00	$150,000
		that about 3300 feet of road at $45/foot would be required.					
		SUBTOTAL THIS SHEET					

QUANTITIES			**PRICES**		
BY Richard Hannan, HDR Engineering, Inc.	**CHECKED**	Terrance Hsu, HDR Engineering, Inc.	**BY** Richard Hannan, HDR Engineering, Inc.	**CHECKED**	Shane Cline, HDR Engineering, Inc.
DATE PREPARED	**PEER REVIEW / DATE**		**DATE PREPARED**	**PEER REVIEW / DATE**	

BUREAU OF RECLAMATION **ESTIMATE WORKSHEET** SHEET 4 OF 4

FEATURE: **Thief Valley Dam Raise** **Detail 3 of 3**	**PROJECT:** **Eastern Oregon Water Storage Appraisal Study** **WOID:** **ESTIMATE LEVEL:** Appraisal **REGION:** **UNIT PRICE LEVEL:** July-09 **FILE:**

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	10	Fish Passage (Trap and Haul)		1	LS	$9,700,000	9,700,000
		Fish Passage costs are based on conceptual level designs for					
		similar projects. The results were obtained and incorporated into an					
		alternative study at another site (HDR 2009). Since the size of the					
		streams were of the same order of magnitude those cost were used for this					
		project with adjustments for project size.					
	11	Mobilization and Demobilization					
		Mobilization and Demobilization was developed by reviewing values					
		used for other project of similar size and complexity. A value of					
		9% of the Field Construction cost before contingency was found to be					
		a typical. (HDR 2009, USACE 2006, USACE 2008)					
		Contingency					
		A contingency of 30% has been applied to the unit costs and					
		A contingency of 30% has been applied to the unit costs and					
		mob and demob. This was selected due to the uncertainties					
		associated with the quantities, uncertainties associated with					
		the final project configuration, and to cover missed work tasks.					
		Indirect Cost					
		Indirect at 32% - See Section 4 or the main report for description.					
		SUBTOTAL THIS SHEET					

QUANTITIES		**PRICES**	
BY Richard Hannan, HDR Engineering, Inc.	**CHECKED** Terrance Hsu, HDR Engineering, Inc.	**BY** Richard Hannan, HDR Engineering, Inc.	**CHECKED** Shane Cline, HDR Engineering, Inc.
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

THIEF VALLEY DAM ENLARGEMENT

from Bid

New spillway dam 1v on 1h u/s face, and d/s face with 12' crest. Incorporates old structure. Old structure filled with CDF backfill

Spillway RCC Vol = (Top width + base width)2 * height * width/27 - Vol of outline of existing structure
Assumed Existing spillway Structure Volume modeled as 1v on 1h u/s face vert d/s face with base at 3080 and top at 3142 to simplify computations = 19,100 cy
Abutment section assumed to be 1v on 1h u/s, and vert d/s with 12' crest
Spillway walls 15' high Stilling basin 10' deep & 100' long

HEIGHT/PARAMETER DETERMINATION TABLE (based upon existing design)								CROSS SECTIONAL AREA BY DAM HEIGHT			HORIZONTAL DISTANCE AT CREST BY DAM HEIGHT			VOLUME BY DAM HEIGHT		
base elev	crest elev	Abutment el	Spillway height	abutment Height above base	U/S slope	D/S Slope	crest width	Spillway Section	Abutment Wall Sections	Abutments	left side	valley section	right side	Spillway Volume	Abutment Walls Right and Left	Abutments Right and Left
feet	feet	feet	feet	feet	Horz/1	Horz/1	feet	Sq feet	Sq feet	Sq feet	feet	feet	feet	Cubic Yds	Cubic Yds	Cubic Yds
3,080	3,133	3,142	53	63	1.00	1.00	12	1,205	4,378	819	60	268	60	11,961	4,864	1,819
3,080	3,135	3,144	55	65	1.00	0.33	10	1,433	4,708	3,083	63	220	63	11,676	5,650	7,137
3,080	3,140	3,149	60	70	1.00	0.33	10	2,038	5,568	3,818	69	220	69	16,606	6,682	9,722
3,080	3,145	3,154	65	75	1.00	0.33	10	2,693	6,478	4,603	75	220	75	21,943	7,774	12,786
3,080	3,150	3,159	70	80	1.00	0.33	10	3,398	7,438	5,438	81	220	81	27,687	8,926	16,364
3,080	3,155	3,164	75	85	1.00	0.33	10	4,153	8,448	6,323	88	220	88	33,839	10,138	20,491
3,080	3,160	3,169	80	90	1.00	0.33	10	4,958	9,508	7,258	94	220	94	40,399	11,410	25,201
3,080	3,165	3,174	85	95	1.00	0.33	10	5,813	10,618	8,243	100	220	100	47,365	12,742	30,530
3,080	3,170	3,179	90	100	1.00	0.33	10	6,718	11,778	9,278	106	220	106	54,739	14,134	36,511
3,080	3,175	3,184	95	105	1.00	0.33	10	7,673	12,988	10,363	113	220	113	62,521	15,586	43,179
3,080	**3,178**	**3,188**	**98**	**108**	**1.00**	**0.33**	**10**	**8,270**	**13,738**	**11,038**	**116**	**220**	**116**	**67,385**	**16,486**	**47,525**
3,080	3,180	3,190	100	110	1.00	0.33	10	8,678	14,248	11,498	119	220	119	70,710	17,098	50,570

Assumptions:
Unit costs include contractor markup and profit
Unit cost include the cost of excavation/purchasing, processing, hauling, placing, and compaction

- RCC cost computed by multiplying Volume of RCC required by an assumed unit cost of $150.00/cy. ($150 was computed from an assumed base cost of $80.00/CY factored to include volume required, location, and requirements for incidental conventional concrete.
- Foundation Exc based upon computed foundation excavation including stilling basin quantity times assumed unit cost
- Grout Curtain cost based upon cost/foot of North Powder Dam Spillway * length of dam to be grouted at selected elevation
- Existing Spillway Section backfill. Quantity is constant. Controlled Density Fill (CDF) material assumed to be used for ease of placement.
- Relocation Costs are based on an assumed cost of $45.00 Per foot x computed road relocation requirements.
- Fish Passage Cost based on Cost Chart provided by Jason Kent relating Height vs. Estimated Cost.
- Mob and Demob assumed to be 9% of construction cost
- A contingency of 30% added to total cost to cover unknowns.

DAM COST BY HEIGHT

Spillway RCC	Spillway Wall RCC	Abutment RCC	Foundation Excavation	Grout Curtain Extension	Spillway Fill CDF	Extend Outlets	Stilling Basin Concrete/RCC	Dowels	clearing, dewater, mis	Relocations	Fish Passage	Mob Demob	Subtotal	Contingency	TOTAL	Cost/ft of height
$150.00	$150.00	$150.00	$70.00	LS	LS assume 19,000cy @ $70/CY	LS	LS	LS	LS	LS	LS	at 9% of Construction cost				
Cost /cuyd	Cost /cuyd	Cost /cuyd	Cost /cuyd	Cost /cuyd	Cost /cuyd	Job	Job	Job	Job	Job	job	Job		30%	Job	
$1,794,111.11	$729,666.67	$272,833.33	$724,500.00	$300,000.00	$1,330,000.00	$200,000.00	$925,000.00	$13,000.00	$20,000.00	$150,000.00	$5,200,000.00	$1,049,320.00	$12,708,431.11	$3,812,529.33	$16,520,960.44	Existing dam height
$1,751,444.44	$847,440.00	$1,070,486.11	$726,331.02	$300,000.00	$1,330,000.00	$200,000.00	$925,000.00	$13,000.00	$20,000.00	$150,000.00	$5,700,000.00	$1,173,033.14	$14,206,734.72	$4,262,020.41	$18,468,755.13	$9,234,377.57
$2,490,888.89	$1,002,240.00	$1,458,263.89	$731,192.13	$300,000.00	$1,330,000.00	$200,000.00	$925,000.00	$13,000.00	$20,000.00	$150,000.00	$6,100,000.00	$1,324,852.64	$16,045,437.55	$4,813,631.26	$20,859,068.81	$2,979,866.97
$3,291,444.44	$1,166,040.00	$1,917,916.67	$736,458.33	$300,000.00	$1,330,000.00	$200,000.00	$925,000.00	$13,000.00	$20,000.00	$150,000.00	$6,600,000.00	$1,498,487.35	$18,148,346.79	$5,444,504.04	$23,592,850.83	$1,966,070.90
$4,153,111.11	$1,338,840.00	$2,454,652.78	$742,129.63	$300,000.00	$1,330,000.00	$200,000.00	$925,000.00	$13,000.00	$20,000.00	$150,000.00	$7,000,000.00	$1,676,406.02	$20,303,139.54	$6,090,941.86	$26,394,081.40	$1,552,593.02
$5,075,888.89	$1,520,640.00	$3,073,680.56	$748,206.02	$300,000.00	$1,330,000.00	$200,000.00	$925,000.00	$13,000.00	$20,000.00	$150,000.00	$7,500,000.00	$1,877,077.39	$22,733,492.85	$6,820,047.86	$29,553,540.71	$1,343,342.76
$6,059,777.78	$1,711,440.00	$3,780,208.33	$754,687.50	$300,000.00	$1,330,000.00	$200,000.00	$925,000.00	$13,000.00	$20,000.00	$150,000.00	$7,900,000.00	$2,082,970.23	$25,227,083.84	$7,568,125.15	$32,795,208.99	$1,214,637.37
$7,104,777.78	$1,911,240.00	$4,579,444.44	$761,574.07	$300,000.00	$1,330,000.00	$200,000.00	$925,000.00	$13,000.00	$20,000.00	$150,000.00	$8,400,000.00	$2,312,553.27	$28,007,589.56	$8,402,276.87	$36,409,866.43	$1,137,808.33
$8,210,888.89	$2,120,040.00	$5,476,597.22	$768,865.74	$300,000.00	$1,330,000.00	$200,000.00	$925,000.00	$13,000.00	$20,000.00	$150,000.00	$8,800,000.00	$2,548,295.27	$30,862,687.12	$9,258,806.14	$40,121,493.25	$1,084,364.68
$9,378,111.11	$2,337,840.00	$6,476,875.00	$776,562.50	$300,000.00	$1,330,000.00	$200,000.00	$925,000.00	$13,000.00	$20,000.00	$150,000.00	$9,200,000.00	$2,799,664.98	$33,907,053.59	$10,172,116.08	$44,079,169.66	$1,049,504.04
$10,107,777.78	**$2,472,840.00**	**$7,128,708.33**	**$781,375.00**	**$300,000.00**	**$1,330,000.00**	**$200,000.00**	**$925,000.00**	**$13,000.00**	**$20,000.00**	**$150,000.00**	**$9,700,000.00**	**$2,981,583.10**	**$36,110,284.21**	**$10,833,085.26**	**$46,943,369.47**	**$1,043,185.99**
$10,606,444.44	$2,564,640.00	$7,585,486.11	$784,664.35	$300,000.00	$1,330,000.00	$200,000.00	$925,000.00	$13,000.00	$20,000.00	$150,000.00	$9,700,000.00	$3,076,131.14	$37,255,366.05	$11,176,609.81	$48,431,975.86	$1,030,467.57

Table C-3. North Powder Cost Estimate Worksheets

BUREAU OF RECLAMATION **ESTIMATE WORKSHEET** SHEET 1 OF 4

FEATURE: North Powder River Embankment Dam Site Summary Sheet 1 of 1	**PROJECT:** Eastern Oregon Water Storage Appraisal Study
	WOID: / **ESTIMATE LEVEL:** Appraisal
	REGION: / **UNIT PRICE LEVEL:** July-09
	FILE: C:\Documents and

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		The North Powder River Storage Project consists of:					
		169 foot high zoned embankment dam					
		Regulating Outlet and conduit					
		Spillway					
		Relocated Road					
		Trap and Haul Fish Facility					
	1	Shell material U/S and D/S		1,019,647	CY	$17.00	17,333,999
	2	Filter Zones U/S and D/S		62,174	CY	$30.00	1,865,208
	3	Impervious Core		127,844	CY	$15.00	1,917,667
	4	Foundation Excavation		276,010	CY	$9.50	2,622,098
	5	Foundation Grout Curtain		1	LS	$1,958,499.20	1,958,499
	6	Spillway Construction		1	LS	$8,481,120.00	8,481,120
	7	Regulating Outlet and Stilling Basin		1	LS	$2,500,000.00	2,500,000
	8	Relocations		1	LS	$9,000,000.00	9,000,000
	9	Fish Passage (Trap and Haul)		1	LS	$12,000,000.00	12,000,000
	10	Clearing grubbing dewatering and miscellaneous foundation work		1	LS	$2,951,600.00	2,951,600
		Subtotal					**60,630,191**
		Mobilization and Demobilization at 9%					5,456,717
		Subtotal Construction Field Costs					**66,086,908**
		Contingency @ 30%					19,826,072
		Total for Construction Field Cost					**85,912,981**
		Indirect @ 32%					27,492,154
		Total Project Cost					**113,405,134**
		SUBTOTAL THIS SHEET					

QUANTITIES		**PRICES**	
BY Richard Hannan, HDR Engineering, Inc.	**CHECKED** Terrance Hsu, HDR Engineering, Inc.	**BY** Richard Hannan, HDR Engineering, Inc.	**CHECKED** Shane Cline, HDR Engineering, Inc.
DATE PREPARED Reformatted from July 2009 estimate	**PEER REVIEW / DATE**	**DATE PREPARED** **Reformatted from July 2009 estimate**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION **ESTIMATE WORKSHEET** SHEET 2 OF 4

FEATURE: North Powder River Embankment Dam Site	**PROJECT:** Eastern Oregon Water Storage Appraisal Study
	WOID: / **ESTIMATE LEVEL:** Appraisal
	REGION: / **UNIT PRICE LEVEL:** July-09
Details 1 of 3	**FILE:** C:\Documents and Settings\rhannan\My Documents\HDR PROJECTS\Burnt & Powder River Feasibility\[EstWrkshtTemplate042310.xls]Template Sheet 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Information in this spread sheet is from TAB "N Powder"					
	1	Shell material U/S and D/S		1,019,647	CY	$17.00	$17,333,999
		Excavate, haul, place and compact suitable material from					
		on-site including material from spillway excavation and					
		local borrow areas. Material will be granular and free draining.					
		unit price of $17.00/CY based on (HDR 2009)					
	2	Filter Zones U/S and D/S					
		Material assumed to be manufactured off-site from regional deposits		62,174	CY	$30.00	$1,865,208
		of sand and gravel to meet filter criteria. Cost covers procurement,					
		hauling, placing, and compaction. A unit price of $30.00/CY based					
		on (HDR 2009)					
	3	Impervious Core		127,844	CY	$15.00	$1,917,667
		Excavate, haul, place and compact suitable material from					
		on-site borrow located in U/S reservoir area					
		Material will be suitable clay or silt clay mix compacted at appropriate					
		moisture content. Watering is assumed.					
		unit price of $15.00/CY based on (HDR 2009)					
	4	Foundation Excavation		276,010	CY	$9.50	$2,622,098
		This item assumes that unsuitable foundation material extends to					
		an average depth of 20 feet on abutments and valley section.					
		Unsuitable material would be wasted on site. Suitable material					
		would be stockpiled for use in the embankment. This costs covers					
		excavation, and hauling to disposal or stockpile at Unit Cost					
		of $9.50 (HDR 2009) **SUBTOTAL THIS SHEET**					

QUANTITIES		**PRICES**	
BY Richard Hannan, HDR Engineering, Inc.	**CHECKED** Terrance Hsu, HDR Engineering, Inc.	**BY** Richard Hannan, HDR Engineering, Inc.	**CHECKED** Shane Cline, HDR Engineering, Inc.
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION	ESTIMATE WORKSHEET	SHEET 3 OF 4

FEATURE: North Powder River Embankment Dam Site	**PROJECT:** Eastern Oregon Water Storage Appraisal Study
	WOID: / **ESTIMATE LEVEL:** Appraisal
	REGION: / **UNIT PRICE LEVEL:** July-09
Details 2 of 3	**FILE:** C:\Documents and

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Information in this spread sheet is from TAB "N Powder"					
	5	Foundation Grout Curtain		1	LS	$1,958,499.20	$1,958,499
		Cost for construction of the grout curtain was derived from the original CH2M-Hill design and cost estimate (PVWCD 1980) indexed to 2009 level and adjusted for the reduced foundation size. The cost is assumed to cover cost of drilling, grouting, and water testing.					
	6	Spillway Construction		1	LS	$8,481,120.00	$8,481,120
		Cost for construction of the spillway and spillway channel was derived from the original CH2M-Hill design and cost estimate (PVWCD 1980) indexed to 2009 level. It was assumed that the configuration would be similar but lower on the abutment. The cost is assumed to cover cost of of excavation and concrete placement					
	7	Regulating Outlet and Stilling Basin		1	LS	$2,500,000.00	$2,500,000
		Cost for construction of the regulating outlet and outlet conduit was derived from the original CH2M-Hill design and cost estimate (PVWCD 1980) with modifications. The original configuration assumed a tunnel. This estimate assumes a cut and cover excavation for the outlet conduit and that the conduit would be sized to provide for diversion during construction similar to the original plan. Unit costs from the 1980 estimate related to tunneling were remove from the original Regulating Outlet estimate.					
		SUBTOTAL THIS SHEET					

QUANTITIES		PRICES	
BY Richard Hannan, HDR Engineering, Inc.	**CHECKED** Terrance Hsu, HDR Engineering, Inc.	**BY** Richard Hannan, HDR Engineering, Inc.	**CHECKED** Shane Cline, HDR Engineering, Inc.
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION **ESTIMATE WORKSHEET** SHEET 4 OF 4

FEATURE: North Powder River Embankment Dam Site	**PROJECT:** Eastern Oregon Water Storage Appraisal Study
	WOID: / **ESTIMATE LEVEL:** Appraisal
	REGION: / **UNIT PRICE LEVEL:** July-09
Detail 3 of 3	**FILE:** C:\Documents and Settings\rhannan\My Documents\HDR PROJECTS\Burnt & Powder River Feasibility\[EstWrkshtTemplate042310.xls]Template Sheet 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	8	Relocations		1	LS	$9,000,000	9,000,000
		Relocation cost are based on the estimate from Browne Consulting (Browne 2008) and adjusted to reflect the reduced mileage of required road and utility relocations.					
	9	Fish Passage (Trap and Haul)		1	LS	$12,000,000	12,000,000
		Fish Passage costs are based on conceptual level designs for similar projects. The results were obtained and incorporated into an alternative study at another site (HDR 2009). Since the size of the streams were of the same order those cost were used for this project with some adjustments for project size.					
	10	Clearing grubbing dewatering and miscellaneous foundation work		1	LS	$2,951,600.00	2,951,600
		Clearing, grubbing, dewatering and miscellaneous cost were taken from the original CH2M-Hill 1980 cost estimate and indexed to 2009. No adjustments were made for reservoir size.					
	11	Mobilization and Demobilization					
		Mobilization and Demobilization was developed by reviewing values used for other project of similar size and complexity. A value of 9% of the Field Construction cost before contingency was found to be a typical. (HDR 2009, USACE 2006, USACE 2008)					
		Contingency					
		A contingency of 30% has been applied to the unit costs and mob and demob. This was selected due to the uncertainties associated with the quantities, uncertainties associated with the final project configuration, and to cover missed work tasks.					
		Indirect Cost					
		Indirect at 32% - See Section 4 or the main report for description.					
		SUBTOTAL THIS SHEET					

QUANTITIES		**PRICES**	
BY Richard Hannan, HDR Engineering, Inc.	**CHECKED** Terrance Hsu, HDR Engineering, Inc.	**BY** Richard Hannan, HDR Engineering, Inc.	**CHECKED** Shane Cline, HDR Engineering, Inc.
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

NORTH POWDER

- Cost and volume per height of hypothetical dam
- Geometry of dam based upon configuration of existing North Powder River Dam Plans

Area U/S shell = Area u/s emb - (filter and impervious u/s of crest) = (u/s slope*h*h/2) - (u/s filter)-(emb u/s of crest) = (2*h*h/2) - (10*h)-(0.25*h*h/2)
Area U/S and D/S filter = width*ht = 10*h
Area imp core = (wide of top + wide of base)/2*h) crest width = 20' base width = 20 + 0.25h Vol = (20 + (20+0.25*h)/2*h
Area D/S shell = d/s emb + emb d/s of filter = (d/s slope*h*h/2) + (slope filter*h*h/2) = (2*h*h/2) + (0.25*h*h/2)

Volume computations assume that the abutment slopes are relatively uniform and the valley section is flat.
Vol = material left of valley + material in valley section + material right of valley section
Vol = (0 + Area)/2*left side dist. + (Area * valley section distance) + (Area + 0)/2 * right side distance

HEIGHT/PARAMETER DETERMINATION TABLE (based upon existing design)						**CROSS SECTIONAL AREA BY DAM HEIGHT**							**HORIZONTAL DISTANCE AT CREST BY DAM HEIGHT**			**VOLUME BY DAM HEIGHT**							U/S Shell
height	base elev	crest elev	U/S slope	D/S Slope	crest width	U/S Shell	U/S Filter	Core	D/S filter	D/S Shell	Found Ex	Total Area	left side	valley section	right side	U/S Shell	U/S Filter	Core	D/S filter	D/S Shell	Found Ex	Total Vol	$17.00
feet	feet	feet	Horz/1	Horz/1	feet	Sq feet	Sq feet	Sq feet	Sq feet	Sq feet	Sq feet	Sq feet	feet	feet	feet	Cubic Yds	Cubic Yds	Cubic Yds	Cubic Yds	Cubic Yds	Cubic Yds	Cubic Yds	Cost /cuyd
20	3,790	3,810	2.25	2	32	150	200	450	200	450	2,340	1,450	25	220	40	1,404	1,872	4,212	1,872	4,212	21,904	13,573	$23,870
40	3,790	3,830	2.25	2	32	1,000	400	1,000	400	1,800	4,040	4,600	50	220	81	10,573	4,229	10,573	4,229	19,032	42,716	48,637	$179,747
60	3,790	3,850	2.25	2	32	2,550	600	1,650	600	4,050	5,740	9,450	75	220	121	30,054	7,072	19,447	7,072	47,733	67,651	111,377	$510,920
80	3,790	3,870	2.25	2	32	4,800	800	2,400	800	7,200	7,440	16,000	100	220	161	62,393	10,399	31,196	10,399	93,589	96,709	207,976	$1,060,679
100	3,790	3,890	2.25	2	32	7,750	1,000	3,250	1,000	11,250	9,140	24,250	126	220	202	110,136	14,211	46,186	14,211	159,875	129,890	344,619	$1,872,314
120	3,790	3,910	2.25	2	32	11,400	1,200	4,200	1,200	16,200	10,840	34,200	151	220	242	175,830	18,508	64,780	18,508	249,864	167,193	527,491	$2,989,114
130	3,790	3,920	2.25	2	32	13,488	1,300	4,713	1,300	19,013	11,690	39,813	163	220	262	216,205	20,839	75,541	20,839	304,770	187,391	638,194	$3,675,479
160	3,790	3,950	2.25	2	32	20,800	1,600	6,400	1,600	28,800	14,240	59,200	201	220	323	371,257	28,558	114,233	28,558	514,048	254,168	1,056,654	$6,311,367
169	**3,790**	**3,959**	**2.25**	**2**	**32**	**23,301**	**1,690**	**6,950**	**1,690**	**32,131**	**15,005**	**65,762**	**212**	**220**	**341**	**428,609**	**31,087**	**127,844**	**31,087**	**591,038**	**276,010**	**1,209,665**	**$7,286,357**
180	3,790	3,970	2.25	2	32	26,550	1,800	7,650	1,800	36,450	15,940	74,250	226	220	363	506,082	34,311	145,820	34,311	694,791	303,840	1,415,315	$8,603,400
200	3,790	3,990	2.25	2	32	33,000	2,000	9,000	2,000	45,000	17,640	91,000	251	220	404	669,044	40,548	182,467	40,548	912,333	357,635	1,844,941	$11,373,756
220	3,790	4,010	2.25	2	32	40,150	2,200	10,450	2,200	54,450	19,340	109,450	276	220	444	862,690	47,271	224,536	47,271	1,169,949	415,552	2,351,716	$14,665,724
223	3,790	4,013	2.25	2	32	41,283	2,230	10,676	2,230	55,945	19,595	112,364	280	220	450	894,540	48,321	231,336	48,321	1,212,250	424,595	2,434,768	$15,207,185
240	3,790	4,030	2.25	2	32	48,000	2,400	12,000	2,400	64,800	21,040	129,600	301	220	484	1,089,564	54,478	272,391	54,478	1,470,912	477,592	2,941,824	$18,522,596
260	3,790	4,050	2.25	2	32	56,550	2,600	13,650	2,600	76,050	22,740	151,450	327	220	525	1,352,215	62,171	326,397	62,171	1,818,496	543,756	3,621,450	$22,987,659
280	3,790	4,070	2.25	2	32	65,800	2,800	15,400	2,800	88,200	24,440	175,000	352	220	565	1,653,188	70,348	386,916	70,348	2,215,976	614,041	4,396,778	$28,104,204
300	3,790	4,090	2.25	2	32	75,750	3,000	17,250	3,000	101,250	26,140	200,250	377	220	605	1,995,031	79,011	454,314	79,011	2,666,625	688,450	5,273,992	$33,915,519
320	3,790	4,110	2.25	2	32	86,400	3,200	19,200	3,200	115,200	27,840	227,200	402	220	646	2,380,288	88,159	528,953	88,159	3,173,717	766,982	6,259,276	$40,464,896

Values in the original design section

Assumptions:
Unit costs include contractor markup and profit
Unit cost of embankment material includes the cost of excavation/purchasing, processing, hauling, placing, and compaction

- Embankment cost computed by multiplying Volume of each zone by cost/unit for that material.
- Grout Curtain cost based upon cost/foot of North Powder Dam Spillway * length of dam to be grouted at selected elevation
- Spillway, and regulating Outlet Cost based upon Original Construction Cost estimate indexed to 2009
- Clearing, dewatering, and miscellaneous cost were taken form the original cost estimate and indexed to 2009 cost
- Relocation Costs are based on cost presented in the cost estimate report by Browne Consulting 2008 and factored based on estimated miles of relocation requirements.
- Fish Passage Cost based on Cost Chart provided by Jason Kent relating size vs. Estimated Cost for similar project (HDR 2009)
- Mob and Demob assumed to be 9% of construction cost
- A contingency of 30% added to total cost to cover unknowns

DAM COST BY HEIGHT

U/S Filter	Core	D/S filter	D/S Shell	Foundation EX	Grout Curtain	spillway	Regulating Outlet	clearing, dewater, mis	Relocations	Fish Passage	Mob Demob	Subtotal	Contingency		Cost/ft of height
$30.00	$15.00	$30.00	$17.00	$9.50							@ 9% cost	Dollars		total	
Cost /cuyd	Cost /cuyd	Cost /cuyd	Cost /cuyd	Cost /cuyd	Job	Job	Job	Job	Job	job	of construction		30%	Job	
$56,164	$63,185	$56,164	$71,610	$208,089	$723,016	$8,481,120	$2,500,000	$2,951,600	$0	$5,000,000	$1,812,134	$21,946,952	$6,584,086	$28,531,038	$1,426,552
$126,880	$158,600	$126,880	$323,544	$405,805	$888,852	$8,481,120	$2,500,000	$2,951,600	$0	$5,000,000	$1,902,872	$23,045,900	$6,913,770	$29,959,670	$748,992
$212,147	$291,702	$212,147	$811,461	$642,687	$1,054,689	$8,481,120	$2,500,000	$2,951,600	$0	$5,000,000	$2,040,162	$24,708,634	$7,412,590	$32,121,224	$535,354
$311,964	$467,947	$311,964	$1,591,019	$918,735	$1,220,526	$8,481,120	$2,500,000	$2,951,600	$0	$5,000,000	$2,233,400	$27,048,954	$8,114,686	$35,163,641	$439,546
$426,333	$692,792	$426,333	$2,717,875	$1,233,951	$1,386,363	$8,481,120	$2,500,000	$2,951,600	$2,000,000	$9,700,000	$3,094,981	$37,483,662	$11,245,099	$48,728,760	$487,288
$555,253	$971,693	$555,253	$4,247,688	$1,588,333	$1,552,199	$8,481,120	$2,500,000	$2,951,600	$4,000,000	$10,500,000	$3,680,303	$44,572,557	$13,371,767	$57,944,324	$482,869
$625,170	$1,133,121	$625,170	$5,181,096	$1,780,212	$1,635,118	$8,481,120	$2,500,000	$2,951,600	$6,000,000	$10,800,000	$4,084,928	$49,473,013	$14,841,904	$64,314,916	$494,730
$856,747	$1,713,493	$856,747	$8,738,816	$2,414,598	$1,883,873	$8,481,120	$2,500,000	$2,951,600	$9,000,000	$12,000,000	$5,193,752	$62,902,113	$18,870,634	$81,772,746	$511,080
$932,604	**$1,917,667**	**$932,604**	**$10,047,642**	**$2,622,098**	**$1,958,499**	**$8,481,120**	**$2,500,000**	**$2,951,600**	**$9,000,000**	**$12,000,000**	**$5,456,717**	**$66,086,908**	**$19,826,072**	**$85,912,981**	**$508,361**
$1,029,320	$2,187,305	$1,029,320	$11,811,447	$2,886,480	$2,049,709	$8,481,120	$2,500,000	$2,951,600	$12,000,000	$13,100,000	$6,176,673	$74,806,374	$22,441,912	$97,248,287	$540,268
$1,216,444	$2,737,000	$1,216,444	$15,509,667	$3,397,529	$2,215,546	$8,481,120	$2,500,000	$2,951,600	$15,000,000	$13,500,000	$7,208,920	$87,308,026	$26,192,408	$113,500,434	$567,502
$1,418,120	$3,368,035	$1,418,120	$19,889,133	$3,947,745	$2,381,383	$8,481,120	$2,500,000	$2,951,600	$15,000,000	$14,100,000	$8,110,888	$98,231,869	$29,469,561	$127,701,429	$580,461
$1,449,626	$3,470,043	$1,449,626	$20,608,251	$4,033,656	$2,406,000	$8,481,120	$2,500,000	$2,951,600	$15,000,000	$14,200,000	$8,258,140	$100,015,247	$30,004,574	$130,019,821	$583,049
$1,634,347	$4,085,867	$1,634,347	$25,005,504	$4,537,128	$2,547,220	$8,481,120	$2,500,000	$2,951,600	$15,000,000	$15,000,000	$9,170,975	$111,070,702	$33,321,211	$144,391,913	$601,633
$1,865,124	$4,895,952	$1,865,124	$30,914,438	$5,165,677	$2,713,056	$8,481,120	$2,500,000	$2,951,600	$15,000,000	$15,700,000	$10,353,578	$125,393,328	$37,617,998	$163,011,327	$626,967
$2,110,453	$5,803,747	$2,110,453	$37,671,592	$5,833,394	$2,878,893	$8,481,120	$2,500,000	$2,951,600	$15,000,000	$16,200,000	$11,668,091	$141,313,546	$42,394,064	$183,707,610	$656,099
$2,370,333	$6,814,708	$2,370,333	$45,332,625	$6,540,276	$3,044,730	$8,481,120	$2,500,000	$2,951,600	$15,000,000	$16,900,000	$13,159,912	$159,381,158	$47,814,347	$207,195,505	$690,652
$2,644,764	$7,934,293	$2,644,764	$53,953,195	$7,286,326	$3,210,566	$8,481,120	$2,500,000	$2,951,600	$15,000,000	$17,300,000	$14,793,437	$179,164,963	$53,749,489	$232,914,451	$727,858

Table C-4. East Pine Cost Estimate Worksheets

BUREAU OF RECLAMATION **ESTIMATE WORKSHEET** SHEET 1 OF 4

FEATURE: East Pine Creek Embankment Dam Site Summary Sheet 1 of 1	**PROJECT:** Eastern Oregon Water Storage Appraisal Study
	WOID: **ESTIMATE LEVEL:** Appraisal
	REGION: **UNIT PRICE LEVEL:** July-09
	FILE:

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		The East Pine Creek Storage Project consists of:					
		220 foot high zoned embankment dam					
		Regulating Outlet and conduit					
		Spillway					
		Relocated Road					
		Trap and Haul Fish Facility					
	1	Shell material U/S and D/S		1,654,914	CY	$17.00	28,133,534
	2	Filter Zones U/S and D/S		84,327	CY	$30.00	2,529,804
	3	Impervious Core		518,610	CY	$15.00	7,779,149
	4	Foundation Excavation		205,259	CY	$9.50	1,949,962
	5	Foundation Grout Curtain		1	LS	$2,105,958.12	2,105,958
	6	Spillway Construction		1	LS	$8,481,120.00	8,481,120
	7	Regulating Outlet and Stilling Basin		1	LS	$2,500,000.00	2,500,000
	8	Relocations		1	LS	$882,000.00	882,000
	9	Fish Passage (Trap and Haul)		1	LS	$14,000,000.00	14,000,000
	10	Clearing grubbing dewatering and miscellaneous foundation work		1	LS	$2,951,600.00	2,951,600
		Subtotal					**71,313,127**
		Mobilization and Demobilization at 9%					6,418,181
		Subtotal Construction Field Costs					**77,731,308**
		Contingency @ 30%					23,319,392
		Total for Construction Field Cost					**101,050,700**
		Indirect @ 32%					32,336,224
		Total Project Cost					**133,386,925**
		SUBTOTAL THIS SHEET					

QUANTITIES		**PRICES**	
BY Richard Hannan, HDR Engineering, Inc.	**CHECKED** Terrance Hsu, HDR Engineering, Inc.	**BY** Richard Hannan, HDR Engineering, Inc.	**CHECKED** Shane Cline, HDR Engineering, Inc.
DATE PREPARED Reformatted from July 2009 estimate	**PEER REVIEW / DATE**	**DATE PREPARED** Reformatted from July 2009 estimate	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION **ESTIMATE WORKSHEET** SHEET 2 OF 4

FEATURE: East Pine Creek Embankment Dam Site Details 1 of 3	**PROJECT:** Eastern Oregon Water Storage Appraisal Study **WOID:** **ESTIMATE LEVEL:** Appraisal **REGION:** **UNIT PRICE LEVEL:** July-09 **FILE:**

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Information in this spread sheet is from TAB "East Pine"					
	1	Shell material U/S and D/S		1,654,914	CY	$17.00	$28,133,534
		Excavate, haul, place and compact suitable material from					
		on-site including material from spillway excavation and					
		local borrow areas. Material will be granular and free draining.					
		unit price of $17.00/CY based on (HDR 2009)					
	2	Filter Zones U/S and D/S					
		Material assumed to be manufactured off-site from regional deposits		84,327	CY	$30.00	$2,529,804
		of sand and gravel to meet filter criteria. Cost covers procurement,					
		hauling, placing, and compaction. A unit price of $30.00/CY based					
		on (HDR 2009)					
	3	Impervious Core		518,610	CY	$15.00	$7,779,149
		Excavate, haul, place and compact suitable material from					
		on-site borrow located in U/S reservoir area					
		Material will be suitable clay or silt clay mix compacted at appropriate					
		moisture content. Watering is assumed.					
		unit price of $15.00/CY based on (HDR 2009)					
	4	Foundation Excavation		205,259	CY	$9.50	$1,949,962
		This item assumes that unsuitable foundation material extends to					
		an average depth of 18 feet on abutments and valley section.					
		Unsuitable material would be wasted on site. Suitable material					
		would be stockpiled for use in the embankment. This costs covers					
		excavation, and hauling to disposal or stockpile at Unit Cost					
		of $9.50 (HDR 2009) **SUBTOTAL THIS SHEET**					

QUANTITIES		PRICES	
BY Richard Hannan, HDR Engineering, Inc.	**CHECKED** Terrance Hsu, HDR Engineering, Inc.	**BY** Richard Hannan, HDR Engineering, Inc.	**CHECKED** Shane Cline, HDR Engineering, Inc.
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION **ESTIMATE WORKSHEET** SHEET 3 OF 4

FEATURE: **East Pine Creek Embankment Dam Site** **Details 2 of 3**	**PROJECT:** **Eastern Oregon Water Storage Appraisal Study** **WOID:** / **ESTIMATE LEVEL:** Appraisal **REGION:** / **UNIT PRICE LEVEL:** July-09 **FILE:**

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Information in this spread sheet is from TAB "East Pine"					
	5	Foundation Grout Curtain		1	LS	$2,105,958.12	$2,105,958
		Cost for construction of the grout curtain was derived from the original CH2M-Hill design and cost estimate for the North Powder Project (PVWCD 1980) indexed to 2009 level and adjusted for the size and configuration at East Pine. The cost is assumed to cover cost cost of drilling, grouting, and water testing.					
	6	Spillway Construction		1	LS	$8,481,120.00	$8,481,120
		Cost for construction of the Spillway Construction was derived from the original CH2M-Hill design and cost estimate for the North Powder Project (PVWCD 1980) indexed to 2009 level and adjusted for the size and configuration at East Pine. The cost is assumed to cover cost the spillway and stilling basin construction.					
	7	Regulating Outlet and Stilling Basin		1	LS	$2,500,000.00	$2,500,000
		Cost for construction of the Regulating Outlet and Stilling Basin was derived from the original CH2M-Hill design and cost estimate for the North Powder Project (PVWCD 1980) indexed to 2009 level and adjusted for the size and configuration at East Pine.					
		SUBTOTAL THIS SHEET					

QUANTITIES		**PRICES**	
BY Richard Hannan, HDR Engineering, Inc.	**CHECKED** Terrance Hsu, HDR Engineering, Inc.	**BY** Richard Hannan, HDR Engineering, Inc.	**CHECKED** Shane Cline, HDR Engineering, Inc.
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

BUREAU OF RECLAMATION **ESTIMATE WORKSHEET** SHEET 4 OF 4

FEATURE: East Pine Creek Embankment Dam Site	**PROJECT:** Eastern Oregon Water Storage Appraisal Study
	WOID: / **ESTIMATE LEVEL:** Appraisal
	REGION: / **UNIT PRICE LEVEL:** July-09
Detail 3 of 3	**FILE:**

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	8	Relocations		1	LS	$882,000	882,000
		Relocation cost are based on an estimated cost of $45.00/foot of					
		relocated road and adjusted were made to reflect the required mileage.					
		road and utility relocations. Unit Cost from HDR 2009					
	9	Fish Passage (Trap and Haul)		1	LS	$14,000,000	14,000,000
		Fish Passage costs are based on conceptual level designs for					
		similar projects. The results were obtained and incorporated into an					
		alternative study at another site (HDR 2009). Since the size of the					
		streams were of the same order of magnitude those cost were used for this					
		project with adjustments for project size.					
	10	Clearing grubbing dewatering and miscellaneous foundation work		1	LS	$2,951,600.00	2,951,600
		Clearing, grubbing, dewatering and miscellaneous cost were taken					
		from the original CH2M-Hill 1980 cost estimate for North Powder and indexed to 2009.					
		No adjustments were made for differences between N.P. and East Pine					
	11	Mobilization and Demobilization					
		Mobilization and Demobilization was developed by reviewing values					
		used for other project of similar size and complexity. A value of					
		9% of the Field Construction cost before contingency was found to be					
		a typical. (HDR 2009, USACE 2006, USACE 2008)					
		Contingency					
		A contingency of 30% has been applied to the unit costs and					
		mob and demob. This was selected due to the uncertainties					
		associated with the quantities, uncertainties associated with					
		the final project configuration, and to cover missed work tasks.					
		Indirect Cost					
		Indirect at 32% - See Section 4 or the main report for description.					
		SUBTOTAL THIS SHEET					

QUANTITIES		PRICES	
BY Richard Hannan, HDR Engineering, Inc.	**CHECKED** Terrance Hsu, HDR Engineering, Inc.	**BY** Richard Hannan, HDR Engineering, Inc.	**CHECKED** Shane Cline, HDR Engineering, Inc.
DATE PREPARED	**PEER REVIEW / DATE**	**DATE PREPARED**	**PEER REVIEW / DATE**

EAST PINE

Area U/S shell = Area of u/s embankment - filter and core U/s of crest = (u/s slope*h*h/2) - (10*h)-(.5*h*h/2) = (2*h*h/2) -(10*h)- (0.5*h*h/2)
Area U/S and D/S filter = width*ht = 10*h

Area imp core = (wide of crest+wide of base)/2*h crest width = 13' base width = 13 + 1.0h = (13 + (13+1.0*h))/2*h
Area D/S shell = (u/s slope*h*h/2) - (10*h) (.5*h*h/2) = (2*h*h/2) (10*h) (0.5*h*h/2)

HEIGHT/PARAMETER DETERMINATION TABLE (based upon existing design						CROSS SECTIONAL AREA BY DAM HEIGHT							HORIZONTAL DISTANCE AT CREST BY DAM HEIGHT			VOLUME BY DAM HEIGHT						
base elev	crest elev	height	U/S slope	D/S Slope	crest width	U/S Shell	U/S Filter	Core	D/S filter	D/S Shell	Found Ex	Total Area	left side	valley section	right side	U/S Shell	U/S Filter	Core	D/S filter	D/S Shell	Found Ex	Total Vol
feet	feet	feet	Horz/1	Horz/1	feet	Sq feet	Sq feet	Sq feet	Sq feet	Sq feet	Sq feet	Sq feet	feet	feet	feet	Cubic Yds	Cubic Yds	Cubic Yds	Cubic Yds	Cubic Yds	Cubic Yds	Cubic Yds
3,100	3,120	20	2.75	2	26	250	200	460	200	100	1,210	2,420	34	90	44	1,193	955	2,195	955	477	5,775	5,775
3,100	3,140	40	2.75	2	26	1,400	400	1,320	400	800	2,160	6,480	67	90	88	8,697	2,485	8,200	2,485	4,969	13,418	76,835
3,100	3,160	60	2.75	2	26	3,450	600	2,580	600	2,100	3,110	12,440	101	90	132	26,396	4,591	19,740	4,591	16,067	23,795	71,385
3,100	3,180	80	2.75	2	26	6,400	800	4,240	800	4,000	4,060	20,300	135	90	176	58,178	7,272	38,543	7,272	36,361	36,907	147,628
3,100	3,200	100	2.75	2	26	10,250	1,000	6,300	1,000	6,500	5,010	30,060	168	90	220	107,929	10,530	66,337	10,530	68,443	52,753	263,767
3,100	3,220	120	2.75	2	26	15,000	1,200	8,760	1,200	9,600	5,960	41,720	202	90	264	179,533	14,363	104,847	14,363	114,901	71,335	428,007
3,100	3,230	130	2.75	2	26	17,713	1,300	10,140	1,300	11,375	6,435	48,263	219	90	286	224,745	16,495	128,662	16,495	144,332	81,651	530,729
3,100	3,260	160	2.75	2	26	27,200	1,600	14,880	1,600	17,600	7,860	70,740	269	90	352	403,849	23,756	220,929	23,756	261,314	116,701	933,609
3,100	3,280	180	2.75	2	26	34,650	1,800	18,540	1,800	22,500	8,810	88,100	303	90	396	564,333	29,316	301,955	29,316	366,450	143,486	1,291,370
3,100	3,293	193	2.75	2	26	39,975	1,930	21,134	1,930	26,007	9,428	100,403	325	90	425	688,460	33,239	363,966	33,239	447,694	162,363	1,566,798
3,100	3,300	200	2.75	2	26	43,000	2,000	22,600	2,000	28,000	9,760	107,360	337	90	440	762,215	35,452	400,606	35,452	496,326	173,005	1,730,050
3,100	**3,320**	**220**	**2.75**	**2**	**26**	**52,250**	**2,200**	**27,060**	**2,200**	**34,100**	**10,710**	**128,520**	**370**	**90**	**484**	**1,001,381**	**42,163**	**518,610**	**42,163**	**653,533**	**205,259**	**2,257,850**
3,100	3,340	240	2.75	2	26	62,400	2,400	31,920	2,400	40,800	11,660	151,580	404	90	528	1,285,717	49,451	657,694	49,451	840,661	240,248	2,882,974
3,100	3,360	260	2.75	2	26	73,450	2,600	37,180	2,600	48,100	12,610	176,540	438	90	573	1,619,110	57,314	819,585	57,314	1,060,302	277,971	3,613,624
3,100	3,380	280	2.75	2	26	85,400	2,800	42,840	2,800	56,000	13,560	203,400	472	90	617	2,005,445	65,752	1,006,010	65,752	1,315,046	318,429	4,458,006
3,100	3,400	300	2.75	2	26	98,250	3,000	48,900	3,000	64,500	14,510	232,160	505	90	661	2,448,608	74,767	1,218,697	74,767	1,607,483	361,621	5,424,322
3,100	3,420	320	2.75	2	26	112,000	3,200	55,360	3,200	73,600	15,460	262,820	539	90	705	2,952,486	84,357	1,459,372	84,357	1,940,205	407,549	6,520,776

Annual Cost Calculations

The total estimated construction costs were amortized to estimate the average annual cost per acre-foot of additional water supplied by the proposed reservoirs. The construction cost was amortized with Microsoft Office Excel 2007 PMT functions as follows:

Rate = 4.125 percent from:

Annual Plan Formulation and Evaluation interest rate per Reclamation MEMORANDUM to Commissioner from Director, Policy and Administration, November 22, 2010

Nper = 40 years length of repayment period per Reclamation guidance

PV = Total estimated construction cost as calculated for each proposed reservoir

PMT = Calculated annual cost of repayment

The results for each proposed reservoir are summarized below in Table C-5.

Table C-5. Proposed East Pine Reservoir Estimated Costs.

Proposed Reservoir	Plan Formulation and Evaluation Interest Rate (Rate)	Repayment Period In Years (Nper)	Construction Cost (PV)	Annual Cost of Repayment (PMT)
Hardman	4.125%	40	$50,000,000	$2,600,000
Thief Valley Enlargement	4.125%	40	$62,000,000	$3,200,000
North Powder	4.125%	40	$113,000,000	$5,800,000
Wolf Creek	4.125%	40		
East Pine	4.125%	40	$133,000,000	$7,000,000

The estimated annual cost of repayment (PMT) for each proposed reservoir was used to estimate the annual cost per acre foot of water supplied by the proposed reservoir. The annual repayment cost for each proposed reservoir was rounded and divided by the additional water supply (Estimated Average Annual Water Supply) to obtain the annual cost per acre foot (Estimated Average Annual Cost), or:

$$\text{Estimated Average Annual Cost (per acre-foot)} = \frac{\text{Annual repayment cost (\$)}}{\text{Estimated Average Annual Water Supply (average. acre-feet)}}$$

An additional $15 per annual acre-foot was then added to the Estimated Average Annual Cost per acre-foot to account for operations, maintenance costs. These reflect similar costs for Mason Dam (Phillips Reservoir) per personal communication with Peggy Browne (Browne 2010).

The results are shown in Table C-6 below.

Table C-6. Summary of Estimated Costs for Proposed Reservoirs.

No.	Proposed Storage Reservoir	Construction Cost	Storable Volume at 80 percent Reliability (acre-feet)	Cost per acre-foot of Storage Volume	Estimated Average Annual Supply (acre-feet)	Estimated Average Annual Cost per acre-foot[1]
83	Hardman	$50,000,000	4,800	$10,400	1,500	$1,750
30	Thief Valley Reservoir Enlargement	$62,000,000	43,000	$1,400	29,000	$130
40	North Powder	$113,000,000	5,300	21,400	4,500	$1,320
	Wolf Creek					
6	East Pine	$133,000,000	21,000	$6,500	13,700	$520

[1]Includes $15 per acre foot of operation, maintenance, and replacement costs (Browne 2010).

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Memo

To:	Christine Whitaker		
From:	Ron Mason & Rich Hannan	Project	BOR Studies in the Burnt/Powder River Basin
CC:			
Date:	6-26-09	Job No:	0-08807

RE: Site Visit to Potential Dam Site in the Burnt and Powder basins. Summary of field observations

Introduction

During the time period 2-4 June 2009 HDR staff (Mason and Hannan)from the Portland HDR office traveled to four project site that have the potential to be storage site for inclusion into a Bureau of Reclamation Report that HDR is helping to prepare. These sites visits were in support of preparing a cost estimate for four project sites. HDR staff traveled from Portland on 2 June and returned to Portland late on 4 June. Four project sites were visited in the Burnt and Powder River basins. The four sites are as follows:

- Hardman dam site
- North Powder River dam site
- Thief Valley dam site (existing dam site)
- East Pine dam site

Peggy Browne of Browne Consulting, Baker City, Oregon, provided logistical support and escorted us to the project sites. Peggy was very helpful. Irrigation district managers usually met HDR staff at the project site during the visit and helped to explain the project background and intended use of the stored water if a project was constructed.

Based on field observations and review of previous report produced by others, all four sites have the potential for further examination as a viable storage project. Field inspection of the sites revealed no physical characteristics that would eliminate a site from further evaluation.

Summary Existing Conditions and Observations

Site #1 -- North Powder River Dam Site
Summary of observations:

- The rock on left abutment at the higher elevations appears to have some shear zones that might requires some special treatment;
- The highway to Anthony Lakes has recently been relocated, this highway will need to be relocated again which will add additional cost to the project. This relocation has the potential to be a major cost item for this project location;
- Discussions with the local State of Oregon Geologist in Baker City reveals that mudflows down the North Powder River have recently occurred and will mostly likely continue to occur due to upstream glaciers. This will effectively reduce the amount of water storage behind the dam site over time. Engineering measures can be taken to make dam safe with regards to mudflows.
- Diversion of stream flow will be difficult and expensive during construction.

- A tunnel for diversion of flows during construction might be required, but would be expensive to construct.
- Due to the existing valley section at the dam site, the layout for the dam will somewhat complex and will need detailed construction monitoring.
- A dam could be constructed at this project site but has some concerns(dewatering during construction, dam alignment issues, foundation treatments) that will need to be dealt with during the final design phase.

Site #2 -- East Pine Dam Site
Summary of observations:

- Significant amount of geotechnical investigations have already been conducted by others. A review of this project data reveals no major geotechnical concerns that can't be addressed.
- There appears to be some inactive faults in the area which might need to be included in the project design if this proposed site goes to the next phase of ingestions;
- Overall, a very good site to locate a dam;
- The dam site location has been selected which will create maximum use of upstream valley storage;
- The area is heavily forested and should provide reasonable amount of water for downstream users;
- A preliminary design for this project was developed by the Soil Conservation Service in 1975;
- This site has the potential to be a very good dam site.

Site #3 -- Thief Valley Dam Site
Summary of observations:

- The existing dam is located in an excellent section of the valley;
- The drainage area above the existing dam site is very large almost 915 sq. miles. Overall water yield from the watershed should be very good;
- The upstream area has a large storage potential based on a relatively small raise in the existing dam;
- At the time of the site visit, water was going over the spillway, the top of the dam is one large free overflow spillway;
- At full pool conditions, wind and wave action has created a lake shoreline erosion problem which could account for some of the sediment infill into the reservoir. This same action would occur due to similar soil types if a new d/s project was created;
- Rock conditions at the existing dam are very good based on visual inspection;
- It appears that river downstream from the existing dam is very steep. This would require that a new downstream project be very tall in comparison to the existing dam.
- Based on a discussion with the local state of Oregon geologist, the area downstream from the existing dam is prone to landslide which could be problematic for sitting a new dam downstream from the existing dam;

- The potential for a new down stream dam site is problematic. Considerations should be given to improvements at the existing dam site;
- Field observation indicate that a potential raise using Roller Compact Concrete (RCC) should be given consideration and further evaluation;
- The existing Amberson section of the dam could be backfilled Controlled Density Fill, CDF and the capped with RCC;
- The cost of RCC is relatively inexpensive when compared the cost of a new embankment dam;
- The existing concrete dam has the potential for a RCC dam raise.

Site #4 -- Hardman Dam Site
Summary of observations:

- Based on discussions with local irrigation managers some amount of geotechnical investigations have already been conducted by others, but data has not been available for review;
- The site is located in an excellent section of the valley;
- Both abutments appear to have very good rock conditions.
- The right abutment would be an ideal location for the emergency spillway;
- This project location would be an excellent candidate for an RCC structure; although an earth embankment dam would also work;
- Upstream valley storage potential is very good due to the valley configuration;
- Some relocation of a county road would be required;
- Overall, this site has the potential to be an excellent site for a dam.